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Jožef Stefan Institute, Ljubljana, Slovenia

Annual report 2010

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Ljubljana, May 2010

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INTRODUCTION

The difficult period that Europe is currently going through, which is to a large extent a consequence of the economic crisis and the subsequent aftershocks, is giving rise to what is called the "innovation union". While the rest of the world has been developing intensely, the European goal to become the most competitive and advanced economy by 2010 has not been realised. It is, therefore, not surprising that the new European 2020 Strategy is even more ambitious and committed. The European 2020 Innovation Policy now provides the basis for all other individual European policies; it is no longer an option that European countries may choose, rather it is a binding commitment. This new strategy not only emphasizes collaborative research, but also the delivery of innovations. Attention is thus being shifted from joint research to the joint planning and coordination of national strategies.

Our new, emerging strategy paper called The Research and Innovation Strategy of Slovenia includes science in the national innovation system, representing, in this way, an important shift towards a broad national commitment. However, judging from the current daily developments, European appeals for change are not having much impact on the majority, and neither is the economic crisis that hit us more than other developed countries and caused the collapse of certain institutions. I wonder what else needs to happen before our society understands that clinging to old and ineffective solutions, bureaucratic practices carried out in the name of the law and futile arguments about unimportant issues will not allow our country to move ahead with other developed nations. We still live with the belief, or hope, that development, knowledge and innovation are not expected from everybody, as they are only the responsibility of some small groups in our society.

In view of the above, when reading the Institute's annual report for 2010, I admire the top-level results that our researchers have achieved in the areas of research and technology. The goals that we set ourselves show that we are focused on international cooperation at the highest level, the development of new technologies, forming links with industry, as well as with other research and educational institutions, and the development of a modern research infrastructure.

In addition, I need to mention that certain developments do fill us with optimism. In 2010 we witnessed an increase in the interest of industrial organisations to cooperate with our Institute and to employ young PhD graduates that have finished their research with us. Our efforts to set up stronger links also became more intensive and extensive, as we know that basic and applied research go hand in hand, stimulating and reinforcing each other. Our Institute wins all its funds for our activities competitively, through direct projects with the end users, or through various national and international agencies. At the end of 2010 the Institute had a record number of employees, which reflects our success at home and internationally in obtaining new projects. Most of our researchers are employed only for the duration of a new project, which makes the Institute more competitive. And it is especially gratifying that only the employment of young researchers and post-doctoral researchers is on the increase, while the employment of other staff showed a slight decrease.

Among the various achievement made in 2010, I am especially keen to mention the first micro laser in the world, developed in our Department for Solid State Physics, which has had a fantastic response from the scientific and business communities around the world. I see this achievement as an example that requires our full attention: we should think about whether we can, and in what way, use this scientific and technological achievement that has almost unimaginable application potentials, to create a highly developed technological product that a company, a new or an existing one, can sell successfully. I believe that this is the central issue that our state should discuss in all its complexity, together with our European partners, instead of having empty discussions about artificially created issues.

Prof. Jadran Lenarčič
Director of the Jožef Stefan Institute

Prof. Jadran Lenarčič, in a discussion with Margherita Hack during her visit to the Institute.

A BRIEF HISTORY OF THE JOŽEF STEFAN INSTITUTE

1946
~ Decision taken by the Slovenian Academy of Science and Arts to build a Physics Institute

1949
~ Research connected to the peaceful use of atomic energy started, financed by the Federal Government

1952
~ Institute renamed the Jožef Stefan Physics Institute and moved to new laboratories on its present site

1954
~ The betatron and an electron microscope installed as the institute's first major pieces of equipment

1956
~ Van de Graaff accelerator, constructed at the institute, started operation

1958
~ Institute reorganised and new fields of activity defined: nuclear physics, solid-state physics, chemistry, and radiobiology

1959
~ Institute renamed the Jožef Stefan Nuclear Institute. The major source of income was provided by the Yugoslav Atomic Energy Commission

Mass spectrometer at the JSI (about 1960)

1962
~ One of the first compounds of a noble gas, XeF_6, synthesised at the institute
~ The first computer for research, ZUSE Z 23, installed

1966
~ Nuclear research reactor TRIGA starts operation

1968
~ Yugoslav Atomic Energy Commission ceases to operate; The Republic of Slovenia becomes the institute's dominant source of research funding

1969
~ Institute is renamed as the Jožef Stefan Institute

1970
~ University of Ljubljana becomes a co-founder of the Jožef Stefan Institute, together with the Federal Executive Council

1971
~ A new unit, INOVA, established with the aim of applying the institute's expertise and output to productive use in the national economy

Institute buildings after the opening 1953

1972
~ New computer Cyber 72 purchased, and the Republic Computer Centre established as an independent unit of the Jožef Stefan Institute

1974
~ Collaboration with the international centre CERN in the field of high-energy physics started
~ SEPO group for evaluating environmental interventions is established

1976
~ First Yugoslav 8-bit processor computer DARTA 80

1979
~ Contract defining cooperation between the Jožef Stefan Institute and the Nuclear Power Plant Krško is signed
~ First robot in Slovenia is constructed

1982
~ Ecological Laboratory with Mobile Unit established as a special unit of the Slovenian Civil Protection Organisation

1983
~ Stefin, a cysteine proteinase inhibitor named after Jožef Stefan, isolated and its primary structure determined

The Reactor Centre, Podgorica, built in 1966

1985
~ "2000 New Young Researchers" project established by the Slovenian Research Council
~ Centre for Hard Coatings established by the Jožef Stefan Institute and the firm SMELT

1987
~ INEA established by the Jožef Stefan Institute as an independent company to promote technology transfer in the fields of cybernetics and energy management

Nuclear magnetic resonance spectrometer

1989
~ Milan Čopič Nuclear Training Centre established

1990
~ The first Slovenian supercomputer, CONVEX, installed at the Jožef Stefan Institute

1992
~ New technology centres established by the Ministry of Science and Technology
~ Jožef Stefan Institute restructured by the Slovenian Government as a public research institution
~ Jožef Stefan Technology Park founded, later to become the Ljubljana Technology Park

1995
~ Jožef Stefan Institute is a co-founder of the international postgraduate school for environmental sciences, the Nova Gorica Polytechnic
~ Research institutes in Velenje, ERICo and Valdoltra established by the Institute

1997
~ 3.5-MeV electrostatic accelerator, TANDETRON, installed

1999
~ Jožef Stefan Institute celebrates its 50th anniversary

2003
~ Jožef Stefan International Postgraduate School established

2004
~ Jožef Stefan Institute is chosen as the coordinator of four Research Centres of Excellence

2007
~ nanomanipulation of single atoms using low-temperature scanning tunneling microscope
~ New ERDA/RBS beamline installed at the TANDETRON accelerator at the Microanalytical center

The beginnings of robotics at the JSI, in 1985

FORMER DIRECTORS

Prof. Anton Peterlin, first Director of the Jožef Stefan Institute

Prof. Anton Peterlin, Founder and first Director of the Jožef Stefan Institute, 1949–1955
Karol Kajfež, 1955–1958
Lucijan Šinkovec, B. Sc., 1959–1963
Prof. Milan Osredkar, 1963–1975
Prof. Boris Frlec, 1975–1984
Prof. Tomaž Kalin, 1984–1992
Prof. Danilo Zavrtanik, 1992–1996
Prof. Vito Turk, 1996–2005

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PARTICIPATION IN REGIONAL DEVELOPMENT OF RESEARCH

Ljubljana Technology Park Ltd.

University of Nova Gorica

Jožef Stefan International Postgraduate School

Technology Centres

Technology Centre for Circuits, Components, Materials, Technologies and Equipment for Electrotechnic (TC SEMTO)

Technology Centre for Production Automation, Robotics and Informatics (ARI)

Nanotesla Institute Ljubljana

Development Centre for Hydrogen Technologies

Technology Centre for Circuits, Components, Materials, Technologies and Equipment for Electrotechnic (TC SEMTO)

Centres of excellence

Nanocenter - Center of excellence in Nanoscience and Nanotechnology

Centre of Excellence for Integrated Approaches in Chemistry and Biology of Proteins (CIPKeBiP)

Centre of Excellence NAMASTE

Center of Excellence for Polymer Materials and Technologies (PoliMaT)

EN-FIST Centre of Excellence

CEBIC Centre of excellence for Biosensors, Instrumentation and Process Control

CO NOT: Centre of Excellence for Low-Carbon Technologies

Centre of Excellence for Space Sciences and Technologies SPACE-SI

MANAGEMENT

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Prof. Jadran Lenarčič

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Dr. Boris Pukl (to 3. 7. 2010)

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Dr. Boris Pukl (from 3. 7. 2010)

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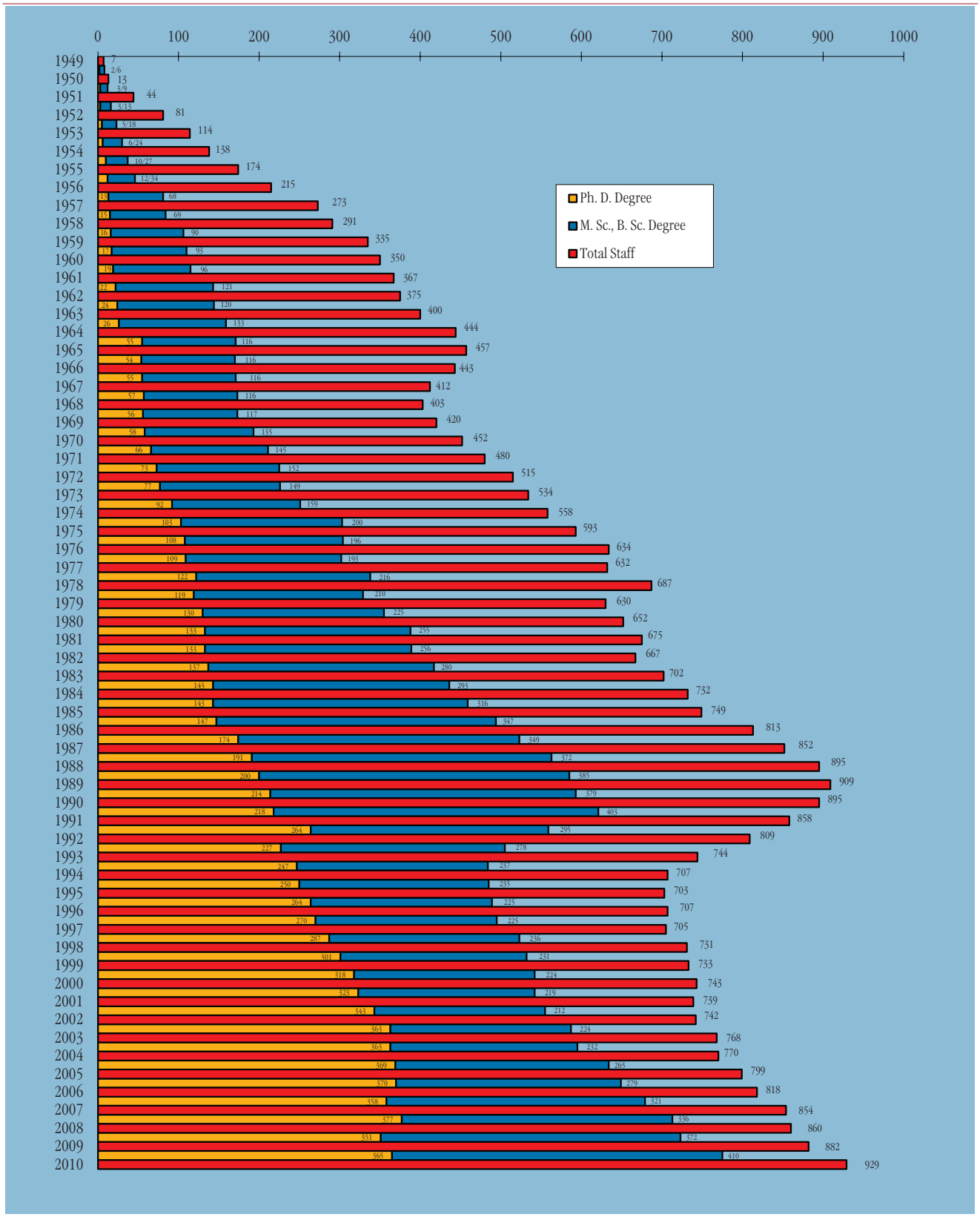
1949-2010



RECIPIENTS OF THE JSI AWARDS AND TITLES

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DELEGATIONS AND VISITORS

H. E. Mr Sandër Kovaçi, the Ambassador of the Republic of Albania in Slovenia, 12 January 2010

Mr Bradley A. Freden, Chargé D'Affaires, Embassy of the United States of America, Ljubljana, Slovenia, 27 January 2010

Mrs Roberta Ferrazza, the Directress of the Italian Institute of Culture in Slovenia, 3 February 2010

Mr Simon Vrhunec, M. Sc., the Director of the University Medical Centre Ljubljana, 11 March 2010

Mrs Irit Savion Waidergorn, Chargé D'Affaires, Embassy of the State of Israel, Vienna, Austria, 24 March 2010

Participants at the panel discussion entitled A time of crisis or a time of vision?, 25 March 2010:
Mr Franjo Bobinac, M, Sc., President of the Management Board and CEO, Gorenje, d. d., Velenje
Mr Samo Hribar Milič, M. Sc., General Manager of the Chamber of Commerce and Industry of Slovenia, Ljubljana
Mr Stojan Petrič, Chairman, Kolektor Group, d. o. o., Idrija
Prof. Dušan Mramor, Dean, Faculty of Economics, University of Ljubljana

Mr Tomaž Berginc, President of the Management Board and CEO, ETI Elektroelement, d. d., Izlake, 12 May 2010

Dr. Takeshy Shimazaky, National Institute of Advanced Industrial Science and Technology (AIST), USA, 28 May 2010

H. E. Mr Jos Douma, the Ambassador of the Kingdom of the Netherlands, 2 June 2010

Prof. Margherita Hack, astrophysicist, Italy, 29 September 2010

Mr Stane Rožman, President of the Management Board, Krško Nuclear Power Plant, 4 October 2010

H. E. Mr Robert Reich, the Ambassador of Switzerland in Slovenia, 11 October 2010

Dr. Stojan Sorčan, Director General, Directorate for Higher Education, Ministry of Higher Education, Science and Technology, 15 October2010

Mr Ivo Boscarol, General manager and founder, Pipistrel, d. o. o., Ajdovščina, 21 October 2010

Mr Martin Novšak, Director, GEN energija, d. o. o., Krško, 22 October 2010

Dr. Edvard Kobal, Director, Slovenian Science Foundation, Ljubljana, 11 November 2010

Mrs Maxime Feraille, Embassy of the French Republic, Ljubljana, Attache for Science, 11 November 2010

Acad. Prof. Boštjan Žekš, Minister, the Government Office for Slovenes Abroad, Ljubljana, 19 November 2010

Mr Bojan Marin, M. Sc., Director, Balder, d. o. o., Ljubljana, 24 December 2010

INTERNATIONAL COOPERATION

Multilateral international cooperation	No. of projects
7. FP (COOPERATION: HEALTH, FOOD, AGRICULTURE/FISHERIES, BIOTECHNOLOGY, INFORMATION COMMUNICATION TECHNOLOGIES, NANOSCIENCES + NANOTECHNOLOGIES, MATERIALS + NEW PRODUCTION TECHNOLOGIES, ENERGY, ENVIRONMENT AND CLIMATE CHANGE, TRANSPORT (INCLUDING AERONAUTICS), SOCIO-ECONOMIC SCIENCES + THE HUMANITIES, SPACE, SECURITY; IDEAS: FRONTIER RESEARCH (EUROPEAN RESEARCH COUNCIL); PEOPLE: MARIE CURIE FELLOWSHIPS; CAPACITIES: RESEARCH INFRASTRUCTURES, SMEs, REGIONS OF KNOWLEDGE, RESEARCH POTENTIAL, SCIENCE AND SOCIETY, INCO (HORIZONTAL), DEVELOPMENT OF POLICIES)	57
7. FP - EURATOM	23
6. FP (LIFESCIHEALTH, IST, NMP, AERO, TREN, SPACE, FOOD, ENERGY, TRANSPORT, GLOBAL, CITIZENS, SSP, NEST, SME, INCO, ERA-NET, MOBILITY, INFRASTRUCTURES, SCIENCE AND SOCIETY, RESEARCH/INNOVATION POLICIES)	16
IEE	7
CIP	3
CENTRAL EUROPE	1
LEONARDO DA VINCI	2
E-CONTENTPLUS, PHEA	4
E-PARTICIPATION	1
E-CONTENTS AND E-SERVICES	3
ERASMUS	1
EUREKA	5
COST	16
NATO (SfP)	3
IAEA	21
ERA-NET (MATERA, MNT, MNT II, SEE, ERASME)	9
HFSPO	2
OTHERS (DELPHI, HERA-B, ATLAS, CERN RD-39, CERN RD-42, CERN RD-50, BELLE, BELLE II, CIMA, NFM, SCOPES, EUROSTARS, MŠŠ, SIM-RIS, EUSAS, ARTEMIS, SERENA - OECD, CAMP, SETH-2, UNESCO-ROSTE, F4E, EURADOS, SLOVENIA - RTD AUDIT...)	26
TOTAL	**200**

Bilateral cooperation	No. of projects
Albania	1
Argentine	2
Austria	10
Belgium	10
Bulgaria	2
Bosnia and Herzegovina	3
Brazil	2
Czech Republic	3
Montenegro	2
Denmark	1
France (PROTEUS - 10)	14
Croatia	19
Japan	12
China	10
Korea	1

Bilateral cooperation	No. of projects
Hungary	6
Germany	6
The Netherlands	1
Poland	5
Portugal	3
Romania	2
Russia	1
Serbia	5
Sweden	1
Switzerland	1
Turkey	1
Ukraine	5
Great Britain	2
USA	20
TOTAL	**151**

INTERNATIONAL COOPERATION AGREEMENTS

In 2010, cooperation agreements were signed between the Jožef Stefan Institute and:

1. X6D Limited, Limassol, Cyprus
2. TEMAS AG, Arbon, Switzerland
3. Center for Ecological – Noosphere, Studies of National Academy of Sciences, Yerevan, Republic of Armenia
4. University of Jaén, Jaén, Spain
5. Aalto University School of Science and Technology, Espoo, Finland
6. IPSA Institute, Sarajevo, Bosnia and Herzegovina
7. SAP AG, Walldorf, Germany
8. Recommind GmbH, Rheinbach, Germany
9. Ghana India Kofi Annan Centre of Excellence in ICT, Ghana's First Advanced Information Technology Institute, Accra, Ghana
10. Inquus Corporation, Atlanta, GA, USA

COOPERATION WITH UNIVERSITIES

FULL-TIME FACULTY MEMBERS

Professors

1. **Asst. Prof. Denis Arčon**, University of Ljubljana, Faculty of Mathematics and Physics
2. **Prof. Iztok Arčon**, University of Nova Gorica
3. **Asst. Prof. Irena Ban**, University of Maribor, Faculty of Chemistry and Chemical Engineering
4. **Prof. Janez Bonča**, University of Ljubljana, Faculty of Mathematics and Physics
5. **Prof. Ivan Bratko**, Academician, University of Ljubljana, Faculty of Computer and Information Science
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34. **Jasna Prebil**, *Binding of amphitropic proteins to phospholipid membranes and their influence on the shape of phospholipid vesicles* (mentor Saša Svetina; co-mentor Blaž Rozman)
35. **Matej Pregelj**, *Magnetic properties of two-dimensional systems of magnetic clusters with triangular geometry* (mentor Denis Arčon)
36. **Nataša Radić**, *The effect of medicinal mushroom and plant extracts on gene expression in model cell lines* (mentor Borut Štrukelj)
37. **Miha Renko**, *Comperative view into protease - inhibitor interaction* (mentor Dušan Turk)
38. **Nuša Resman**, *Immune response activation through TLR4/MD-2 receptor complex* (mentor Roman Jerala; co-mentor Janko Kos)
39. **Dejan Škrabelj**, *Optical field generation in Q-switched unstable laser resonators* (mentor Irena Drevenšek Olenik; co-mentor Marko Marinček)
40. **Uroš Tkalec**, *Colloidal interactions and novel colloidal structures in thin nematic layers* (mentor Igor Muševič)
41. **Aneta Trajanov**, *Analysis of results of ecological simulation models with machine learning* (mentor Sašo Džeroski)
42. **Hana Uršič Nemevšek**, *Structural and electrical properties of 0.65PMN-0.35PT thick films on different substrates* (mentor Marija Kosec; co-mentor Marko Hrovat)
43. **Asja Veber**, *Synthesis and characterization of $Bi_{12}SiO_{20}$ thin films prepared by sol-gel method* (mentor Danilo Suvorov)
44. **Jernej Vidmar**, *Role of MRI in the analysis and prognosis of thrombolysis with thrombolytic agents* (mentor Igor Serša; co-mentor Aleš Blinc)
45. **Marko Viršek**, *Structural, electrical and optical properties of low dimensional crystals of molybdenum and tungsten compounds* (mentor Maja Remškar)
46. **Stanislav Vrtnik**, *Electrical and magnetic properties of Al-based quasicrystals and giant-unit-cell intermetallics* (mentor Janez Dolinšek)
47. **Blaž Zupančič**, *NMR study of photoisomerization in bulk and confined liquid crystals* (mentor Boštjan Zalar)
48. **Erik Zupanič**, *Low-temperature STM study and manipulation of single atoms and nanostructures* (mentor Albert Prodan; co-mentor Miha Škarabot)
49. **Jure Žabkar**, *Learning of qualitative relationships* (mentor Ivan Bratko; co-mentor Janez Demšar)
50. **Zora S. Žunić**, *Identification and assessment of high radon areas in some rural regions on the Balkans* (mentor James P. McLaughlin; co-mentor Peter Stegnar)

Master's theses

1. **Saša Brečko**, *Analiza spletišč javnega sektorja in možne izboljšave za večjo dostopnost* (mentor Vladislav Rajkovič)
2. **Marjan Brelih**, *Informacijska rešitev celovitega energetskega upravljanja* (mentor Vladislav Rajkovič)
3. **Janez Bucik**, *A program module for online analytical data processing in the Navision information System* (mentor Marko Bohanec)
4. **Anita Danč**, *Synthesis and characterization of CdTe nanoparticles by sonochemical method in aqueous solution* (mentor Matjaž Kristl; co-mentor Mihael Drofenik)
5. **Valerija Danč**, *Synthesis and characterization of CdS and CdSe nanoparticles by sonochemical method in aqueous solution* (mentor Irena Ban; co-mentor Mihael Drofenik)
6. **Marija Dolenec**, *Odločitveni model za izbiro najboljšega hotelskega proizvoda* (mentor Vladislav Rajkovič)

7. **Avgust Drol**, *Model za oceno primernosti programske opreme v zavarovalnici* (mentor Vladislav Rajkovič)
8. **Matjaž Ferjančič**, *Effects of Snubber Modeling Assumptions on the Earthquake Induced Stresses in Pipe* (mentor Leon Cizelj)
9. **Simona Golob**, *Recycling of grinding slime from automotive industry* (mentor Radmila Milačič)
10. **Jana Hribar**, *Development and validation of method for biological activity determination of recombinant darbepoetin alfa* (mentor Borut Štrukelj)
11. **Maja Jug**, *Reflection of light on the wavy surface* (mentor Mojca Čepič)
12. **Tomaž Klančnik**, *Identity management in cloud computing* (mentor Borka Jerman Blažič)
13. **Valentin Koblar**, *Ocenjevanje kakovosti grafitnih polizdelkov z računalniškim vidom in s strojnim učenjem* (mentor Bogdan Filipič)
14. **Maja Končar**, *Študija prehoda na protokol IPv6 pri večjem internetnem operaterju in ocena potrebnih finančnih vlaganj* (mentor Borka Jerman Blažič)
15. **Damjan Kosec**, *Uporaba odločitvenega modela v okviru spletnega portala* (mentor Vladislav Rajkovič)
16. **Mateja Košir**, *Slovenian Film Terminology in a Corpus of Film Reviews* (mentor Tomaž Erjavec)
17. **Janez Kralj**, *Targeting clients through knowledge discovery from databases* (mentor Marko Bohanec)
18. **Ivan Lorencin**, *Technical and economic optimization of energy investments with evolutionary algorithms* (mentor Miran Mihelčič; co-mentor Bogdan Filipič)
19. **Jerneja Milavec**, *Electrooptic properties of holographic polymer - dispersed liquid crystals* (mentor Irena Drevenšek Olenik)
20. **Jerneja Pavlin**, *Analysis of the First Year University Students' Conceptions about Liquid Crystals* (mentor Nataša Vaupotič; co-mentor Mojca Čepič)
21. **Toni Petrovič**, *Reference activities of $_{40}K$ radionuclide in various samples* (mentor Matej Lipoglavšek; co-mentors Benjamin Zorko, Marijan Nečemer)
22. **Helena Plahuta**, *Corpus Linguistics Methods in the Drafting of Equestrian Terminology Dictionary* (mentor Tomaž Erjavec)
23. **Boštjan Podboršek**, *Prenova sistema za pomoč uporabnikom informacijske tehnologije* (mentor Vladislav Rajkovič)
24. **Marija Podbregar**, *Odločitveni model za izbiro dobavitelja repromaterialov v proizvodnih podjetjih* (mentor Vladislav Rajkovič)
25. **Janez Podobnik**, *The use of magnetic resonance imaging in monitoring effects of enviroment on respiratory organs* (mentor Igor Serša; co-mentor Igor Kocijančič)
26. **Danica Radmanovac**, *Distribution of nanoparticles of fullerenol in human serum in presence of doxorubicin* (mentor Svjetlana Trivic; co-mentor Alenka Mertelj)
27. **Maja Simon**, *Model združevanja nepremičninskih evidenc geodetske uprave* (mentor Vladislav Rajkovič)
28. **Eva Stergaršek Kuzmič**, *Detecting new objects and building models with active robot system* (mentor Aleš Leonardis; co-mentor Aleš Ude)
29. **Damjana Šajne**, *Preparation and assessment of e-learning materials for primary schools with an example in teaching engineering and technology* (mentor Tanja Urbančič)
30. **Simon Torkar**, *Informatizacija procesa obravnave pacienta v primarnem zdravstvu* (mentor Vladislav Rajkovič)
31. **Petra Vide Ogrin**, *Development of digital library tools for history studies* (mentor Maja Žumer; co-mentor Tomaž Erjavec)
32. **Aljaž Vidmar**, *Usage of WEB 2.0 technologies for the development of modern web applications (* mentor Branko Kavšek)
33. **Rok Zajc**, *Odločitveni model za pomoč pri izbiri telekomunikacijskega sistema* (mentor Vladislav Rajkovič)

Specialist theses

1. **Sabina Jakomin**, *Efficiency of the elemental analysis for investigation of the textile fibers in forensics* (mentor Katja Drobnič; co-mentors Žiga Šmit, Jure Majdič)
2. **Mateja Tršan**, *Good manufacturing practices of sterile products in hospital pharmacy with a focus on testing of bacterial endotoxin* (mentor Slavko Pečar)

ART EXHIBITIONS AT THE JSI

Klavdij Tutta, 11 January-29 January
Nataša Mirtič, 1 February-25 February
Ana Šalamun, 1 March-18 March
Silvester Komelj, 22 March-15 April
Dušan Jež, 19 April-13 May
Natalija Šeruga, 17 May-6 June
Nikolaj Mašukov, 7 June-1 July
Ljubljana Fine Artist Society, 5 July-1 September
Keiko Vahčič, 6 September-30 September
Milan Golob, 4 October-21 October
Janez Korošin, 25 October-18 November
Lučka Šićarov, 22 November-9 December
Petar Beus, 13 December-24 January 2011

Director of the JSI Prof. Jadran Lenarčič at the opening of the exhibition works of Silvester Komel

INSTITUTE COLLOQUIA

3 February 2010: **Andrea Lorenzoni**
A.S.I. Agenzia Spaziale Italiana
Italy in Space

3 March 2010: **Janja Vaupotič**
Josef Stefan Institute
Radon - dangerous radioactive gas and useful research tool

10 March 2010: **Andrew Bleloch**
University of Liverpool and SuperSTEM Laboratory
Understanding materials atom by atom: a new era of aberration corrected electron microscopy

22 March 2010: **Peter Day**
University College and Royal Institution, London, UK
Materials Chemistry – a Science for the 21st Century, What is it and why does it matter?

23 March 2010: **Roman Jerala**
National institute of chemistry Slovenia and Faculty of Chemistry and Chemical Technology, University of Ljubljana
From understanding of molecular mechanisms of innate immunity to therapy

24 March 2010: **Igor Muševič**
Faculty of Mathematics and Physics , University of Ljubljana and Jožef Stefan Institute
Neumatic colloids and photonics

7 April 2010: **Leon Žlajpah**
Josef Stefan Institute
Robot Manipulator Control Design

12 May 2010: **Erich Leitgeb**
Institute of Broadband Communications, Graz University of Technology, Graz, Austria
Optical Wireless Technologies for Broadband Communications

26 May 2010: **Sergey V. Reznik**
Bauman Moscow State Technical University (BMSTU), Moscow, Russia
Inverse Problem Solutions in Heat Transfer: Applications in Development of New Manufacturing Technologies for Ceramics and Glass, and Studies of Advanced Materials Thermophysical Properties

22 September 2010: **Alfred Leitenstorfer**
Department of Physics and Center for Applied Photonics, University of Konstanz,Germany
Quantum Physics with Ultrabroadband and Intense Terahertz Pulses

28 September 2010: **Rinku Majumder**
Department of Biochemistry & Biophysics, University of North Carolina at Chapel Hill, USA
Novel reagents to bypass limitations of existing clotting assays

6 October 2010: **Dušan Petrač**
Cousultat at JET Propulsion Laboratory, NASA
Infrared Astronomical Satellite (IRAS)

13 October 2010: **Jürgen Rödel**
Institute of Materials Science, Technische Universität Darmstadt, Germany
Application and Research in Piezoceramics

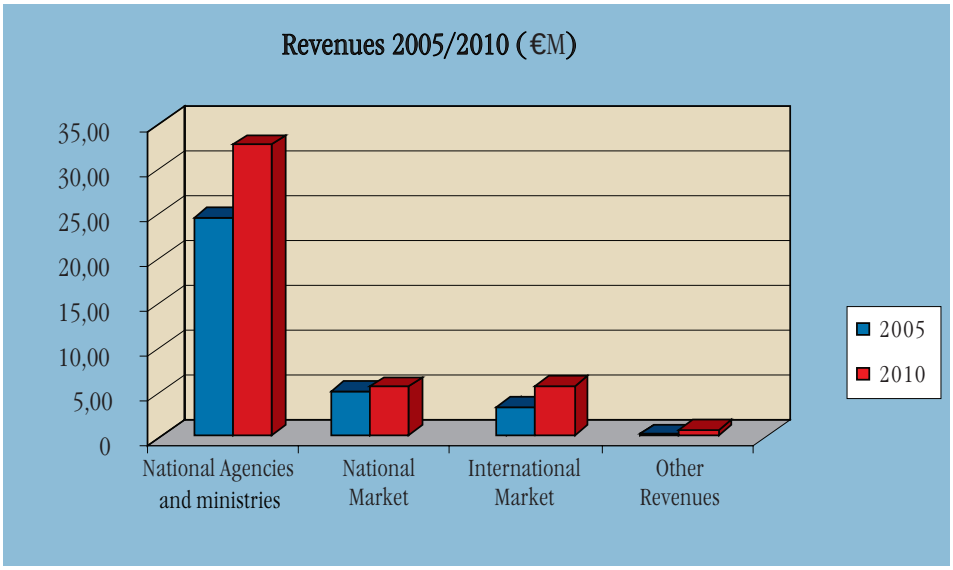
17 November 2010: **Igor Križaj**
Jožef Stefan Institute
Poisoning of the motoneuron nerve terminal by snake venom phospholipase A2 – our current understanding of the mechanism

8 December 2010: **Zdravko Kutnjak**
Jožef Stefan Institute
What has development of new generation of cooling devices, artificial muscles, and new enhanced sources of ultrasound in common with the phase diagram of water?

FINANCING

REVENUES JSI (€) AND NUMBER OF PROJECTS

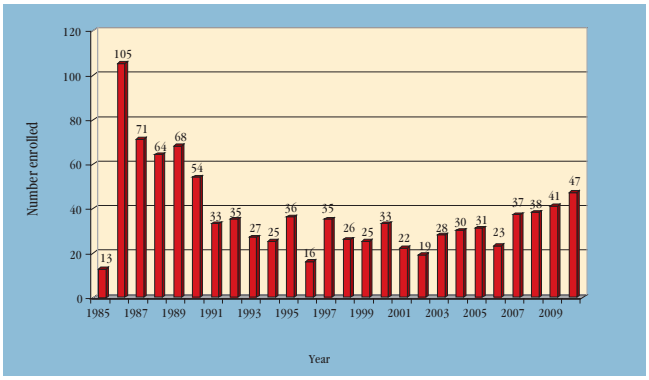
	2010	Contribution 2010	2005	Contribution 2005	Index 2010/2005	No. of Contracts in 2010
National Agencies and Ministries	34,433,391	73.9 %	25,823,581	74.7 %	133.3	440
National Market	5,748,309	12.3 %	5,224,503	15.1 %	110.0	168
International Market	5,820,943	12.5 %	3,367,551	9.7 %	172.9	369
Other Revenues	622,278	1.3 %	158,571	0.5 %	392.4	
TOTAL	**46,624,921**	**100.0 %**	**34,574,206**	**100.00 %**	**134.9**	**977**



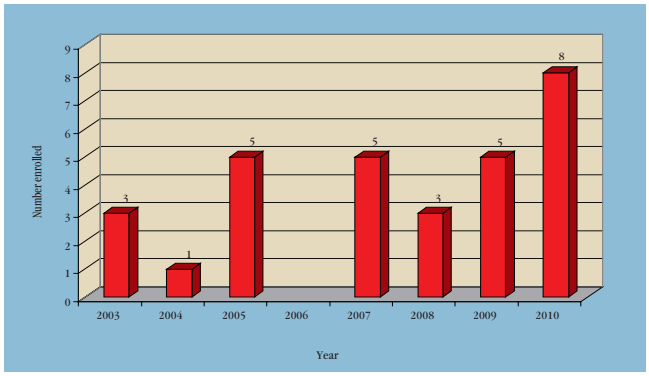
POSTGRADUATES FINANCED

1985-2010

by Slovenian Research Agency



by Industry



JSI UNDERGRADUATE SCHOLARSHIPS

1977-2010

Year	FMF		FKKT UNI LJ	FKKT UNI MB	NTF	FDV	FA	BF	FE and FRI	Other UNI LJ	FG and FERI	UNG	IPS	Total
	Physics	Mathematics												
... 1982	115	38	100						50	12				315
1983	10	1	5						9		1			26
1984	11	3	7					1	12		1			35
1985	18	4	6					1	19		1			49
1986	16	8	4						22	2				52
1987	20	8	4						23	2				57
1988	26	7	8					1	27	2				71
1989	26	6	10					1	19	3	1			66
1990	26	5	11					2	25		1			70
1991	23	2	9					2	24	2	1			63
1992	22	3	16					3	17	1				62
1993	21	1	15					3	13	1				54
1994	7	1	8					3	6					25
1995	2		9					3	5					19
1996	2		9					3	5					19
1997	2		12					1	4		1			20
1998	1		6					1	7		1			16
1999	2		7					4	7					20
2000	1		5					3	9					18
2001	3		13					3	10					29
2002	4		20					3	10					37
2003	3		18					2	12	1				36
2004	4		17					1	15	1	2	2		42
2005	3		12			1		2	19		2	1		40
2006	2		12			1		1	17		2	2		37
2007	3		14			1		2	18		2	1		41
2008	2	1	13	3		1		2	15		1	1		39
2009	2	1	17	4		1		5	16		1	2		49
2010	2		11	5	2	1	1	3	10		1	2	5	43
TOTAL	379	89	398	12	2	6	1	56	445	27	19	11	5	1450

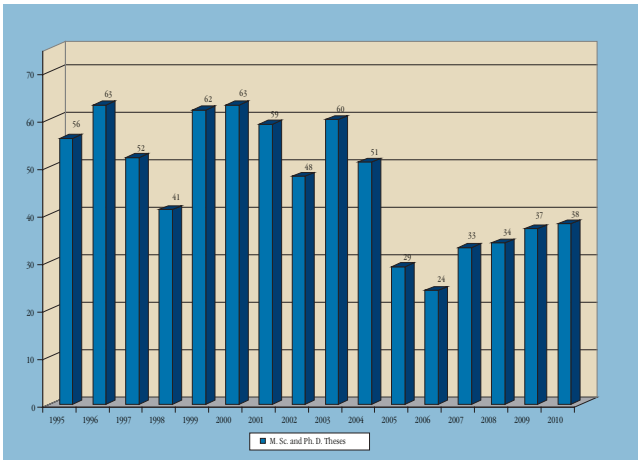
FMF Faculty of Mathematics and Physics, University of Ljubljana
FKKT (Uni-Lj) Faculty of Chemistry and Chemical Technology, University of Ljubljana
FKKT (Uni-Mb) Faculty of Chemistry and Chemical Technology, University of Maribor
NTF Faculty of Natural Sciences and Engineering, University of Ljubljana
FDV Faculty of Social Sciences, University of Ljubljana
FA Faculty of Administration, University of Ljubljana
BF Biotechnical Faculty, University of Ljubljana
FE Faculty of Electrical Engineering, University of Ljubljana
FRI Faculty of Computer and Information Science, University of Ljubljana
FG Faculty of Civil Engineering, University of Maribor
FERI Faculty of Electrical Engineering and Computer Science, University of Maribor
UNG University of Nova Gorica
IPS Jožef Stefan International Postgraduate School
Other UNI LJ Faculty of Pharmacy, Faculty of Mechanical Engineering, Faculty of Economics, Faculty of Medicine, University of Ljubljana

COMPLETED THESES

UNTIL 2010

Year	Ph. D. Theses	M. Sc. Theses	Total
...1962	15	6	21
1963	7		7
1964	7	2	9
1965	16		16
1966	2		2
1967		8	8
1968	4	8	12
1969	3	6	9
1970	2	12	14
1971	7	6	13
1972	11	24	35
1973	8	14	22
1974	21	10	31
1975	10	20	30
1976	6	31	37
1977	5	16	21
1978	10	20	30
1979	7	11	18
1980	13	10	23
1981	12	15	27
1982	13	18	31
1983	5	10	15
1984	14	17	31
1985	6	14	20
1986	8	15	23

Year	Ph. D. Theses	M. Sc. Theses	Total
1987	18	21	39
1988	12	26	38
1989	15	33	48
1990	16	41	57
1991	22	47	69
1992	19	42	61
1993	28	36	64
1994	27	37	64
1995	34	22	56
1996	38	25	63
1997	29	23	52
1998	21	20	41
1999	33	29	62
2000	36	27	63
2001	31	28	59
2002	29	19	48
2003	41	19	60
2004	31	20	51
2005	22	7	29
2006	22	2	24
2007	26	7	33
2008	29	5	34
2009	30	7	37
2010	33	5	38
TOTAL	854	841	1695



PATENTS GRANTED

1. Laser system
   Marko Marinček, Marko Čenčič
   Patent No. US 7778306 (B2)
2. Method and device for measuring ultrahigh vacuum
   Alenka Vesel, Miran Mozetič
   Patent No. US 7800376 (B2)
3. Ceramic material, sintered ceramic and component made therefrom, production method and use of the ceramic
   Pavol Dudešek, Christian Hoffmann, Danilo Suvorov, Matjaž Valant
   Patent No. US 7816293 (B2)
4. Variable contrast, wide viewing angle LCD light-switching filter
   Janez Pirš, Andrej Vrečko, Silvija Pirš, Bojan Marin
   Patent No. EP 1883854 (B1)
5. Keramisches Material, gesinterte Keramik, Verfahren zur Herstellung und Verwendung der Keramik
   Pavol Dudešek, Christian Hoffmann, Danilo Suvorov, Matjaž Valant
   Patent No. DE 102006024231 (B4)
6. Procedure for the preparation of ceramics based on alkaline niobates tantalates using mechanochemical activation
   Tadej Rojac, Marija Kosec, Janez Holc
   Patent No. SI 22838 (A)
7. Shoe inner dimension measurement method
   Aleš Jurca, Damir Omrčen
   Patent No. SI 22848 (A)
8. Peptide uroaktivin as an activator of enzyme urokinase
   Nataša Obermajer, Bojan Doljak, Janko Kos
   Patent No. SI 22865 (A)
9. Antioxidative extract obtained from pine and fir bark
   Borut Štrukelj, Samo Kreft, Andrej Umek, Damjan Janeš
   Patent No. SI 22882 (A)
10. Inhibition of cathepsin X as a tool for treatment of neurodegenerative diseases
    Nataša Obermajer, Zala Jevnikar, Urša Pečar Fonović, Bojan Doljak, Janko Kos
    Patent No. SI 22890 (A)
11. The method and capacitive sensor for counting aerosol nanoparticles
    Maja Remškar, Ivan Iskra, Marko Viršek, Mark Pleško, Damjan Golob
    Patent No. SI 22895 (A)
12. Alumina porcelain with improved thermal properties and its production
    Martina Oberžan, Janez Holc, Marjan Buh, Ivan Lavrač, Marija Kosec
    Patent No. SI 23000 (A)
13. A method and a device for an immediate wood moisture determination
    Igor Serša, Urška Mikac, Maks Merela, Primož Oven
    Patent No. SI 23011 (A)
14. Method of treatment of biomedical polymeric prostheses for improvement of their antithrombogenous properties
    Ita Junkar, Miran Mozetič, Alenka Vesel, Uroš Cvelbar, Metka Krašna, Dragoslav Domanovič
    Patent No. SI 23021 (A)

AWARDS AND APPOINTMENTS

AWARDS MADE TO JSI RESEARCHERS BY THE REPUBLIC OF SLOVENIA

Zois Recognitions and Award of the Republic of Slovenia

Janez Dolinšek
Presented with the Zois Award for top achievements for researching physical properties of new complex materials on metallic basis

Miha Drofenik
Presented with the Zois Award for top research achievements in the area of materials

Barbara Malič
Presented with the Zois Distinction for important achievements in the area of researching ferroelectric ceramics and thin layers

Nataša Obermajer
Mechanism of action and the role of inhibition of cathepsin X in regulation of immune response

Peter Trkman
Cutting stock process optimization in consecutive time periods

AWARDS TO JSI RESEARCHERS BY OTHER INSTITUTIONS

Tomaž Erjavec, Google Digital Humanities Research award, California, USA, Google Inc., Research on language models for Historical Slovene
Marija Kosec, 2010 Ferroelectrics Recognition Award, Edinburgh, Great Britain, IEEE Ultrasonics, Ferroelectrics and Frequency Control Society
Igor Križaj, Toxicon Journal Award: Elsevier Top Reviewer in 2010

The recipients of Zois awards and recognitions

JSI AWARDS AND APPOINTMENTS

The Jožef Stefan Golden Emblem Prize

presented to the following for doctoral theses with high impact :

Urban Bren
Free energy Computer simulations in dealing with the stability and reactivity of DNA

Slavko Pečar, Award for the contribution to the development of university education of pharmacy in Slovenia, Faculty of Pharmacy, University in Ljubljana
Toni Petan, Lapanje Award for Young Scientists of the Slovenian Biochemical Society in 2010 for outstanding achievements in biochemical sciences
Borut Štrukelj, Gold medal of the University of Ljubljana for exceptional merits in developing scientific and pedagogical work at the University of Ljubljana and for strengthening its reputation
Borut Štrukelj, Fulbright Award for visiting professor in 2010

Simon Jazbec, Prešeren Award of the Faculty of Mathematics and Physics for B. Sc. Thesis, Faculty of Mathematics and Physics, University of Ljubljana
Dalija Jesenek, Perlach Award of the Faculty of Natural Sciences and Mathematics for B. Sc. Thesis, Faculty of Natural Sciences and Mathematics, University of Maribor
Tina Kosjek, Krka Award for doctoral thesis
Lidija Kovačič, Maks Samec Award of the Faculty of Chemistry and Chemical Tehnology, University of Ljubljana, for the best Doctoral Thesis in biochemistry in 2010

Aleš Berlec and Borut Štrukelj, Gold Award for innovation, Innovation Fair 2010
Aleš Berlec and Borut Štrukelj, Prize for Innovations in Economy, 3th International Conference on Technology Transfer
Systems and Control programme group at JSI and Domel, d.d. company were granted the TARAS statuette for the most successful cooperation between research teams and organisations on the one hand and development teams in industry and the economy on the other hand, as well as promoting innovation, development and technological excellence, Industrial forum IRT 2010 (Innovation, development and technology), Portorož
Blaž Fortuna, Marko Grobelnik and Dunja Mladenič, Inovations for Economy, Ljubljana, Technology Transfer Conference, Jožef Stefan Institute
Andreja Jelen, Promoters of inventions 2010, Ministry of Higher Education, Science and Technology, Slovenian Research Agency and The society of young researchers Slovenia
Đani Juričić, Janko Petrovčič, Bojan Musizza, Aleš Svetek, Pavle Boškoski, Matej Gašperin and Stanislav Černe, second award among the five awards for the innovation in the economy granted by six foreign experts at the third Technology Transfer Conference, 7-8 October 2010, Ljubljana and Maribor.

Erik Dovgan, Best paper award on study programme Information and Communication Technologies at the 2nd Jožef Stefan International Postgraduate School Students Conference, Ljubljana, 27. 5. 2010
Andrej Gams, Tadej Petrič, Aleš Ude, Leon Žlajpah, Best Paper Research Award, Robotics in Alpe –Adria-Danube Region – RAAD 2010
Sebastjan Glinšek, Award for the best presentation among young researchers on the field of inorganic materials, 18th Conference on Mateirals and Technologies, Portorož
Matjaž Golobič, Andraž Kocjan, Tomaž Kosmač, Peter Jevnikar, The Paffenbarger Award (1st place), for the outstanding student presentation at the annual meeting of the Academy of Dental Materials, Trieste, Italy, October 7-9, 2010
Boštjan Kaluža, Matjaž Gams, Best student paper award at the International Conference on Machine Learning and Data Analysis (ICMLDA'10), San Francisco, California, USA, 20.–22. 10. 2010
Mojca Otoničar, LOTTE-IEEE-UFFC Student Award at the 7th Asian Meeting on Ferroelectricity (AMF-7) and the 7th Asian Meeting on Electroceramics (AMEC-7), Jeju Island, Korea
Mojca Otoničar, Best contribution award at the European Conference Junior EUROMAT 2010, Lausanne, Switzerland, award granted by the Euromat Committee
Paula Pongrac, Jesenko Award for the best Ph. D. thesis in 2009, Biotechnical Faculty, University of Ljubljana, 2010
Brigita Rožič, Recognition for the effective presentation of research findings in terms of scientific quality and their usability (1st Prize - Best conference paper), Jožef Stefan International Postgraduate School
Vojka Žunič, The best presentation among young researchers, research field: Nanomaterials and Nanotechnologies, at the 18th Conference on Materials and Technology, granting by Institute of Metals and Technology, Portorož

The winners of the Jožef Stefan Golden Emblem Prize

REVIEW OF PUBLICATIONS

FOR 2010

Department	Original Articles*	Books	Patent Appl. and Grants	Theses
Department of Theoretical Physics (F-1)	99	7		3
Department of Low and Medium Energy Physics (F-2)	79	2	1	2
Department of Thin Films and Surfaces (F-3)	15	1	1	1
Department of Surface Engineering and Optoelectronics (F-4)	87	1	3	1
Department of Solid State Physics (F-5)	159	3	5	8
Department for Complex Matter (F-7)	57	4	2	
Department of Reactor Physics (F-8)	37	3		
Department of Experimental Particle Physics (F-9)	114	6		1
Department of Inorganic Chemistry and Technology (K-1)	30			
Department of Physical and Organic Chemistry (K-3)	23		1	1
Electronic Ceramics Department (K-5)	48	3	5	1
Engineering Ceramics Department (K-6)	9	3	2	1
Department for Nanostructured Materials (K-7)	65	3	4	1
Department for Synthesis of Materials (K-8)	27	3	1	2
Department for Advanced Materials (K-9)	35		4	1
Department of Biochemistry, Molecular and Structural Biology (B-1)	27	3		2
Department of Molecular and Biomedical sciences (B-2)	10			2
Department of Biotechnology (B-3)	30		5	
Department of Environmental Sciences (O-2)	110	32		2
Department of Automation, Biocybernetics and Robotics (E-1)	48	3	1	3
Department of Systems and Control (E-2)	51	2		1
Laboratory for Open Systems and Networks (E-5)	22			2
Department of Communication Systems (E-6)	44	4	3	2
Computer Systems Department (E-7)	27	1		
Department of Knowledge Technologies (E-8)	80	4		1
Department of Intelligent Systems (E-9)	50			1
Department of Reactor Engineering (R-4)	45	7		
Energy Efficiency Centre (EEC)	5			
Centre for Knowledge Transfer in Information Technologies (CT-3)	3	1		
Milan Čopič Nuclear Training Centre (ICJT)	6	2		
Radiation Protection Unit (SVPIS)	2			
Director's Office (U-1)	2	1		
Technology Transfer Office (U-9)	2			
Jožef Stefan Institute	1332	94	35	39

* Articles in Journals and Conference Proceedings, and Chapters in Books

KNOWLEDGE TRANSFER

The JSI pays a lot of attention to furthering its links with industry. In keeping with European aims and the objectives of the Slovenian government, the JSI organized several important meetings on the subject of cooperation with enterprises and industry. In this way the JSI introduced a new method of cooperation, showing industry and the public that it is aware of its leading role, not only in research but also in the transfer of knowledge into practice.

R & D PROJECT PARTNERS

1. ARAO, Ljubljana
2. BIOMED, d. o. o., Ljubljana
3. Borzen, d. o. o., Ljubljana
4. Brinox inženiring, d. o. o., Ljubljana
5. Cosylab, laboratorij za kontrolne sisteme, d. d., Ljubljana
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8. Elektroinštitut Milan Vidmar, Ljubljana
9. ETA, d. o. o., Cerkno
10. ETI Elektroelement d. d., Izlake
11. Fotona, d. d., Ljubljana
12. GEN energija, d. o. o., Krško
13. Gorenje gospodinjski aparati, d. d., Velenje
14. Gradbeni inštitut ZRMK d. o. o., Ljubljana
15. INEA, d. o. o., Ljubljana
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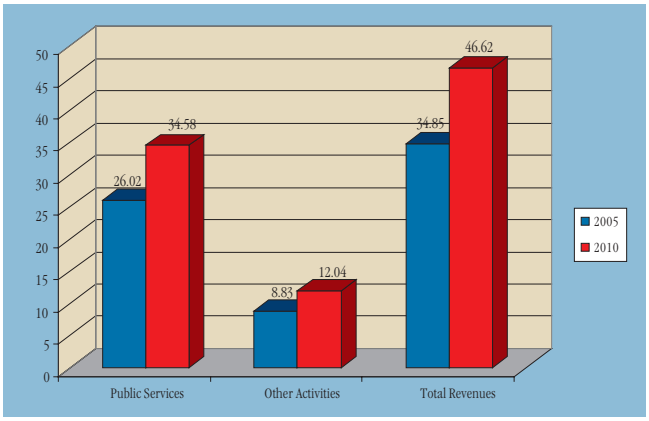
17. JP Vodovod-Kanalizacija, d. o. o, Ljubljana
18. Kemijski inštitut, Ljubljana
19. Krka, tovarna zdravil, d. d., Novo mesto
20. Magneti Ljubljana, d. d., Ljubljana
21. Mednarodna podiplomska šola Jožefa Stefana, Ljubljana
22. Ministrstvo za finance, Ljubljana
23. Ministrstvo za gospodarstvo, Ljubljana
24. Ministrstvo za notranje zadeve, Ljubljana
25. Ministrstvo za obrambo, Ljubljana
26. Ministrstvo za okolje in prostor, Ljubljana
27. Ministrstvo za visoko šolstvo, znanost in tehnologijo, Ljubljana
28. Ministrstvo za zdravje, Ljubljana
29. Mobitel, d. d., Ljubljana
30. Nuklearna elektrarna Krško, Krško
31. Premogovnik Velenje, d. d., Velenje
32. RŽV, d. o. o., Gorenja vas
33. Snaga, d. o. o., Ljubljana
34. Steklarna Hrastnik, d. d. - Opal, d. o. o., Hrastnik
35. Tehnološki park Ljubljana, d. o. o., Ljubljana
36. Univerzitetni klinični center Ljubljana, Ljubljana
37. Varsi, d. o. o., Ljubljana
38. Zavod biomedicinska razvojno inovacijska skupina, LjubljanaSplošna bolnišnica “dr. Franca Derganca”, Šempeter pri Gorici

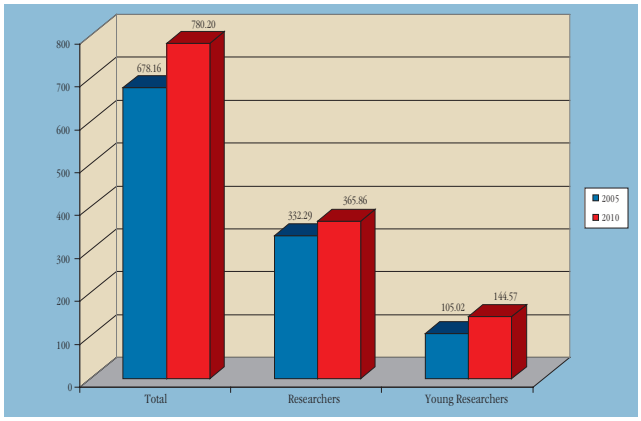
INSTITUTE IN NUMBERS

2005–2010

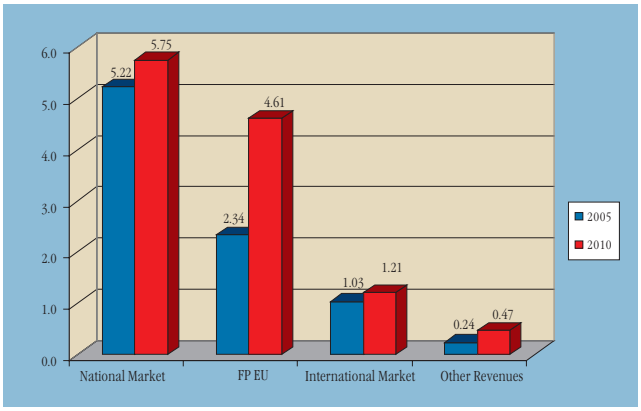
COMPARISON OF REVENUES (€M)



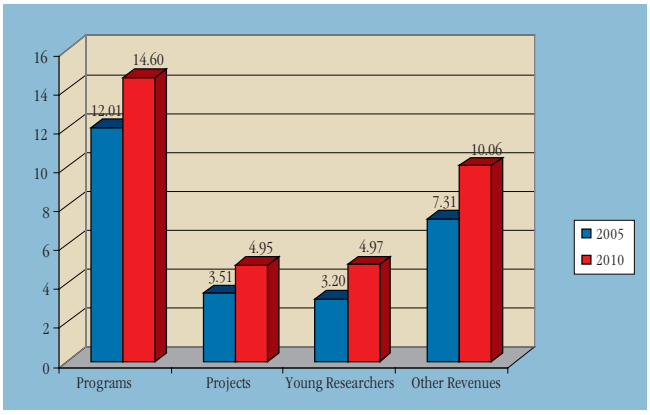
EMPLOYEES (FTE)



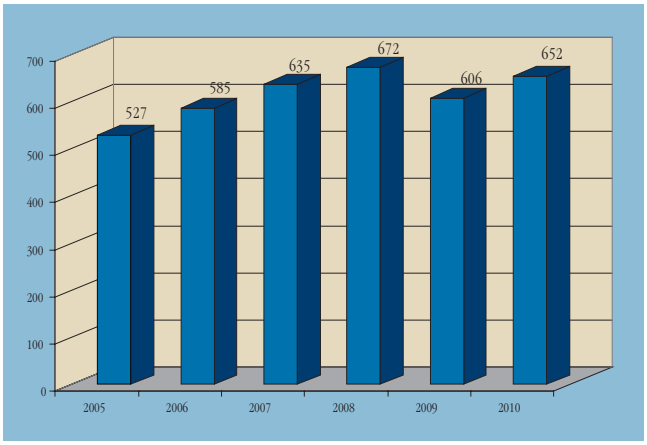
REVENUES FROM OTHER ACTIVITIES (€M)



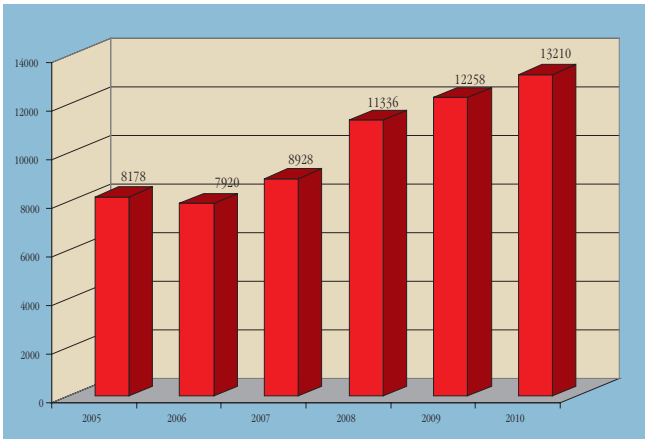
REVENUES FROM PUBLIC SERVICES (€M)



NUMBER OF PUBLICATIONS IN THE WEB OF SCIENCE



NUMBER OF CITATIONS IN THE WEB OF SCIENCE



RESEARCH DEPARTMENTS

DEPARTMENT OF THEORETICAL PHYSICS F-1

The research program of the Department of Theoretical Physics is focused on the theory of condensed-matter physics, statistical physics, the physics of nuclei, particles and fields, as well as biophysics and soft condensed-matter physics. The department also maintains its own high-performance computing facility, for which it develops the necessary software. These studies are carried out in close collaboration with several experimental groups at the Jožef Stefan Institute as well as with local and foreign universities and institutes. The department is also involved in various international projects.

The group of THEORETICAL PHYSICS OF NUCLEI, PARTICLES AND FIELDS has investigated the structure of hadrons, the effective theories of weak and electromagnetic mesonic decays, the unified theory of elementary interactions, the relativistic theory of membranes and precise calculations of the properties of three-body systems in atomic physics.

Head:
Prof. Svjetlana Fajfer

The method to calculate pion electro-production amplitudes in a coupled-channel framework incorporating quasi-bound quark-model states has been generalized so as to include the production of eta mesons and kaons. In a chiral quark model we were able to reproduce the scattering and electro-production amplitudes in the region of the N(1535) and N(1650) resonances in the S11 partial wave.

We find a strong indication that the light scalar mesons sigma and kappa have a sizable tetraquark Fock component. This means that sigma and kappa are not conventional meson states with a pure quark-antiquark valence structure. Our results present a first indication for the tetraquark structure of sigma and kappa within the dynamical lattice QCD simulations.

We have analyzed the importance of flavor effects in models in which leptogenesis proceeds via the decay of Majorana electroweak triplets. Then we explored the parameter regions of such models where flavour effects are important and can enhance the predicted baryon asymmetry in the early universe by more than an order of magnitude. In addition we have shown how electroweak triplet discovery and property measurements at the LHC can probe the mechanism of high-scale baryogenesis.

- **We have shown how D meson oscillations and single top production measurements at the Tevatron in the GUT SU(5) model constrain the pattern of Yukawa couplings at the grand unification scale.**
- **Parity can be maintained at high energies in left-right symmetric theories, which can explain neutrino masses. These theories can be tested at the Large Hadron Collider for the right-handed gauge boson with a mass approximately equal to 2.5 TeV.**

We have searched for signals of Weak Annihilation in inclusive semileptonic D decays. We considered both the widths and the lepton energy moments, which are quite sensitive probes. Our analysis of Cleo data has shown no clear evidence of Weak Annihilation, and allowed us to put bounds on their relevance in charmless B semileptonic decays.

Within a class of SU(5) grand unified models we have explored which coloured scalar states within the 45-dimensional Higgs representation, required to yield satisfactory description of the measured charged lepton and quark masses, may be light enough to be in reach of the LHC. We have shown how contributions due to such resonances can help to reproduce the large measured forward-backward asymmetry in the top-quark pair production recently reported by the CDF experiment, which otherwise significantly deviates from the standard model's predictions. Furthermore, we have shown how D meson oscillations and single top production measurements at the Tevatron in such models constrain the pattern of Yukawa couplings at the grand unification scale.

Within the effective theory approach we have computed new physics contributions to rare radiative top-quark decays including perturbative QCD corrections. We have analyzed the effects of experimental cuts on extracted contributions of individual effective operators and shown how operator mixing at the next-to-leading perturbative order allows us to extract bounds on operators mediating top quark decays to light quarks and gluons from measurements of the top-quark decays to light quarks and photons. Within the same approach we have calculated new physics contributions to the top

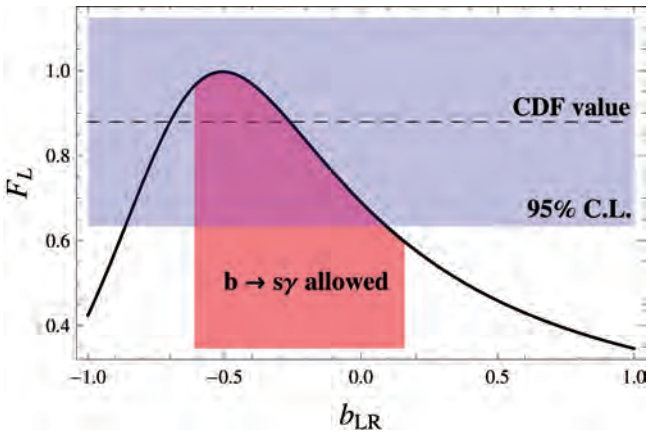


Figure 1: Value of F_L as a function of b_{LR}. Red band shows the interval for b_{LR} allowed by radiative B-meson decays. We also present the experimental CDF values.

The study of non-equilibrium dynamics of an isolated system of interacting fermions revealed unexpected results. While non-integrable systems under the influence of an external electric field follow the generalised linear response, integrable systems react with anomalous oscillations.

quark main decay channel into a b quark and a W gauge boson, including perturbative QCD corrections. We have shown that such corrections can enhance the sensitivity of the right-handed W polarization fraction measurements in this decay for certain effective new physics operators by almost an order of magnitude. At the same time we have extracted the currently best upper bound on certain effective new physics contributions to top-quark interactions using the latest measurements of the longitudinal W polarization fraction in this decay using the CDF collaboration.

We have performed a global analysis of dark matter searches and we have predicted the asymmetries in the two-body B meson decays with nonzero strangeness. We have explored possible modifications of the Higgs signal due to decays into lepton jets. An analysis of the dimuon CP asymmetry as a signal of new physics in B meson mixing has been performed too.

Left-right symmetric theories represent one of the attractive directions beyond the Standard Model. They offer an answer to why parity is violated at low energies and at the same time offer an explanation of light neutrino masses in the context of the well-known seesaw mechanism. Our detailed analysis has shown that the right-handed gauge boson, despite severe bounds, can still be present at an energy scale, well within the reach of the LHC, with a mass bigger than 2.5 or 3 TeV, depending on the choice of the discrete symmetry.

We showed that the fermionic triplet predicted by the ordinary SU(5) GUT could be produced at the LHC with 14 TeV energy and 100 inverse fb luminosity for masses below 700 GeV. We found that some CP violating phases could be directly measured in LR models with a scale below 30 TeV, but not in pure seesaw models. We successfully fit the neutrino, PAMELA and Fermi-LAT data in R-parity violating MSM with gravitino dark matter.

We investigated a model in which spinors are considered as being embedded within the Clifford algebra that operates on them. In the Minkowski space $M_{1,3}$, we have four independent 4-component spinors, each living in a different minimal left ideal of Cl(1,3). We show that under space inversion, a spinor of one left ideal transforms into a spinor of another left ideal. This finding enables us to construct a model of weak interaction that is invariant under space inversion.

The group of SOLID STATE THEORY AND STATISTICAL PHYSICS has been investigating the properties of novel materials with strongly correlated electrons, spin systems, ferroelectics and nanosystems, as well as the proeprties of complex networks and self-organized structures.

Within the broader subject of correlated systems in novel superconductors we further studied the phenomenological theory of the quasiparticle relaxation to explain anomalous normal-state transport in iron pnictides. The theory is based on the two-band description and the spin-fluctuation mediated interband coupling. The memory function approach to spin dynamics in doped antiferromagnets was also investigated to describe a non-universal scaling in underdoped cuprates. Using exact diagonalization within a limited basis space we explored the kinetic energy and the effective mass of polaron and bipolaron within the t-J-Holstein model. With increasing electron-phonon coupling the bipolaron kinetic energy is lowered in comparison with that of the polaron. Our results lead to a novel paradigm where in a correlated system coupled to phonons the bipolaron mobility increases due to kinetic energy gain. We also presented a theory that Sr_2RuO_4 at low temperatures undergoes a transition to an incoherent metal due to Hund coupling and a singular density of states.

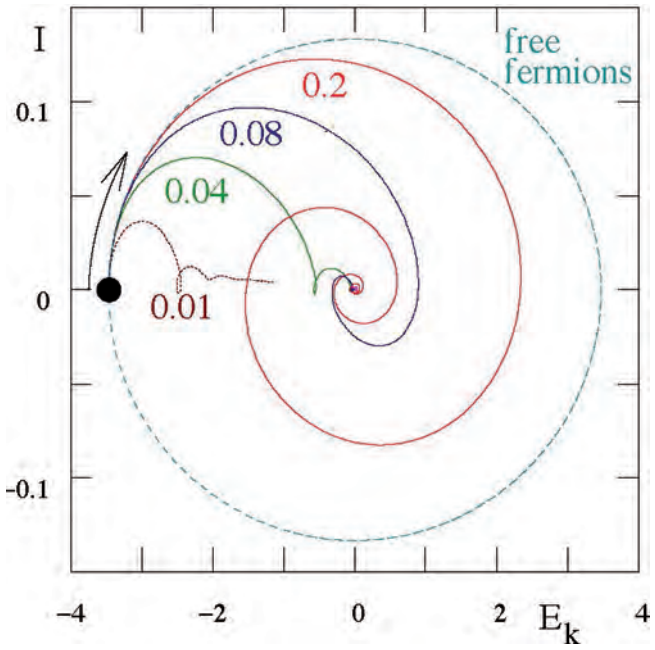


Figure 2: Non-integrable (usual) quantum systems of interacting fermions under a constant external electric field develop a steady current. In contrast, integrable systems exhibit anomalous oscillations, as shown in the figure.

Within the topic of spin systems we used the novel DMRG method to study the dynamics and response of a frustrated Heisenberg chain at finite temperatures. We established a novel phenomena of a central peak at low frequencies and showed that its origin is due to unbound spinons. We explored the influence of dynamical spin impurities on the thermal conductivity of spin chains, as relevant to thermal experiments. Numerically, we also investigated the interplay of interactions and disorder in a chain and showed that generally even the weak interaction destroys the phenomena of Anderson localization. We started systematic studies of the non-equilibrium and driven dynamics of isolated systems of interacting fermions. We showed that in a ring with an induced electric field the non-integrable systems follow a generalised linear response while the integrable systems exhibits anomalous oscillations. In collaboration with the experimental groups we continued the investigation

of relaxor ferroelectrics with the emphasis on the electrocaloric effect and developed a phenomenological model for electrocaloric efficiency.

In the efforts towards the theory of nanosystems we investigated the electron-phonon coupling in molecular conductors. We found that quite generally the coupling to electrons softens the vibrational mode in break junctions. We derived a simple expression relating the spin entanglement of a pair of electrons to calculate the entanglement in many-body states. We also analyzed the spin thermopower in quantum dots and showed that in some regimes the spin Seebeck coefficient can reach large values.

By extending our model of the coupling of the calcium signalling pathway and the contraction of the airway smooth muscle cell to include the effect of the Rho-kinase enzyme, we described the experimental studies of the early phase of force development.

Within the statistical physics research of complex systems and networks we studied single-electron tunnelling processes on nanoparticle films of complex structures and how the nonlinear dynamic features and I-V characteristics depend on the film topology. We investigated the dynamics of clusters of nodes, which in contrast to the dynamics of individual nodes serves as a model for conflicts, in which the network itself can change. We have also shown that the two-dimensional chaotic maps coupled along network links localize to a certain set in the case of E.Coli bacterium. We have also studied the mesoscopic community structure to unravel similarities between the nodes in various networks, which we have obtained by mapping the empirical data onto mathematical graphs. In particular, we have analysed the dynamics of Web users and the mapping of the correlation matrix in the AFM-based dynamic force spectroscopy of HIV1 viruses.

The group of THEORETICAL BIOPHYSICS AND SOFT MATTER PHYSICS focused on polyelectrolytes, liquid crystals, colloids, and phospholipid and biological membranes

We extended our studies of the effects of disorder on the Coulomb interactions in soft matter and we continued to study the structure and packing of nucleic acids in viruses. We have predicted the structural consequences of the encapsidation of nanoparticles into simple RNA viruses and the ensuing changes in the size and symmetry of the virus. We have formulated a new theory of electrostatic interactions for mixed electrolytes in the limit of weak and strong coupling. We also continued our dielectric spectroscopy studies of polyelectrolytes such as hyaluronic acid in aqueous solutions.

Also studied were novel types of order in bent-core liquid-crystals, both in bulk structures and in confined geometries. In terms of a phenomenological model, we analyzed the continuous decrease of the pitch in the liquid-crystalline SmC phase upon cooling. Such behaviour was shown to be expected only in materials where the quadrupolar inter-layer interaction favours the perpendicular arrangement of the molecular tilts in adjacent layers.

We started to investigate the motility of DNA-coated colloids, which is of entropic origin, and the motility of active colloids in critical binary mixtures. We analyzed the behaviour of two-dimensional crystals of colloidal molecules at finite temperatures. Using numerical simulations, we determined the temperatures of the onsets of positional and orientational order. We studied theoretically and experimentally the properties of dispersions of ferroelectric particles in organic solvents.

In a study of the impact of amphitrophic proteins on the shape of phospholipid vesicles, we showed why and how the binding of β_2-glycoprotein to vesicles causes their budding. The theoretical predictions were confirmed by the measurements of the number of buds as a function of the protein concentration. Our analysis of the morphometric properties of the natural random tilings seen in animal and plant tissues, geological formations, and related cellular partition has suggested that the ratio of the polygon area and the perimeter squared is a well-defined quantity strongly correlated to the structure of the tiling.

We investigated the calcium-contraction coupling in airway smooth muscle cells. We extended our model by incorporating the effect of the Rho-kinase enzyme in the early phase of force development and we obtained good agreement with experimental observations. Also studied was the principle of the maximum entropy production in linear irreversible processes. We showed that it is equivalent to Onsager's principle of least dissipation of energy, and we used it to describe bacterial chemotaxis. We have explored the role of stochastic fluctuations in bacterial chemotactic regulation. We have analitically derived the conditions leading to superdiffusive behaviour, which can be an evolutionary privileged search strategy in the fluctuating environment.

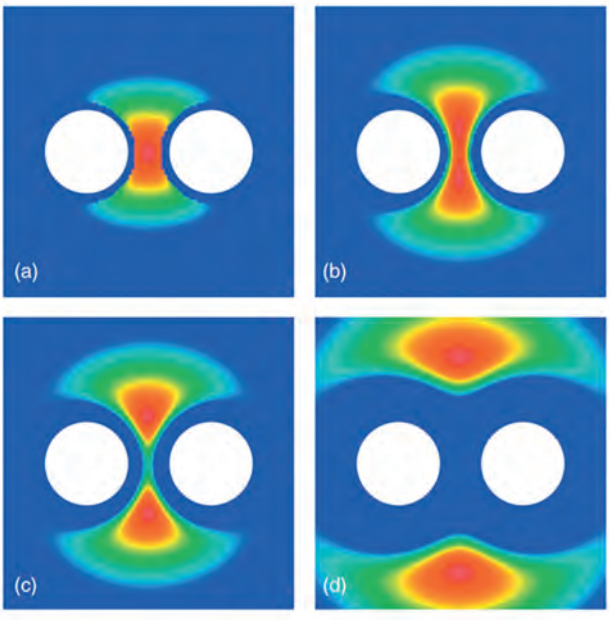


Figure 3: Counter-ion density profile in the vicinity of two like-charged parallel cylinders for four values of the coupling parameter, which controls the volume of the counterion-free depletion zone near the cylinders.

Some outstanding publications in the past year

Theoretical Physics of Nuclei, Particles and Fields

1. Zoltan Ligeti, Michele Papucci, Gilad Perez, Jure Zupan. Implications of the dimuon CP asymmetry in $B_{(d,s)}$ decays. Phys. rev. lett., 2010, vol. 105, no. 13, p. 131601
2. Ilja Doršner, Svjetlana Fajfer, Jernej Kamenik, Nejc Košnik. Light colored scalars from grand unification and the forward-backward asymmetry in $t\bar{t}$ production. Phys. rev., D Part. fields gravit. cosmol., 2010, vol. 81, no. 5, p. 055009

Solid-State Theory and Statistical Physics

1. Lev Vidmar, Janez Bonča, Sadamichi Maekawa, Takami Tohyama. Bipolaron in the t-J model coupled to longitudinal and transverse quantum lattice vibrations. Phys. rev. lett., 2009, vol. 103, p. 186401-1-186401-4, doi: 10.1103/PhysRevLett.103.186401.
2. Marcin Mierzejewski, Peter Prelovšek. Nonlinear current response of an isolated system of interacting fermions. Phys. rev. lett., 2010, vol. 105, p. 186405-1-186405-4, doi: 10.1103/PhysRevLett.105.186405.

Theoretical Biophysics and Soft Matter Physics:

1. H. Takezoe, E. Górecka in M. Čepič, Antiferroelectric liquid crystals: Interplay of simplicity and complexity, Rev. Mod. Phys. 82 (2010), 897-937
2. R. H. French, V. A. Parsegian, R. Podgornik, R. F. Rajter, A. Jagota, J. Luo, D. Asthagiri, M. K. Chaudhury, Y.-M. Chiang, S. Granick, S. Kalinin, M. Kardar, R. Kjellander, D. C. Langreth, J. Lewis, S. Lustig, D. Wesolowski, J. S. Wettlaufer, W.-Y. Ching, M. Finnis, F. Houlihan, O. A. von Lilienfeld, C. J. van Oss in T. Zemb, Long-range interactions in nanoscale science, Rev. Mod. Phys. 82 (2010), 1887-1944

Organization of conferences, congresses and meetings

1. Dressing Hadrons, Bled, 4.-11. 7. 2010

INTERNATIONAL PROJECTS

1. Physics of Complex Colloids: Equlibrium and Driven
   COMPLOIDS
   7. FP, 234810
   EC; Dr. Helmut Schaschl, University of Vienna, Research Services & International Relations, Vienna, Austria
   Asst. Prof. Primož Ziherl, Dr. Jure Dobnikar
2. Low Dimensional Quantum Magnets for Thermal Management
   LOTHERM
   7. FP, 238475
   EC; Dr. Laura Hemker, Leibniz Institute for Solid State and Materials Research Dresden, Dresden, Germany
   Prof. Peter Prelovšek
3. Collective Emotions in Cyberspace
   CYBEREMOTIONS
   7. FP, 231323
   EC; Warsaw University of Technology, Warsaw, Poland
   Prof. Bosiljka Tadič
4. Novel Magnetic-mode Heat Transport for Thermal Management in Microelectronics
   NOVMAG
   6. FP, 032980
   EC; Dr. Christian Hess, Leibniz Institute for Solid State and Materials Research Dresden, Institute for Solid State Research, Dresden, Germany
   Prof. Peter Prelovšek
5. Multifunctional Ceramic Layers with High Electromagnetoelastic Coupling in Complex Geometries
   MULTICERAL
   6. FP, NMP3-CT-2006-032616
   EC; Prof. Andrei Kholkin, University of Aveiro, Department of Ceramics & Glass Engineering, Aveiro, Portugal
   Prof. Raša Pirc, Prof. Robert Blinc, Prof. Marija Kosec, Dr. Janez Holc
6. Physics of Competition and Conflicts
   COST MP0801, EC
   Prof. Bosiljka Tadič
7. Aspects of Physics beyond the Standard Model and the Holographic Quantum Field Theory Gravity Correspodence
   BI-AR/09-11-006
   Prof. Adrián René Lugo, Instituto de Física de La Plata, Departamento de Física, Universidad Nacional de La Plata, La Plata, Argentine
   Asst. Prof. Borut Bajc
8. Study of Excited Hadrons and Tetraquark States in Lattice QCD
   BI-AT/09-10-012
   Prof. Christian B. Lang, Inst. für Physik/Theoret. Physik, Karl-Franzens-Universität Graz, Graz, Austria
   Dr. Saša Prelovšek Komelj
9. Self-organization in Soft Matter Physics
   BI-AT/09-10-007
   Dr. Gerhard Kahl, Institut für Theoretische Physik, Technische Universität Wien, Vienna, Austria
   Dr. Primož Ziherl
10. Flavor of Physics at LHC and Super Flavor Factory
    PROTEUS 2010 – 2011, BI-FR/10-11-PROTEUS-006
    Dr. Emi Kou, Linear Accelerator Laboratory, Universite Paris-Sud 11, UMR 8607, Paris, France
    Asst. Prof. Jure Dobnikar
11. Physics from the Grand Unification Scale to LHC Energies
    PROTEUS 2010 – 2011, BI-FR/10-11-PROTEUS-014
    Dr. Stephane Lavignac, Institute of Theoretical Physics, CEA/Saclay, Gif-sur-Yvette, France
    Asst. Prof. Borut Bajc
12. Adhesion of Liposomes at Electrode
    BI-HR/10-11-010
    Dr. Nadica Ivošević DeNardis, Ruđer Bošković Institute, Zagreb, Croatia
    Asst. Prof. Primož Ziherl
13. Theory of Materials for Spin Electronics and Dynamics of Magnetic Nanostructures
    Joint Research Arrangement
    Dr. Michiyasu Mori, Japan Atomic Energy Agency (JAEA), Ibaraki, Japan
    Prof. Janez Bonča
14. Computational Approaches to Low-Dimensional Quantum Spin Systems and Doped Mott Insulators
    JP/010-obiski
    Prof. Takami Tohyama, Kyoto University, Yukawa Institute for Theoretical Physics, Kyoto, Japan
    Prof. Peter Prelovšek

15. Hubbard, Computational Approach to Doped Mott-Hubbard Insulators
    BI-JP/08-10-002
    Prof. Takami Tohyama, Institute for Materials Research, Kyoto University, Kyoto, Japan
    Prof. Peter Prelovšek
16. Hadron Structure in Chiral Quark Models vs. Lattice QCD
    BI-PL/10-11-018
    Prof. Wojciech Broniowaski, H. Niewodniczanski, Institute of Nuclear Physics, Polish Academy of Science, Krakow, Poland
    Prof. Bojan Golli, Asst. Prof. Simon Širca
17. Quark Models for Meson Electroproduction
    Modelos de quarks para electroproducao de mesoes
    BI-PT/08-09-012
    Prof. Manuel Fiolhais, Physics Department, University of Coimbra, Coimbra, Portugal
    Prof. Bojan Golli, Asst. Prof. Simon Širca
18. Electron Transport in Nanosystems
    BI-UA/09-10-009
    Dr. Sergei Kruchinin, Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine
    Prof. Janez Bonča
19. Self-Assembly in Ionic Liquids
    Research Sub-Contract
    Dr. Sue Cooper, University College London, Research Finance Administrator, Research Administration, London, Great Britain
    Prof. Rudi Podgornik
20. Supersymmetry and Grand Unification
    BI-US/09-12-036
    Dr. Stephen Barr, University of Delaware, Department of Physics and Astronomy, Newark DE, USA
    Asst. Prof. Borut Bajc
21. Continuum and Discrete Theory of Smectic Liquid Crystals
    BI-US/08-10-028
    Dr. Brigita Urbanc, Department of Physics, Boston University, Boston, MA, USA
    Prof. Mojca Čepič
22. Effective Theories for LHC
    BI-US/08-10-021
    Prof. Ira Rothestei, Department of Physics, Carnegie Mellon University, Pittsburgh, PA, USA
    Asst. Prof. Jure Zupan
23. Novel States of Correlated Electron Systems
    BI-US/08-10-002
    Dr. Daniel Batista, Los Alamos National Laboratory, Los Alamos, NM, USA
    Prof. Janez Bonča

R &D GRANTS AND CONTRACTS

1. Theory of Thermal and Spin Transport in Novel Materials with Correlated Electrons
   Prof. Peter Prelovšek
2. Carbon Nanotube-based Spin Qubits
   Prof. Anton Ramšak
3. Active Devices - Dispersion Force Based Nanoactuators
   Prof. Rudolf Podgornik

RESEARCH PROGRAMS

1. Biophysics of Polymers, Membranes, Gels, Colloids and Cells
   Prof. Rudolf Podgornik
2. Theory of Condensed Matter and Statistical Physics
   Prof. Janez Bonča
3. Theoretical Physics of Nuclei, Particles and Fields
   Prof. Svjetlana Fajfer

MENTORING

Ph. D. Theses

1. Matej Kanduč, *Macromolecular interactions in the limit of weak and strong electrostatic coupling* (mentor Rudolf Podgornik)
2. Jure Kokalj, *Spectral sum rules and dynamical properties of strongly correlated electrons* (mentor Peter Prelovšek)
3. Nejc Košnik, *Standard model and signatures of new physics in weak and radiative decays of heavy mesons* (mentor Svjetlana Fajfer)
4. Jasna Prebil, *Binding of amphitropic proteins to phospholipid membranes and their influence on the shape of phospholipid vesicles* (mentor Saša Svetina; co-mentor Blaž Rozman)

M. Sc. Theses

1. Maja Jug, *Reflection of light on the wavy surface* (mentor Mojca Čepič)
2. Jerneja Pavlin, *Analysis of the First Year University Students' Conceptions about Liquid Crystals* (mentor Nataša Vaupotič; co-mentor Mojca Čepič)

VISITORS FROM ABROAD

1. Dr Malcolm Fairbairn, King´s College, London, United Kingdom, 7.-9. 1. 2010
2. Dr Marcin Mierzejewski, University of Katowice, Katowice, Poland, 4.-15. 1. 2010
3. Mauricio Sturla, National University of La Plata, La Plata, Argentina, 10.-20. 1. 2010
4. Dr Tobias Huber, Siegen University, Siegen, Germany, 20.-22. 1. 2010
5. Prof. Dr Ong Lye Hock, Universiti Sains Malaysia, Penang, Malaysia, 1. 3.-31. 5. 2010
6. Dr Osor S. Barišić, Institut za fiziku, Zagreb, Croatia, 26. – 29.1.2010
7. Dr Andreas Weiler, CERN, Geneva, Switzerland, 15.-20. 2. 2010
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4. Roger H. French, Rudolf Podgornik, (24 authors), "Long range interactions in nanoscale science", *Rev. mod. phys.*, vol. 82, pp. 1887-1944, 2010.
5. Milovan Šuvakov, Bosiljka Tadić, "Modeling collective charge transport in nanoparticle assemblies", *J. phys., Condens. matter*, vol. 22, no. 16, pp. 163201-1-163201-23, 2010.
6. Hideo Takezoe, Ewa Górecka, Mojca Čepič, "Antiferroelectric liquid crystals: interplay of simplicity and complexity", *Rev. mod. phys.*, vol. 82, no. 1, pp. 897-937, 2010.

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2. Saša Svetina, "The primary characteristic of early cells is very likely to be the cell cycle", In: *Open questions on the origins of life: extended abstracts*, (Origins of life and evolution of the biosphere, Vol. 40, com. 4/5, special issue), Kepa Ruiz-Mirazo, ed., Pier Luigi Luisi, ed., Springer, 2010, Heidelberg, pp. 440-444.

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2. Mojca Čepič, Saša Ziherl, Jure Bajc, Katarina Susman, Jerneja Pavlin, Nataša Vaupotič, "Physics and nature - a new course for the first year students of physics education", In: *Socio-cultural and human values in science and technology education: proceedings*, XIV. IOSTE Symposium, International Organization for Science and Technology Education, June 13.-18. 2010, Bled, Slovenia, Slavko Dolinšek, ed., Ljubljana, Institute for Innovation and Development of University, 2010, pp. 1-10.
3. Jure Drobnak, "Model independent analysis of FCNC top quark decay", In: *Physics challenges in the LHC Era 2010*, (Frascati physics series, vol. 60), Second Young Researchers Workshop, May 10-13, 2010, Fracrati, Enrico Nardi, ed., Frascati, Instituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati, 2010, pp. 7-12.
4. Fei Gao, Klemen Bergant, Biagio Forte, Samo Stanič, Darko Veberič, Andrej Filipčič, Marko Zavrtanik, Xiaoquan Song, Dengxin Hua, "Long-range scanning Mie lidar for quantitative measurements of atmospheric extinction over Vipava valley, Slovenia", In: *Proceedings of the 25th International Laser Radar Conference, St.-Petersburg, 5-9 July 2010*, Tomsk, Publishing House of IAO SB RAS, 2010, pp. 604-607.
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11. Jerneja Pavlin, Saša A. Glažar, Iztok Devetak, Mojca Čepič, "First year university students' conceptions about liquid crystals in Slovenia: Elektronski vir", In: *Socio-cultural and human values in science and technology education: proceedings*, XIV. IOSTE Symposium, International Organization for Science and Technology Education, June 13.-18. 2010, Bled, Slovenia, Slavko Dolinšek, ed., Ljubljana, Institute for Innovation and Development of University, 2010, 2 pp.
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15. Igor Sega, Peter Prelovšek, "Freezing of spin dynamics and ω/T scaling in underdoped cuprates: [presented at International Conference on Magnetism, ICM 2009, 26-31 July 2009, Karlsruhe, Germany]", *Journal of physics, Conference series*, vol. 200, no. 1, pp. 012179-1-012179-4, 2010.
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17. Katarina Susman, Saša Ziherl, Jerneja Pavlin, Mojca Čepič, "Concepts of density and buoyancy in eighth grade of primary school", In: *Socio-cultural and human values in science and technology education: proceedings*, XIV. IOSTE Symposium, International Organization for Science and Technology Education, June 13.-18. 2010, Bled, Slovenia, Slavko Dolinšek, ed., Ljubljana, Institute for Innovation and Development of University, 2010, pp. 1-2.
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19. Saša Ziherl, Katarina Susman, Mojca Čepič, Jerneja Pavlin, Saša A. Glažar, Nataša Vaupotič, "A teaching unit on liquid crystals", In: *Socio-cultural and human values in science and technology education: proceedings*, XIV. IOSTE Symposium, International Organization for Science and Technology Education, June 13.-18. 2010, Bled, Slovenia, Slavko Dolinšek, ed., Ljubljana, Institute for Innovation and Development of University, 2010, pp. 1-7.

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1. Vito Babič, Ruben Belina, Mojca Čepič, Iztok Kukman, Aleš Mohorič, Gorazd Planinšič, Anton Ramšak, Ivica Tomič, Miro Trampuš, Miran Tratnik, Aleš Drolc, ed., Joži Trkov, ed., *Fizika, Zbirka maturitetnih nalog z rešitvami 2004-2009*, (Maturitetni izpiti), 1. izd., Ljubljana, Državni izpitni center, 2010.
2. Boris Majaron, Marko Mikuž, Anton Ramšak, *Kolokvijske naloge iz fizike I*, (Zbirka izbranih poglavij iz fizike, 32), 4. popravljena izd., Ljubljana, DMFA - založništvo, 2010.
3. Nataša Vaupotič, *Elektromagnetizem: električno polje in električni tok: zapiski predavanj in spletno gradivo*, Maribor, Fakulteta za naravoslovje in matematiko, 2010.
4. Nataša Vaupotič, *Kvantna mehanika: zapiski predavanj in spletno gradivo*, Maribor, Fakulteta za naravoslovje in matematiko, 2010.
5. Nataša Vaupotič, *Mehanika: zapiski predavanj in spletno gradivo*, Maribor, Fakulteta za naravoslovje in matematiko, 2010.
6. Primož Ziherl, Gregor Skačej, *Rešene naloge iz termodinamike*, (Zbirka izbranih poglavij iz fizike, 42), 3. natis, Ljubljana, DMFA - založništvo, 2010.

Theses

Ph. D. Theses

1. Matej Kanduč, *Macromolecular interactions in the limit of weak and strong electrostatic coupling: doctoral thesis*, Ljubljana, [M. Kanduč], 2010.
2. Jure Kokalj, *Spectral sum rules and dynamical properties of strongly correlated electrons: doctoral thesis*, Ljubljana, [J. Kokalj], 2010.
3. Nejc Košnik, *Standard model and signatures of new physics in weak and radiative decays of heavy mesons: doctoral thesis*, Ljubljana, [N. Košnik], 2010.

B. Sc. Theses

1. Denis Golež, *The bound states of bipolaron in doped antiferromagnet: undergraduate thesis*, Ljubljana, [D. Golež], 2010.
2. Vasja Susič, *The E6 Gauge Group: undergraduate thesis*, Ljubljana, [V. Susič], 2010.

DEPARTMENT OF LOW AND MEDIUM ENERGY PHYSICS F-2

Work in the low-energy physics part of the F-2 department was mainly driven by the research programme "Study of atoms, molecules and structures with photons and particles" (P1-0112), two projects that are running within the frame of the Slovenia Fusion Association (EUROATOM-MHEST) and international projects that were assigned to us as a member of the European network of ion accelerator facilities SPIRIT. Basic and applied research was performed at home, mainly at the Microanalytical Infrastructure Center (MIC), and abroad, most frequently at synchrotron labs accross Europe (Elettra, ESRF, Soleil, Hasylab), where we have conducted research on projects proposed by ourselves or in the frame of our collaborations.

Head:
Asst. Prof. Matej Lipoglavšek

In the field of electron/metastable spectroscopy we have taken part in two experiments at the synchrotron Soleil and two experiments at Elettra. At the beamlines TEMPO-B and Pleiades we have measured with a French group the production of Auger electrons emitted upon the photoexcitation of simple molecules (O_2, CO_2, CO, N_2) using a highly efficient magnetic bottle spectrometer that allowed the observation of double K-hole creation. For that purpose the synchrotron was operating in single-bunch mode that allows enough time to collect emitted electrons by the time-of-flight spectrometer. We have also observed interference among coincidence pairs of electrons emitted in Auger decay following the photoionization of two different edges Xe[$4d_{5/2,3/2}$] and Kr[$3d_{5/2,3/2}$]. The realization of this experiment crucialy depended on our expertize to establish the communication between data collecting and beamline control computers along the only available hardware channel. The third experiment was performed on the GasPhase beamline at Elettra in collaboration with Italian and Hungarian researchers and involved the observation of similar interference effects, this time involving Ar[$2p_{3/2,1/2}$] edges. The multi-coincidence set-up was employed with 10 independent electron spectrometers; this allows sufficiently good instrumental resolution to see the effect at higher electron energies. The same beamline was employed later, together with Swedish researchers, to observe two-color photoexcitations in the domain of singly excited helium via the detection of helium metastable yield. In 2010 we published a detailed analysis of electron impact induced resonant Auger decay spectra recorded previously at the University of Miskolc (Hungary) (Phys. Rev., A, 82 (2010) 032508). We have shown that in contrast to photoexcitation, the resonant Auger process at a low electron-impact energy proceeds through Ar[$2p_{3/2}$]4s and Ar[$2p_{3/2}$]4p states with different total angular momenta. We have published the analysis of a previous year's experiment where the helium lamp was employed to separate singlet and triplet components in the molecular beam of helium metastable atoms upon the decay of doubly photoexcited helium states (Phys. Rev., A, 81 (2010) 062510). The study was complicated by the presence of spin-orbit mixing in the helium singly excited states. We have interpreted the angular dependent photoelectron spectra acquired at GasPhase beamline with a new velocity imaging detector upon two-color excitation of neon (synchrotron + infrared laser) via [$2p^5$]3d intermediate states (Phys. Rev., A 82 (2010) 052522). In 2010, the analysis of the experiment with the free-electron-laser FLASH, where the signature of the two-photon excitation of 3d electron in neon was observed in the photoelectron spectra [2], was published.

In 2010, the JSI high-resolution x-ray spectrometer was employed to perform experiments on the ID26 beamline at ESRF in Grenoble. In the first part, performed in collaboration with German researchers, we have measured highly resolved x-ray emission spectra in the region of sulphur K_α and K_β emission lines in different silicates (sodaliti) and for several silicate glasses with a low sulphur content in order to determine the oxidation number and the local electronic structure of sulphur in these materials. We have also recorded the K_β emission spectra of several sulphur model compounds that are present in naturaly occuring sediments and soils. The results for samples prepared by the Department of wood ecology at the Swedish University of Agricultural Sciences (SEK) allow for the quantitative determination of relative share of elementary S_8 that occurs in different organic disulfides

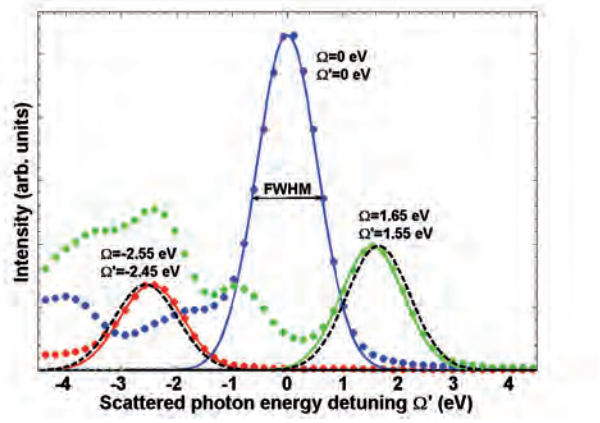

Figure 1: Experimental RIXS spectra of CH_3I recorded at the incident photon energies corresponding to I $2p_{3/2} \rightarrow 15a^2_1$ excitation exactly at resonance energy (Ω = 0 eV), as well as above (Ω =1.65 eV) and below (Ω = -2.55 eV) the resonance energy. The spectra are plotted as a function of Ω', the scattered photon energy relative to the maximum of the L_3-$N_{4,5}$ emission line in the case of the Ω = 0 excitation. Dashed lines show the expected positions of the emission lines in the case of a linear dispersion. A significant deviation is noted due to competition of molecular dissociation with the electronic decay of I $2p_{3/2}$ hole occuring with a 200 attosecond lifetime.

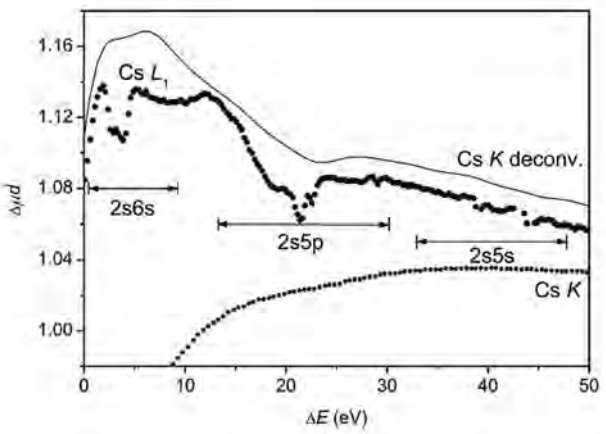

Figure 2: Cs L_1 (2s) absorption spectrum measured with high resolution in the region of double excitations. As shown by comparison with the Cs K (1s) absorption spectrum, much finer details are observed in the L_1 case because of the smaller natural linewidth of the 2s hole and better instrumental resolution (Phys. rev., A, 022513 (2010) 82).

and monosulfides. Together with French researchers we have measured in the second experiment the K_α and K_β x-ray spectra emitted by photoexcited molecules CS_2, OCS, $SOCl_2$ and CH_3Cl. With high instrumental resolution it is possible to observe the effects due to the competition of the closing-up of the CH_3 umbrella that competes with the fast decay of K or L_3 hole in the adjacent atom. In the case of iodine, the decay time of L_3-hole emission is extremely fast (200 as), but the spectral effects are still discernible. In 2010 we published an analysis of RIXS measurements of HCl, that points out the presence of the interference effects due to the coherent excitation of σ^* resonance and Rydberg states [1]. We also published two papers about previous studies of silicate glass and other samples by different techniques, including RIXS, that were applied in the past (Glass Technol., 51 (2010) 63, Inorg. Chem., 49 (2010) 6468). We have published the work that deals with the measurement of Coster-Kronig decay branching ratios for XeL subshells using combined high-resolution absorption and emission measurements (Phys. Rev., A, 81 (2010) 012501). Paper (Nucl. instrum. methods phys. res., B Beam interact. mater. atoms., 3438 (2010) 268) demonstrates that under certain conditions the detection limits obtained by high-resolution ("crystal") x-ray spectroscopy greatky exceed the detection limits obtainable by the usual ("absorption") spectroscopy. In collaboration with Swiss researchers we have published comparative studies dealing with hypersatellite x-ray transitions originating from double K-hole excitations (Phys. Rev., A, 063408 (2010) 82) and with the analysis of depth-profile measurements of Al impurities in Si wafers using the grazing-angle high-resolution x-ray spectroscopy (Spectrochim. acta, Part B: At. spectrosc.. 65 (2010) 445).

With its successful scientific projects, the group for x-ray absorption spectroscopy gained collaboration beamtime at two synchrotron facilities, providing access to the advanced analytic technologies with synchrotron light to a number of collaborating laboratories in Slovenia and abroad. In the 3-year project II-20080058 EC at HASYLAB "XAS analysis of transition metals in lead-free piezoelectric thin films and in catalysts based on porous silicates" at Hasylab we performed structural analyses of new mesoporous catalysts, doped with the transition metals Ti, Mn, Fe, Ni and Zn, of ferroelectric materials' $K(Ta,Nb)O_3$ and $CaCu_3Ti_4O_{12}$ thin layers on a Pt substrate, in collaboration with groups from the Institute of Chemistry and from the department K5 of JSI (Chemistry (Weinh., Print). 16 (2010) 5783; J. nanopart. res., [in press], doi: 10.1007/s11051-010-9929-y ; J. nanopart. res. 12 (2010) 1263). The project In-situ XAS studies of high energy density cathode materials for Li-ion batteries at Elettra, in collaboration with the group of the Institute of Chemistry and the Centre of excellence CO NOT, comprised an in-situ study of valence and structural changes of Li-ion batteries with Li-Fe sillicate and Li-V titanate. The results will be used for the optimization of the synthesis of the cathode materials with the highest possible capacity(J. power sources. doi: 10.1016/j. jpowsour.2010.09.004 ; J. Electrochem. Soc., 157 (2010) A1309). In collaboration with the Faculty of Biotechnology of Ljubljana University, the study of binding of metals Cd and Zn, and nanoparticles CuO in hyperaccumulating plants was continued (Plant soil., 331 (2010) 439; . Soil heavy metals, (Soil biology, 19). Heidelberg [etc.]: Springer, p. 113, (2010)). At the XAFS station at ELETTRA, at the invitation of the chief scientist, dr. Giuliana Aquilanti, we joined a project for the development of the fluorescence detection technique. The new technique was tested on samples from other collaboration projects. The Fe and Cu XAFS spectra of samples of Fe gallic inks in the historic manuscripts from mid-19th century, and of green pigments malachite and verdigris from painting techniques on documents from the National and University Library of Ljubljana were measured. The results will be used in the selection of optimum restoration procedures. Similarly, the doping sites of Mn in the crystal structure of Sr titanate were analyzed, to explain the unusual magnetic properties of the doped material. Another publication concerns the structural analysis of spinel phases of mixed Zn-Mn oxides (J. Am. Ceram. Soc., 93 (2010) 590). The study of the monatomic absorption in Xe gas and Cs vapor in high-resolution absorption spectra in the L-edge region was concluded with a publication. New details in multi-electron excitations were found, leading to a new insight into the collective excitations in the L-shell photoeffect (Phys. rev., A, 022513 (2010) 82).

Within our collaboration at the ALOISA and Nanospectroscopy beamlines (Elettra synchrotron, Laboratorio IOM CNR TASC) we studied the universality of mechanisms for molecular recognition and the self-assemblying of archetypal biomolecules such as L-tyrosine and L-methionine aminoacids, UHV deposited on Ag and Au substrates (ACS nano, 4, (2010) 1218). We found that zwitterionic bimolecules exhibit pairing into extended linear chains through the amino-carboxylic groups and order into extended grating-like mesostructures. Our studies of the CysteAmmine/Au interface showed that a compact, self-assembled monolayer of CA provides an effective amine functionalization of the metal surface able to act as a linker to other biomolecules and proteins (The Journal of Physical Chemistry. C, Nanomaterials and Interfaces, 114 (2010) 15011). Using resonant X-ray photoemission

spectroscopy, we determined the relationship between electronic energy level alignment at a metal-molecule interface and single-molecule junction transport data. For three 1,4-benzenediammine/Au systems we showed that the energy of the highest occupied molecular level (HOMO) in the molecular films correlates with single molecule dc conductance from STM-based break junction experiments, which also agrees with theoretical calculations (Nano lett. 10 (2010)). We have also studied the ultrafast charge-transfer properties at the hybrid BDA/Au interface by resonant X-ray photoemission and we determined the molecular orbitals that favour fast electron delocalization to the substrate. Our observations evidence a major role of amine–Au bonding in providing elevated dc conductive properties in single molecular BDA/Au junctions(Phys. rev., B, 81 (2010) 245403). By low-energy electron microscopy & microprobe electron diffraction and X-ray microspectroscopy we characterized corrugation over nm lengthscales in SiO_2-supported and freely suspended exfoliated graphene. We showed that single-layer corrugation, which dampens out rapidly for double- and triple-layer films, largely results from graphene conformation to the substrate. For suspended graphene we observed that the origin of its corrugation is intrinsic and extrinsic, since it depends on both sample temperatures and the adsorbate impurity load (ACS nano, 4 (2010) 4879).

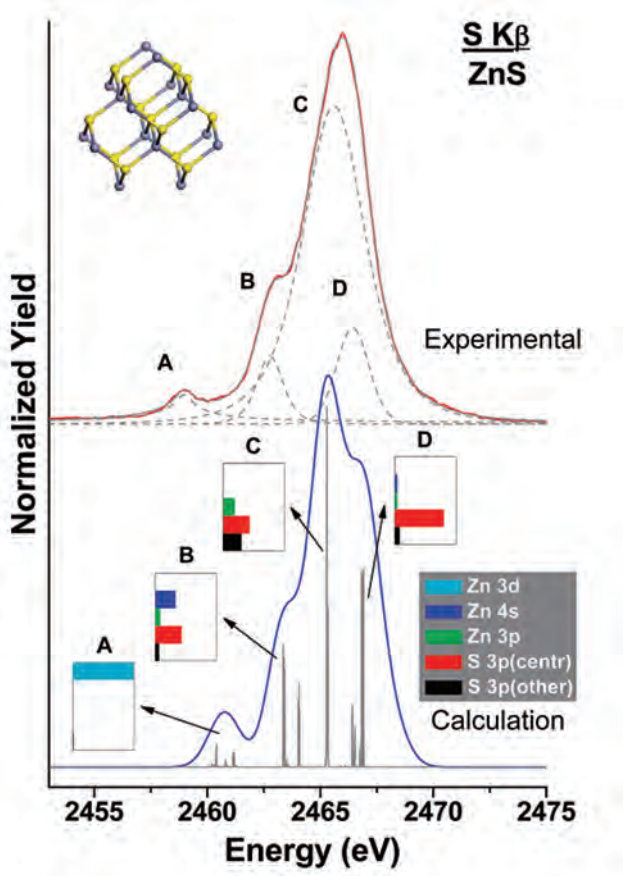

Figure 3: Sulphur K_β X-ray experimental spectra of ZnS along with a theoretical spectrum calculated with a 0.45-nm cluster approximation. Colour schemes show specific atomic contributions to different spectral lines emitted in the radiative decay of the 1s hole in sulphur (Inorg. Chem., 49 (2010) 6468).

Using Mössbauer spectroscopy we studied the properties of different materials by measuring their hyperfine magnetic and electric fields. Our interest was focused on the properties of magnetic nanoparticles (Fresenius Environ. Bull.. 19 (2010) 248), cathode materials for lithium batteries (Inorg. Chem., 49 (2010) 7446) and multiferroic materials (J. Appl. Phys., 107 (2010) 043511). Most of our research focuses on the structural and electronic properties of nanoparticles and the interactions between them. On selected sediments from the Kupa drainage basin Mössbauer spectroscopy and solid-state NMR methods has been used for the identification of poorly crystalline and amorphous phases. Quantitative information about the relative population of the iron species together with the specific properties of the individual iron sites as oxidation states, and possible iron minerals were obtained. In multiferroic materials we investigated the nature of magnetic ordering by studying the samples with Mössbauer spectroscopy in external magnetic fields. The local electronic and structural, as well as the macroscopic magnetic properties of $K_3Cr_2Fe_3F_{15}$, have been studied between room temperature and 4 K. The system has been found to be isostructural with ferroelectric and weakly ferromagnetic $K_3Fe_5F_{15}$ above the ferroelectric transition temperature *T*c. The X-band and 216 GHz Cr^{3+} electron paramagnetic resonance (EPR) spectra, as well as the magnetic susceptibility and Mössbauer data show the existence of two magnetic relaxor-type transitions around 37 and 17 K. The magic angle sample spinning NMR, EPR, and the Mössbauer data further demonstrate the existence of two nonequivalent Fe, Cr, and K sites in the unit cell, as well as the presence of a rapid exchange at higher temperatures. The observation of the Fe^{2+} EPR and Mössbauer spectra shows that the Fe^{2+} ion is in a high spin state.

Activity on the project "Hydrogen-Deuterium Molecule Wall Interaction", Project 1.4.1 of the Work Program (WP2010) of the Association EURATOM-MHEST (Slovenian Fusion Association-SFA) was continued during 2010. Within this project we were working on the following two tasks from the WP2010 of the EU Task Force for Plasma-Wall Interaction (TF PWI) of EFDA (European Fusion Development Agreement): "Interaction of excited H_2 and D_2 molecules with high-Z surfaces" (WP10-PWI-05-01-01/MHEST/BS) and "In-situ studies of formation of mixed layers under neutral atom/molecule impact on surface" (WP10-PWI-04-04-01). A detailed study of the interaction of small hydrocarbons (C_2H_4 in C_2H_6) with hot tungsten was initiated. As a consequence of the thermal dissociation of these molecules the production of vibrationally excited hydrogen molecules was observed for the first time. Our new arrangement allows a study hydrogen atom recombination on sample temperature. A tungsten sample was mounted on the temperature-controlled holder close to the detection region of the vibrational spectrometer and directly exposed to the H-atom beam. Deposition and erosion of polymer-like hydrogenated carbon layers induced by the exposure of copper, silicon and tungsten to hydrogen (H) or deuterium (D) atom beam was studied by means of the ion-beam analytical methods ERDA and RBS. An accurate value of the elastic cross-section for ^{7}Li-D scattering was determined experimentally so that the measurements of deuterium concentrations can be put on the absolute scale. New quantitative results were acquired on the deposition and removal rate of hydrogenated

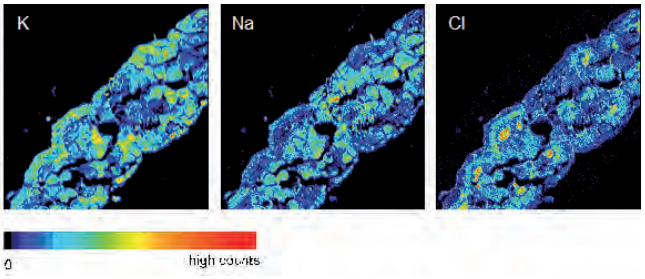

Figure 4: Elemental maps of roots of a desert plant Bassia Indica, measured by micro-PIXE at the JSI ion-beam accelerator. The project was performed in collaboration with prof. Avi Golan from Ben Gurion University in Negev (Israel) and the Laboratory for Plant Physiology of the Faculty of Biotechnology in Ljubljana in the frame of the transnational access TNA026 of the 7th EU framework project SPIRIT (www.spirit-ion.eu).

carbon layers. Besides this, we have observed the deposition of tungsten from a hot capillary of the atom beam source. The deposition rates were determined for Cu and Si. Measurements of the low-energy hydrogen ion (H-) yield produced by dissociative electron attachment (DEA) to some small hydrocarbons were performed. These yields are proportional to the relative cross-sections for DEA. In collaboration with JPL (USA) we have published the absolute cross-sections for Fe^{+q} scattering on CO and CO_2 (Phys. Rev., A, 81 (2010) 062715). Upon invitiation we joined in October 2010 the COST action CM0805 – "The chemical cosmos; understanding chemistry in astronomical environments". We actively participated in the work of STAC (Science and Technology Advisory Committee) of EFDA and in the ad-hoc group of STAC for monitoring JET activities as well as in the EU TF PWI.

Year 2010 was marked by an intensive research with ion beams generated in the Microanalytical Center (MIC). In this year the accelerator "Tandetron" has provided more than 4000 hours of ion beam. Attention was devoted to further develop the confocal x-ray spectroscopy that was set up for the first time in MIC in 2007. In 2010 we have constructed and put into use a new spectrometer for confocal PIXE and tested several types of x-ray confocal lenses. In collaboration with the University of Surrey we have measured the three-dimensional structure of microparticles that are collected by phorensic research after the use of shooting weapons. With the micro-PIXE method we have measured the distribution of Na and Cl in roots of a desert plant Bassia Indica in collaboration with the University Ben Gurion in Negev, Israel. The goal of the research is to uncover mechanisms that direct the growth of roots in the direction of salinity gradient in soils. Our studies in the field of nanotoxicology were very succesful. We have shown that upon exposure to silver nanoparticles the organism of cancer Porcellio Scaber accumulates silver. We have finished the studies of elemental concentrations in the buckwheat seed (Nucl. Instrum. Methods Phys. Res., B Beam Interact. Mater. Atoms., 268 (2010) 2205). With the micro-NRA method we have continued with the the studies of deposition of fusion fuel in slits of the fusion-of reactor walls Tore Supra in the frame of the international project "Deuterium Inventory in Tore Supra (DITS)", 7th EU Framework EURATOM and rejected the results of other labs that showed increased fuel concentration at the slit ends. We have investigated the properties of thin layers with the ERDA and RBS methods in collaboration with the University in Leoben and investigated the concentration profiles of hydrogen in diamond-like thin amorphous carbon layers (Diamond & Related Materials, 19 (2010) 1245–1248). In the 7th EU framework programme "SPIRIT" (www.spirit-ion.eu) we have enabled international access to European researchers in the field of the elemental mapping of biological tissues and geological samples, the in-air PIXE analysis of archaeological samples and high-resolution x-ray spectrometry. Altogether, 9 projects with international access were executed in 2010 that were proposed by researchers from Israel, Lithuania, Spain, France, Croatia and Hungary. In the second half of the year we have intensively continued the development of digital deconvolution of signals from semi-conductor ionization detectors based on FPGA software and hardware in collaboration with a domestic industrial partner and began the testing of the final product. We have published the results (Atmos. Environ,. 44 (2010) 4954) of the analysis of elemental concentration measurements in aerosol particles in our chemistry laboratory and mechanical workshop (Figure 5.).

Glass beads originating from the graves in central and eastern Slovenia were analyzed. The beads were made from the traditional, Roman-type glass and glass made from the ash of halophytic plants, which came into use after 800 AD. The results are important for the beads' dating. We also analyzed a series of glasses from the site Tonovcov grad and a series of 1st-4th c. Roman glasses from Bulgaria. For the analysis of metals, we determined the composition of the metalwork on four La Tène swords. Though stylistically iron-age, the metalwork is made of brass, which demonstrates interesting relations between the Romans on one and Celts and Germans on the other side. Furthermore, we analyzed a series of objects from the Middle Bronze Age in Hungary. The results will help to distinguish the Carpathian or Alpine origin of the ore according to its trace elements. From the instrumental point, the system for the measurement of the proton dose was improved, which is used for the normalization in Rutherford and γ-ray spectroscopy.

In the A1 Collaboration at MAMI (Mainz, Germany) we have performed a series of measurements with the new KAOS spectrometer, which allows for the detection of positively and negatively charged reaction products up to momenta of 1.5 GeV/c. For this spectrometer, our group has continued to develop the second threshold aerogel Cherenkov counter which rests upon our experience on earlier prototypes from 2008 and 2009. Several calibration experiments were performed with both the hadron and the electron arm of KAOS now almost fully instrumented, devoted mostly to the electroproduction of charged kaons and the formation of hyperons in nuclei. With the standard three-spectrometer setup of the A1 Collaboration, a high-precision double-polarization measurement of electroproduction of neutral pions on protons in the region of the Roper resonance was performed. Presently, we

are performing the calibration stages of the analysis. We have also performed a precision experiment in which we searched for hypothetical light bosons mediating the interactions of dark matter. The data analysis is ongoing.

At Jefferson Laboratory, in the framework of the Hall A Collaboration, we have performed two extensive experiments. We have collaborated on the E06-002 experiment, which uses the parity-violating weak neutral interaction to probe the neutron distribution in lead nuclei, thus enabling us to measure the RMS neutron radius to an accuracy of about 1%. The second measurement (experiments E07-007 and E08-025) was devoted to the study of deeply virtual Compton scattering on protons.

In collaboration with the Department of Theoretical Physics at the JSI and the University of Coimbra, we have continued our investigations of dynamical processes in protons and neutrons in the energy region of the Roper resonance and of the negative-parity resonances.

We have obtained excellent results for the complete electroproduction amplitudes.

Members of the Infrastructure Group for Ionizing Radiation Measurements conducted scientific research in connection with the Programmes P1-0102 and P1-0112, on the projects "Quality and genuineness of honey on Slovenian market", and "Natural and anthropogenic gamma and beta emitters in geological waters in Slovenia". The researchers were also involved in other research fields related to ionising radiation and nuclear physics. From the bibliography, it follows that the achievements of the researchers in 2010 were solid. In addition, the Group was active in conducting radiological monitoring of the living environment in Slovenia, radiological monitoring of fodder in Slovenia, regular off-site radiological monitoring around Krško NPP, independent verification of the regular radiological monitoring around Krško NPP, intercomparisons, proficiency tests, material characterizations, calibrations of the radiation gauges, TLD measurements of personal and environmental doses. Members of the Infrastructure Group also took part in regular drills and special tasks with the radiological mobile unit. In 2010, two diploma theses and one MSc thesis were finished.

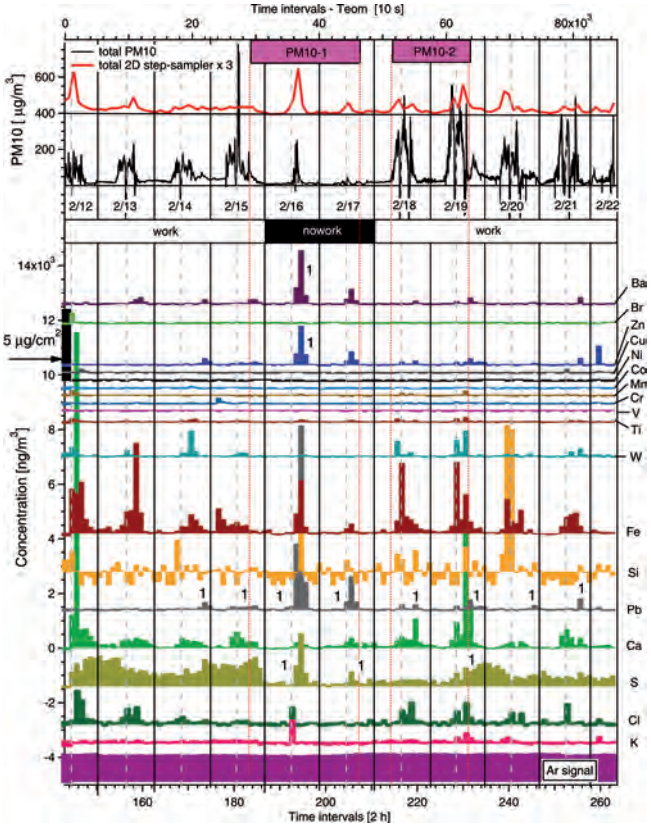

Figure 5: Total PM10 mass and mass concentrations for 19 elements in indoor air in the mechanical workshop as a function of time. Time stamps for noon (vertical dashed line) and midnight (vertical full line) are added for orientation. Horizontal bars denote weekends ("nowork") and working days ("work"). A vertical bar, the first on the left in the Ni data row, denotes the standard areal density of a Ni foil. The Ar signal in PIXE spectra serves to monitor the spot-to-spot stability of the 3 MeV proton beam exposure (Atmos. Environ,. 44 (2010) 4954).

Some outstanding publications in the past year

1. M. Kavčič, M. Žitnik, K. Bučar, A. Mihelič, S. Carniato, L. Journel, R. Guillemin, and M. Simon, "Electronic state interferences in resonant X-ray emission after K-shell excitation in HCl", Phys. Rev. Lett. 105, 113004 (2010).
2. M. Meyer, D. Cubaynes, V. Richardson, J. T. Costello, P. Radcliffe, W. B. Li, S. Düsterer, S. Fritzsche, A. Mihelič, K. G. Papamihail, and P. Lambropoulos, "Two-photon excitation and relaxation of the 3d-4d resonance in atomic Kr", Phys. Rev. Lett. 104, 213001 (2010).
3. J. C. Bernauer et al. (A1 Collaboration), Phys. Rev. Lett. 105 (2010) 242001.
4. A. Puckett et al. (Hall A Collaboration), Phys. Rev. Lett. 104 (2010) 242301.

Awards and appointments

1. Paula Pongrac: Jesenkova nagrada, Ljubljana, Biotehniška fakulteta, Award for the best PhD thesis in 2010

INTERNATIONAL PROJECTS

1. Support of Public and Industrial Research Using Ion Beam Technology
   SPIRIT
   7. FP, 227012, FP7-INFRASTRUCTURES-2008-1
   EC; Prof. Wolfhard Möller, Forschungszentrum Dresden-Rossendorf e.V., Dresden, Germany
   Asst. Prof. Primož Pelicon

2. Application of Ion Beam Analytical Method to the Studies of Plasma Wall Interaction in Tokamaks - 1.4.3.-FU; Distribution of Retained Deuterium accessed by Micro-NRA (WP10-PWI-01-02/MHEST/PS - b)
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   Annex No. 1, 3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Primož Pelicon

3. Hydrogen/Deuterium Molecule Wall Interaction; Processes with Neutral Hydrogen Atoms and Molecules - 1.4.1.-FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Dr. Iztok Čadež, Prof. Milan Čerček
4. Fusion Expo Activities under an EFDA
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Sabina Markelj, B. Sc., Melita Lenošek Kavčič, B. Sc., Asst. Prof. Igor Lengar, Asst. Prof. Saša Novak Krmpotič, Štefan Kolenko
5. Validation of Rapid Method for Determination of Ra-226 and Ra-228 in Water Samples by LSC
   CSA dtd. 7.10.2010
   Chang Kyu Kim, IAEA, Vienna, Austria
   Dr. Jasmina Kožar Logar
6. Complementing the X-ray Spectrometry Activities with Micro-Beam Facility for Different Applications; Micro-analytical Techniques Based on Nuclear Spectrometry for Environmental Monitoring and Material Studies
   15955/R0
   IAEA, Vienna, Austria
   Dr. Peter Kump
7. IAEA - Fellowship for Mr Mohamad Roumie
   LEB/10013V
   IAEA, Vienna, Austria
   Prof. Žiga Šmit
8. IAEA - Fellowship for Mr Deyan Lesigyarski
   BUL/10031
   IAEA, Vienna, Austria
   Prof. Žiga Šmit
9. IAEA - Fellowship for Mr Paul Mulenga
   C6/ ZAM/08010V
   IAEA, Vienna, Austria
   Denis Glavič Cindro, M. Sc.
10. IAEA - Fellowship for Mr Mohammed Yaqoub
    C6/YEM/08028
    IAEA, Vienna, Austria
    Dr. Peter Kump
11. Archaeometric Investigations of Archaelogical Artifacts from Albania and Slovenia
    BI-AL/10-11-003
    Prof. Aferdita Vevecka-Priftaj, Polytechnic University of Tirana, Tirana, Albania
    Prof. Žiga Šmit
12. Convention de mise a disposition
    Contract between CNRS and IJS dtd. 27.5.2004
    Letter N/REF: NS/MD/CONV/04FRE2681JS/2004 dtd. 8.9.2004
    Dr. Paul Indelicato, Laboratoire Kastler-Brossel (LKB – UMR 8552), Ecole Normale Superieure, Paris, Francija
    Dr. Iztok Čadež
13. Measurement of 3H Activity in Natural Waters with Electrolytic Enrichment
    BI-HR/10-11-009
    Dr. Jadranka Barešić, Ruđer Bošković Institute, Zagreb, Croatia
    Dr. Jasmina Kožar Logar
14. Industrial Research for Company Pankl
    0854343-2,0950981-2
    Alexander Schneeberger, Pankl Engine Systems GmbH & Co. KG, Bruck an der Mur, Germany
    Asst. Prof. Primož Pelicon
15. Development and Support of Java Applications for Use in DESY Accelerator Control
    Attachment #8, 9, 10
    Dr. M. Clausen, DESY (Deutsches Elektronen Synchrotron), Hamburg, Germany
    Asst. Prof. Matej Lipoglavšek, Dr. Mark Pleško
16. Hadron Structure in Chiral Quark Models vs. Lattice QCD
    BI-PL/10-11-018
    Prof. Wojciech Broniowaski, H. Niewodniczanski, Institute of Nuclear Physics, Polish Academy of Science, Krakow, Poland
    Asst. Prof. Simon Širca, Prof. Bojan Golli
17. Quark Models for Meson Electroproduction
    Modelos de quarks para electroproducao de mesoes
    BI-PT/08-09-012
    Prof. Manuel Fiolhais, Physics Department, University of Coimbra, Coimbra, Portugal
    Asst. Prof. Simon Širca, Prof. Bojan Golli

R &D GRANTS AND CONTRACTS

1. Quality and Authenticity of Honey on the Slovenian Market
   Dr. Marijan Nečemer
2. Natural and Man Made Gamma- and Beta Ray Emitters in Underground Waters of Slovenia
   Dr. Matjaž Aleš Korun
3. Novel, Enviromental Friendly, High Energy Density Materials for Use in Li-ion Batteries
   Dr. Darko Hanžel
4. Development of Cherenkov Radiation Detector
   Asst. Prof. Simon Širca

RESEARCH PROGRAMS

1. Subject as Representation: Taste, Respect, Strength (Investigation of Slovenian Material Culture)
   Dr. Marijan Nečemer
2. Mobile Archaeological Heritage: Archaeological and Archaeometric Investigations
   Prof. Žiga Šmit
3. Studies of Atoms, Molecules and Structures with Photons and Particles
   Asst. Prof. Matjaž Žitnik
4. Structure of Hadronic Systems
   Asst. Prof. Simon Širca

NEW CONTRACTS

1. Monitoring of radioactivity in the living environment 2010
   Ministry of Environment and Spatial Planning
   Dr. Benjamin Zorko
2. Monitoring of radioactivity iof drinking water 2010
   Ministry of Health
   Dr. Benjamin Zorko
3. Ecology laboratory with mobile unit
   Ministry of Defence
   Asst. Prof. Matej Lipoglavšek
4. Support to research work of JR Romana Krištof
   AMES d.o.o.
   Dr. Jasmina Kožar Logar
5. Performance of sampling and analyses of fodder samples and elaboration of report "Monitoring of fodder radioactivity"
   Ministry of Agriculture, Forestry and Food
   Dr. Benjamin Zorko
6. Monitoring of central LILW storage facility at Brinje 2010
   Agency of Radwaste Management
   Dr. Marijan Nečemer
7. Professional activities and fulfilment of obligations of the holder of the national measurement standard in the field of ionizing radiation
   Ministry of Higher Education, Science and Technology
   Denis Glavič Cindro, M. Sc.
8. Personal dosimetry with TL dosemeters
   Novo Mesto General Hospital
   Boštjan Črnič, B. Sc.
9. Dosimetry service
   Ministry of the Interior
   Boštjan Črnič, B. Sc.
10. Dosimetry service with TL dosemeters
    Ministry of Finance
    Boštjan Črnič, B. Sc.

MENTORING

Ph. D. Thesis

1. Sabina Markelj, *Interaction and production of vibrationally excited hydrogen molecules on surfaces* (mentor Matjaž Žitnik; co-mentor Iztok Čadež)

M. Sc. Thesis

1. Toni Petrovič, *Reference activities of 40K radionuclide in various samples* (mentor Matej Lipoglavšek; co-mentors Benjamin Zorko, Marijan Nečemer)

Specialization thesis

1. Sabina Jakomin, *Efficiency of the elemental analysis for investigation of the textile fibers in forensics* (mentor Katja Drobnič; co-mentors Žiga Šmit, Jure Majdič)

VISITORS FROM ABROAD

1. Mr. Mohamed Yaqoub, Ministry of Oil and Minerals, Sana'a, Yemen, 05. February - 03. March 2010
2. Proff. Avi Golan, The Jacob Blaustein Institutes for Desert Research, Sede Boqer, Israel, 21.-25. February 2010

3. Dr. Edita Baltrenaite, Vilnius Gediminas Technical University, Vilnius, Lithuania, 13.-17. April 2010
4. Dr. Jadranka Barešić and Dr. Ines Krajcar Bronić, Ruđer Bošković Institute, Zagreb, Croatia, 19.-21. April 2010
5. M. Sc. Paul Mulenga, National Institute for Scientific and Industrial Research, Lusaka, Zambia, 03.-14. May 2010
6. Dr. David Domínguez-Villar, University of Alcalá de Henares, Madrid, Spain, 21.-23. June 2010
7. Dr. Juan Vázquez – Navarro, UAM, Madrid, Spain, 24. June-02. July 2010
8. Miss Rhian Hartshorn, Imperial College London, London, United Kingdom, 12. July – 05. September 2010
9. Dr. Jakub Szlachetko, ESRF, Grenoble, France, 05.-10. September 2010
10. Dr. Stjepko Fazinić, Ruđer Bošković Institute, Zagreb, Croatia, 13.-17. September 2010
11. Mr. Deyan Lesigyarski, Sofia University, Sofia, Hungary, 14. September-15. November 2010
12. Dr. Mohamad Roumie, Lebanese Atomic Energy Commission, Beirut, Lebanon, 04.-08. October 2010
13. Mr. Gabor Santa, Mr. Tamasz Szklenar, Szeged Museum, Szeged, Hungary, 02.-07. November 2010
14. Dr. Sergey Lysukhin, Institute of Nuclear Physics, Almaty, Kazakhstan, 11.-13. November 2010
15. Dr. Isabelle Lefèvre, Université catholique de Louvain, Louvain-la-Neuve, Belgium, 23. November-08. December 2010
16. Proff. Fatos Tartari, Institute of Archaeology, Tirana, Albania, 08.-12. December 2010

STAFF

Researchers

1. Prof. Iztok Arčon*
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7. Prof. Alojzij Franc Kodre*
8. Dr. Peter Kump
9. Prof. Andrej Likar*
10. **Asst. Prof. Matej Lipoglavšek, Head**
11. *Dr. Rafael Martinčič, retired 31.12.10*
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13. Dr. Marijan Nečemer
14. Asst. Prof. Primož Pelicon
15. Zdravko Rupnik, M. Sc.
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21. Dr. Jasmina Kožar Logar
22. Dr. Sabina Markelj
23. Dr. Paula Pongrac
24. Dr. Zdravko Siketić
25. Dr. Matjaž Vencelj
26. Dr. Benjamin Zorko

Postgraduates

27. Rok Bohinc, B. Sc.
28. Jelena Gajević, B. Sc.
29. Nataša Grlj, B. Sc.
30. David Jezeršek, B. Sc.
31. Katarina Kovačič, B. Sc.
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34. Boštjan Črnič, B. Sc.
35. Petra Maver Modec, B. Sc.
36. Matjaž Mihelič, M. Sc.
37. Primož Vavpetič, B. Sc.

Technical and administrative staff

38. Drago Brodnik
39. Mojca Gantar
40. Sandi Gobec
41. Zvonimir Grabnar
42. Mirko Ribič, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

1. Patrick Achenbach, et al. (33 authors), "First measurements of λ and σ^0 hyperons in elementary electroproduction at MAMI", In: *Proceedings of the 10th International Conference on Hypernuclear and Strange Particle Physics, 14-18 September 2009, Tokai, Japan*, (Nuclear physics, A, vol. 835, no. 1/4), B. F. Gibson, ed., Amsterdam, North-Holland, 2010, pp. 313-316.
2. D. Androić, Miha Mihovilovič, (65 authors), "Strange quark contributions to parity-violating asymmetries in the backward angle G0 electron scattering experiment", *Phys. rev. lett.*, vol. 104, no. 1, pp. 012001-1-012001-5, 2010.
3. Willi Auwärter, Dean Cvetko, Gregor Bavdek, (15 authors), "Site-specific electronic and geometric interface structure of Co-tetraphenyl-porphyrin layers on Ag(111)", *Phys. rev., B, Condens. matter mater. phys.*, vol. 81, no. 24, pp. 245403-1-245403-14, 2010.
4. J. C. Bernauer, Simon Širca, (25 authors), "High-precision determination of the electric and magnetic form factors of the proton", *Phys. rev. lett.*, vol. 105, pp. 242001-1-242001-4, 2010.
5. Halka Bilinski, Stanislav Frančišković-Bilinski, Marijan Nečemer, Darko Hanžel, Gabor Szalontai, K. Kovacs, "A combined multi-instrumental approach for the physico-chemical characterization of stream sediments, as an aid to environmental monitoring and pollution assessment", *Fresenius environ. bull.*, vol. 19, issue 2, pp. 248-259, 2010.
6. P. A. Bingham, et al. (11 authors), "A multi-spectroscopic investigation of sulphur speciation in silicate glasses and slags", *Glass Technol.*, vol. 51, no. 2, pp. 63-80, 2010.
7. Robert Blinc, Pavel Cevc, Anton Potočnik, Boris Žemva, Evgeny A. Goreshnik, Darko Hanžel, Alan Gregorovič, Zvonko Trontelj, Zvonko Jagličić, Valentin V. Laguta, Miloš Perović, Naresh S. Dalal, James Floyd Scott, "Magnetic properties of multiferroic $K_3Cr_2Fe_3F_{15}$", *J. appl. phys.*, vol. 107, no. 4, pp. 043511-1-043511-5, 2010.
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9. D. P. Child, M. A. C. Hotchkis, K. Whittle, Benjamin Zorko, "Ionisation efficiency improvements for AMS measurement of actinides", In: *Proceedigs of Eleventh International Conference on Accelerator Mass Spectrometry (AMS-11), Rome, Italy, September 14-19 2008*, (Nuclear instruments & methods in physics research, section B, Beam interactions with materials and atoms, vol. 268, no. 7/8), Amsterdam, North-Holland, 2010, pp. 820-823.
10. M. Coman, Simon Širca, "Cross sections and Rosenbluth separations in $1H(e,e'K^+)\Lambda$ up to $Q^2 = 2.35\ GeV^2$", *Phys. rev. C. Nucl. phys.*, vol. 81, pp. 05201-1-052201-5, 2010.
11. Albano Cossaro, Gregor Kladnik, Dean Cvetko, (11 authors), "Amine functionalization of gold surfaces: ultra high vacuum deposition of cysteamine on Au(11)", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 114, issue 35, pp. 15011-15014, 2010.
12. Simon Čopar, Alojz Kodre, "One-dimensional simulation of thin-film-edge retraction", *Phys. rev., E Stat. nonlinear soft matter phys. (Print)*, vol. 82, pp. 056307-1-056307-5, 2010.
13. Martina Dell'Angela, Gregor Kladnik, Albano Cossaro, M. Kamenetska, I. Tamblyn, S. Y. Quek, J. B. Neaton, Dean Cvetko, Alberto Morgante, L. Venkataraman, "Relating energy level alignment and amine-linked single molecule junction conductance", *Nano lett. (Print)*, vol. 10, pp. 2470-2474, 2010.

14. Robert Dominko, Chutchamon Sirisopanaporn, Christian Masquelier, Darko Hanžel, Iztok Arčon, Miran Gaberšček, "On the origin of the electrochemical capacity of $Li_2Fe_0.8Mn_0.2SiO_4$", *J. Electrochem. Soc.*, vol. 157, no. 12, pp. A1309-A1316, 2010.
15. Robert Dominko, Candela Vidal-Abarca Garrido, Marjan Bele, Mirjana Küzma, Iztok Arčon, Miran Gaberšček, "Electrochemical characteristics of $Li_2 - xVTiO_4$ rock salt phase in Li-ion batteries", *J. power sources*, [7] pp., 2010.
16. Edo Džafić, Paula Pongrac, Matevž Likar, Katarina Vogel-Mikuš, Marjana Regvar, "Colonization of maize (Zea mays L.) with the arbuscular mycorrhizal fungus Glomus mosseae alleviates negative effects of Festuca pratensis and Zea mays root extracts", *Allelopathy J.*, vol. 25, no. 1, pp. 249-257, 2010.
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19. Denis Glavič-Cindro, Matjaž Korun, "Traceability in gamma-ray spectrometry", In: *Proceedings of the 17th International Conference on Radionuclide Metrology and its Applications, ICRM 2009, September 7-11, 2009, Bratislava*, (Applied radiation and isotopes, vol. 68, no. 7/8), Oxford, Pergam, 2010, pp. 1196-1199.
20. Sašo Gyergyek, Darko Makovec, Alojz Kodre, Iztok Arčon, Marko Jagodič, Mihael Drofenik, "Influence of synthesis method on structural and magnetic properties of cobalt ferrite nanoparticles", *J. nanopart. res.*, vol. 12, no. 4, pp. 1263-1273, 2010.
21. J. Hoszowska, J.-Cl. Dousse, W. Cao, K. Fennane, Y. Kayser, M. Szlachetko, J. Szlachetko, Matjaž Kavčič, O. Yaroshchuk, "Double K-shell photoionization and hypersatellite x-ray transitions of $12 \leq Z \leq 23$ atoms", *Phys. rev., A*, vol. 82, no. 6, pp. 063408-1-063408-14, 2010.
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Theses

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DEPARTMENT OF THIN FILMS AND SURFACES F-3

The main field of research of the department is the development, deposition and characterization of hard protective PVD coatings, while research is also done in other fields of thin films and surface physics. Basic research is concentrated on the study of physical and chemical properties of various multicomponent, multilayer and nanostructured coatings. Among the applied research, different coatings are developed for the protection of tools for various production processes in industry.

Head:
Dr. Peter Panjan

As in previous years, the research work has been application oriented, with an emphasis on the support of hard-coating implementation in various technological processes. This includes the development of new coatings, adapting the parameters of known coatings for a specific technological process and the analysis of coatings after usage.

In the past year or two, the biggest success among the new coatings has been achieved with the so-called blue coating. This is a nanolayer AlTiN-based coating, which is suitable for the protection of cutting tools for machining of very hard (up to 62 HRC) and tough materials. The distinct blue colour is a consequence of the selective absorption and interference in the upper few nanolayers; it also enables a much easier detection of tool wear. Last year we filed a patent for the process to prepare this coating. Today, the blue coating is used in daily production in more than 20 companies in Slovenia. The second coating implemented in about the same period is the so-called black coating. This is a double-layer TiAlN and a self-lubricating top layer of nitrogen-doped amorphous carbon. It was implemented in industry too. These TiAlN-based nanolayers were the topics of the PhD thesis of Dr Matjaž Panjan, which was defended in the previous year. In his work he explained the influence of deposition parameters on the nanolayer structure, which he proved both experimentally and using a computer simulation.

We developed a TiAlN-based coating that reduces the permeabiltiy of hydrogen by a factor of 6000 on a selected steel substrate. This achievement was described as a "Success Story" for an ERA-NET project in the field of micro- and nanotechnologies.

We have studied the mechanism of defect formation in thin films for several years. In 2010 we concentrated on the correlation between the defect density and corrosion resistance of hard coatings. For this purpose, selected coatings were exposed to a corrosion medium. The surface was analyzed both before and after the corrosion treatment, in order to figure out which spots suffered localized corrosion attack. Selected spots were analyzed using a focused ion beam, which enables an insight into the internal structure of the defect.

Industrial collaboration includes several studies of wear, the choice of the proper technology and the solving of specific problems. In the previous year such studies were made for the companies PHOS, Kovinos, Unior – program Sinter, Brest Pohištvo, BSH Hišni aparati and Cetis. Every year, we organize several seminars for technologists, while the topic is adapted to the wishes of the client. This time the seminars were organized for the companies Brest Pohištvo, EMO Orodjarna, Impol and Lek. A one-day seminar was prepared with the topic of the protection of tools for plastics processing, organized by the Tool and Die Development Center TECOS. Within the project "Harvesting Knowledge", the head of the department Dr. Peter Panjan had a lecture in the National Assembly of the Republic of Slovenia, entitled "Plasma Surface Engineering as the Basis of Modern Technologies". Among publications, two books need to be mentioned: "Modern process engineering" and "Surface properties and engineering of complex intermetallics", where one chapter was written each by Dr. Peter Panjan and Asst. Prof. Miha Čekada.

In 2010 the Network of Excellence CMA (Complex metallic alloys) was concluded. We headed the subproject for the combinatorial analysis of thin films with a lateral composition gradient. A follow-up of this project is the current 7th Framework project AppliCMA (Development of wear resistant coatings based on complex metallic alloys for functional applications), which is dedicated to the development of applications of these alloys. In 2010 we deposited several coatings of the AlCuFeB and AlMgB systems. There are 17 partners from eight countries in the project. From the Jožef Stefan Institute the departments for Solid State Physics, for Engineering Ceramics, and for development of advanced materials are collaborating, in addition to our own department.

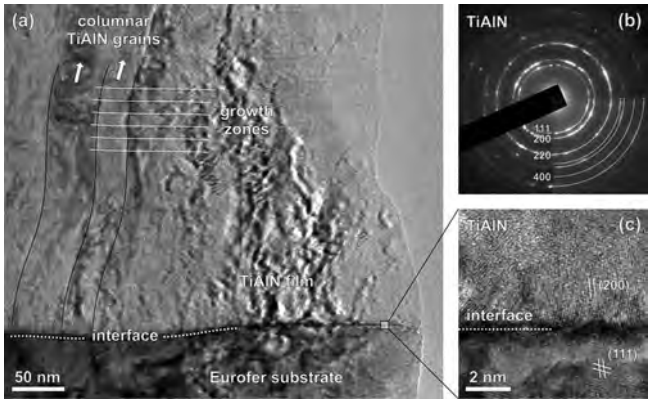

Figure 1:TEM micrograph of the TiAlN cross-section, which reduces the hydrogen permeability by four orders of magnitude. The figure was published on the MNT-ERA-NET projects homepage as a "Success story"

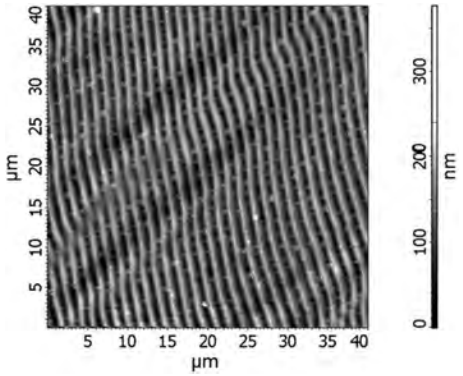

Figure 2: AFM image of the ripple structure formed on the Ti/Al multilayer structure after laser treatment

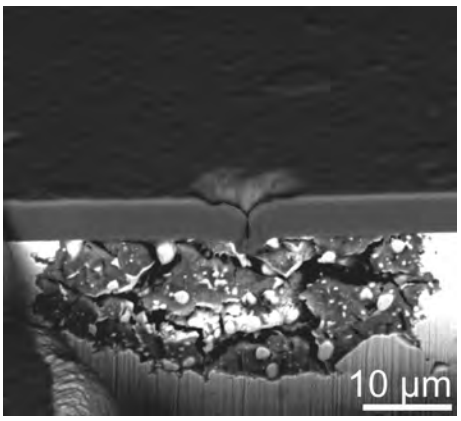

Figure 3: Backscattered SEM micrograph of the pinhole cross-section after corrosion. The cross-section was prepared by the focused ion beam technique.

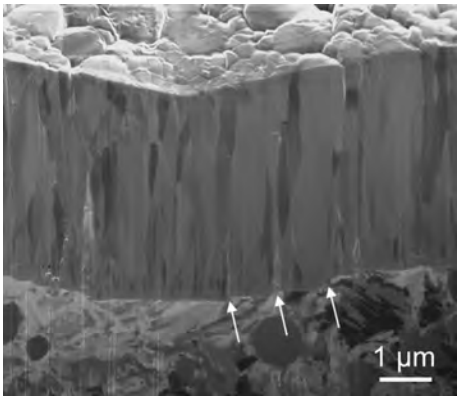

Figure 4: SEM micrograph of the cross-section through an indentation on the TiAlN/VN multilayer coating. The arrows point to steps at the interface formed under the columns during plastic deformation.

The project Hy-Nano-Im (Hydorgen-impermeable nanomaterial coatings for steels, ERA-NET) will end in 2011. Our task was to develop coatings with an as low as possible permeabilty for hydrogen. The project partner from Austria is Joanneum research, MATERIALS – Institute for Surface Technologies and Photonics; from the Jožef Stefan Institute in addition to our department there are the Department for Nanostructured Materials and the Department for Surface Engineering and Optoelectronics. In the previous year we optimized the TiAlN coating, for which we previously established to reduce the permeability for four orders of magnitude. For this achievement we were described as a "Success Story" by the granting authority in the field of micro- and nanotechnologies. We recently deposited this coating on a test reservoir, and thus we showed the applicability of this technology for implementation in industry. Another ERA-NET project expired last year (Improvement of Resurfacing Hip Implants with DLC, TiO_2 and DLC-p-h Nanocomposite Coatings), which was conducted with the Department of Physical and Organic Chemistry, Finish and German partners. Within the program EURATOM our task is the synthesis of various deposits of hydrogenated carbon, which should be as similar as possible to the impurities in the fusion reactor.

Last year we started working on a new project called Nano-tool (Application of NANO coatings on the vital cutting edges and forming parts of progressive and transfer tools and milling tools for automotive production, to increase productivity, persistence and longer life time, ERA-SME). The goal of this project is to improve the lifetime of coatings for the machining of forming tools using nanolayer coatings.

The year 2010 was also fruitful in a bilateral collaboration with Austrian partners from Leoben (Joanneum Research, MATERIALS – Institute for Surface Technologies and Photonics). We are working on diamond-like carbon coatings, deposited by an anode layer source. We made a complete characterization of the system and established optimal deposition parameters for various applications. This was the topic of the bilateral project (Deposition of diamond-like carbon films by anode layer source). We are informally collaborating with several other foreign partners. The Institute for Nuclear Sciences Vinča, Belgrade, needs to be mentioned; we are depositing multilayer structures for subsequent laser treatment. For the Research Institute for Technical Physics and Materials from Budapest we are depositing various structures to study the sputtering analytics.

Some outstanding publications in the past three years

1. Growth defects in PVD hard coatings, Peter Panjan, Miha Čekada, Peter Panjan, Darja Kek-Merl, Vacuum, 2010, vol. 84, no. 1, str. 209-214
2. Analysis of the diffusion processes in Al/Cr and Cr/Fe multilayer using the MRI model, Miha Čekada, Matjaž Panjan, Darjan Cimprič, Janez Kovač, Peter Panjan, Janez Dolinšek, Anton Zalar, Vacuum, 2010, vol. 84, no. 84, str. 147-151
3. Modification of multilayered TiAlN/TiN coating by nanosecond and picosecond laser pulses, B. Gaković, M. Trtica, B. Radak, S. Petrović, P. Panjan, M. Čekada, T. Desai, D. Batani, Journal of Optics A: Pure and Applied Optics 11 (2009) 015601
4. Hydrogen permeation through TiAlN-coated Eurofer '97 steel, Paul J. McGuiness, Miha Čekada, Vincenc Nemanič, Bojan Zajec, Aleksander Rečnik, Surf. coat. technol. 205 (2011) 2709–2713
5. Accurate Raman spectroscopy of diamond-like carbon films deposited by an anode layer source, Markus Kahn, Miha Čekada, Roswitha Berghauser, Wolfgang Waldhauser, C. Bauer, Christian Mitterer, Elmar Brandstätter, Diamond and related materials, 17 (2008) 1647–1651

INTERNATIONAL PROJECTS

1. Development of Wear Resistant Coatings based on Complex Metallic Alloys for Functional Applications
   appliCMA
   7. FP, 214407
   EC; Andreas Merstallinger, Aerospace & Advanced Composites GmbH, Wiener Neustadt, Austria
   Asst. Prof. Miha Čekada, Prof. Janez Dolinšek, Dr. Kristoffer Krnel, Dr. Srečo D. Škapin
2. Plasma Deposition of H:C-metal Coatings - 1.4.5.-FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Dr. Peter Panjan
3. Complex Metallic Alloys
   CMA
   6. FP, NMP3-CT-2005-500140
   EC; Centre National de la Recherche Scientifique, Paris, France
   Dr. Peter Panjan, Prof. Janez Dolinšek, Prof. Spomenka Kobe
4. Hydrogen Impermeable Nano-material Coatings for Steels
   Hy-Nano-IM
   MNT ERA NET
   Asst. Prof. Miha Čekada, Dr. Paul McGuiness, Dr. Vincenc Nemanič
5. Improvement of Resurfacing Hip Implants with DLC, TiO_2 and DLC-p-h Nanocomposite Coatings
   RHSI-DLC-NanoComp
   MATERA ERA NET
   ORTON Research Institute, Helsinki, Finland
   Dr. Darinka Kek Merl, Dr. Ingrid Milošev
6. Aplication of NANO Coatings on the Vital Cutting Edges and Forming Parts of Progressive and Transfer Tools and Milling Tools for Automotive Production, to increase Productivity, Persistence and Longer Life Time
   NANO-TOOL
   ERASME, 3211-10-000188
   EMO-Orodjarna d.o.o., Celje, Slovenia
   Dr. Peter Panjan
7. Deposition of Diamond-like Carbon Coatings by Anode Layer Source for Tribological Applications
   BI-AT/09-10-006
   Dr. Wolfgang Waldhauser, Joanneum Research Forschungsgesellschaft mbH, Niklasdorf, Austria
   Asst. Prof. Miha Čekada
8. Characterization of the Selected Coatings
   Dr. Rainer Cremer, CemeCon AG, Coatings, Technology & Processes, Wüerselen, Germany
   Dr. Peter Panjan

R &D GRANTS AND CONTRACTS

1. Materials and Structures for Optically Variable Security Devices
   Dr. Peter Panjan
2. Development of Electronical Measuring Paltform POWERQ4
   Dr. Peter Panjan
3. Development of New Generation of Hard Coatings with Pulsed Sputter Deposition
   Dr. Peter Panjan
4. PVD Coatings as the Alternative for Corrosion Protection of Fe and Al Alloys
   Dr. Darinka Kek Merl
5. Study of Plasma Parameters for Conditioning of the Inner Surfaces of a Fusion Reactor
   Dr. Peter Panjan

RESEARCH PROGRAM

1. Thin Film Structures and Plasma Surface Engineeing
   Dr. Peter Panjan

VISITORS FROM ABROAD

1. mag. Halil Caliskan, Süleyman Demirel University, Faculty of Engineering and Architecture, Isparta, Turkey, 8. 11. 2009–8. 1. 2010
2. dr. Andrej Furlan, University of Uppsala, Uppsala, Sweden, 19. 3. 2010
3. dr. Biljana Gaković, mag. Dubravka Maravić, Institute for nuclear sciences "Vinča", Belgrade, Serbia, 1.–5. 3. 2010
4. Sanja Šolić, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia, 24.–28. 5. 2010
5. dr. Suzana Petrović, dr. Davor Peruška, Institute for nuclear sciences "Vinča", Belgrade, Serbia 25–28. 5. 2010
6. dr. Wolfgang Waldhauser, dr. Markus Kahn, Betina Ranninger, Joanneum Research, MATERIALS – Institute for Surface Technologies and Photonics, Leoben, Austria, 15.–16. 6. 2010
7. dr. Constantin Vahlas, Interuniversity Materials Research and Engineering Centre, Toulouse, France, 29.–30. 6. 2010
8. Sanja Šolić, Sveučilište u Zagrebu, University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia, 5.–9. 7. 2010
9. Aleksandar Miletić, University of Novi Sad, Novi Sad, Serbija, 2.–30. 9. 2010
10. Benjamin Gadot, Interuniversity Materials Research and Engineering Centre, Toulouse, France, 26. 7.–17. 9. 2010
11. Sanja Šolić, Sveučilište u Zagrebu, Fakultet strojarstva i brodogradnje, Zagreb, Hrvaška, 11.–15. 10. 2010
12. dr. Wolfgang Waldhauser, Joanneum Research, MATERIALS – Institute for Surface Technologies and Photonics, Leoben, Avstrija, 29.–30. 11. 2010

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8. Damjan Matelič
9. Andrej Mohar
10. Tomaž Sirnik

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2. Miha Čekada, Matjaž Panjan, Darjan Cimprič, Janez Kovač, Peter Panjan, Janez Dolinšek, Anton Zalar, "Analysis of the diffusion processes in Al/Cr and Cr/Fe multilayer using the MRI model", In: *Proceedings of the 12th Joint Vacuum Conference, 10th European Vacuum Conference and 7th Annual Meeting of the German Vacuum Society (JVC-12/EVC-10/AMDVG-7), Balatonalmadi, Hungary, 22 - 26 September 2008*, (Vacuum, vol. 84, no. 1), Sándor Bohátka, ed., Béla Pécz, ed., András Berkó, ed., Oxford, New York, Pergamon Press, 2010, pp. 147-151.
3. Markus Kahn, Srečko Paskvale, Miha Čekada, Thomas Schöberl, Wolfgang E. Waldhauser, Christian Mitterer, Primož Pelicon, Elmar Brandstätter, "The relationship between structure and mechanical properties of hydrogenated amorphous carbon films", *Diamond and related materials*, vol. 19, no. 10, pp. 1245-1248, 2010.
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6. Peter Panjan, Miha Čekada, Peter Panjan, Darja Kek-Merl, "Growth defects in PVD hard coatings", In: *Proceedings of the 12th Joint Vacuum Conference, 10th European Vacuum Conference and 7th Annual Meeting of the German Vacuum Society (JVC-12/EVC-10/AMDVG-7), Balatonalmadi, Hungary, 22 - 26 September 2008*, (Vacuum, vol. 84, no. 1), Sándor Bohátka, ed., Béla Pécz, ed., András Berkó, ed., Oxford, New York, Pergamon Press, 2010, pp. 209-214.
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2. Peter Panjan, "Oplemenitenje površin", In: *Moderno proizvodno inženirstvo: [priročnik]*, Ivan Anžel, Jože Balič, Oki Blatnik, Franc Čuš, Igor Drstvenšek, Mirko Ficko, Janez Grum, Niko Herakovič, Mihael Junkar, Zlatko Kampuš, Janez Kopač, Dragica Noe, Henri Orbanić, Ivo Pahole, Peter Panjan, Andrej Polajnar, Henrik Privšek, Marko Starbek, Boštjan Šmuc, Janez Tušek, Joško Valentinčič, Karl Kuzman, ed., Grosuplje, Grafis trade, 2010, pp. 867-911.

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1. Miha Čekada, Franc Zupanič, Peter Panjan, Darja Kek-Merl, Matjaž Panjan, Srečko Paskvale, "Surface growth defect analysis by stylus profilometry and focused ion beam", In: *Fortschritte in der Metallographie: Berichte der 13. Internationalen Metallographie-Tagung Leoben, 29. September bis 1. Oktober 2010*, (Sonderbände der praktischen Metallographie herausgegeben von Günter Petzow, 42), 13. Internationalen Metallographie-Tagung Leoben, 29. September bis 1. Oktober 2010, Albert C. Kneissl, ed., Helmut Clemens, ed., Frankfurt, Werkstoff-Internationsgesellschaft, cop. 2010, pp. 345-350.
2. Peter Panjan, "Plazemsko inženirstvo površin v industrijski proizvodnji", In: *Vir znanja in izkušenj za stroko: zbornik foruma*, Industrijski forum IRT, Portorož, 7.-8. junij 2010, Tomaž Perme, ed., Darko Švetak, ed., Jože Balič, ed., Škofljica, Profidtp, 2010, pp. 165-169.
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1. Ivan Anžel, Jože Balič, Oki Blatnik, Franc Čuš, Igor Drstvenšek, Mirko Ficko, Janez Grum, Niko Herakovič, Mihael Junkar, Zlatko Kampuš, Janez Kopač, Dragica Noe, Henri Orbanić, Ivo Pahole, Peter Panjan, Andrej Polajnar, Henrik Privšek, Marko Starbek, Boštjan Šmuc, Janez Tušek, Joško Valentinčič, Karl Kuzman, ed., *Moderno proizvodno inženirstvo: [priročnik]*, Grosuplje, Grafis trade, 2010.

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1. Matjaž Panjan, *Physical and chemical properties of nanolayered metal-nitride coatings prepared by sputtering: doctoral dissertation*, Ljubljana, [M. Panjan], 2010.

Patent Application

1. Matjaž Panjan, Miha Čekada, Peter Panjan, Damjan Matelič, Andrej Mohar, Tomaž Sirnik, Jožko Fišer, *Trde zaščitne prevleke z možnostjo spreminjanja njihove barve: P-201000399*, Ljubljana, Urad RS za intelektualno lastnino, 2010.

DEPARTMENT OF SURFACE ENGINEERING AND OPTOELECTRONICS F-4

The research program is associated with vacuum science, technology and applications. The main activities are focused on plasma science, the modification of advanced biomedical materials and products for improved biocompatibility, the characterization of inorganic, polymer and composite materials with different thin films on the surface, the modification and characterization of fusion-relevant materials, the thermodynamics of trapped gases and methods for sustaining a ultra-high-vacuum environment, vacuum optoelectronics, and basic research in the field of surface and thin-film characterization by electron spectroscopy techniques.

Head:
Prof. Miran Mozetič

A highly dissociated cold plasma created by inductively coupled radiofrequency discharges was applied either as a source of neutral oxygen or nitrogen atoms, or as a powerful tool for the modification of solid materials. The plasma created in such electrode-less discharges is extremely non-equilibrium and thus suitable for the treatment of both inorganic and delicate organic samples. The research group developed a method for the suppression of tritium retention in current and future fusion reactors with carbon limiters or divertors. Important results towards the minimization of hydrogenated carbon-deposit formation were obtained in collaboration with research groups from Madrid, Spain, and Nieuwegein, The Netherlands. The application of reactive nitrogen particles created in electrode-less discharges effectively interact with hydrogenated carbon radicals in the gas phase, forming stable volatile molecules that do not stick to surfaces at room or elevated temperature and are thus easily pumped away from thermal plasma reactors. Furthermore, N and HN radicals that are formed in an ammonia plasma interact with the deposits already at room temperature, allowing for removal of the deposits.

A hypothesis has been launched to explain the rapid oxidation of metals in an aggressive oxygen plasma resulting in the spontaneous growth of single-crystalline metal oxide nanowires.

Plasma nanoscience is a new, attractive and rapidly expanding field of interdisciplinary research where the research group is extremely active. A specialized workshop was organized at Lake Bohinj in the Slovenian Alps under the supervision of the International Union for Vacuum Science, Techniques and Applications: 62nd IUVSTA Workshop on Plasma Synthesis and Modification of Nanomaterials, 14th – 18th June 2010. The workshop gathered worldwide-renowned scientists and represented one of the most important events in nanoscience. The research group applies oxygen plasma for the direct synthesis of metal oxide nanoparticles on metallic substrates. Since the original invention of the synthesis of niobium oxide nanowires published in Advanced Materials in 2005, the method has been expanded to a variety of metal-oxygen systems and the research group obtained important results on the way to explaining this unusual effect. Although an internationally acceptable theory on the growth of metal oxide nanoparticles under extremely non-equilibrium conditions has not yet been recognized, our recent results employing both theoretical and experimental approaches show possible mechanisms involved in this strange happening. Appropriate hypotheses were published in a new, high-quality international journal – Nanoscale – published by the Royal Society of Chemistry.

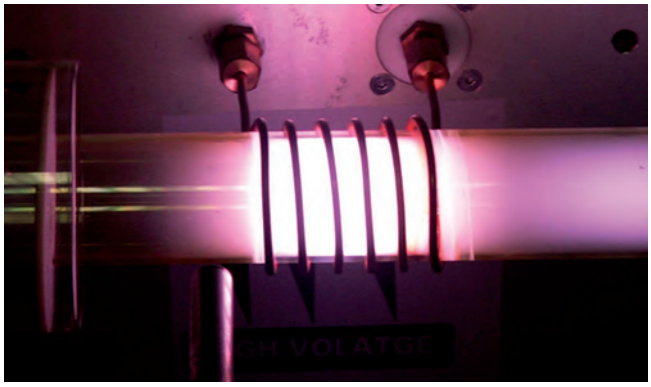

Figure 1: Low-pressure plasma created within a quartz-glass tube by inductively coupled radiofrequency discharge

Oxygen plasma created by powerful electrode-less discharges is too aggressive for the modification of organic materials, but serves as an excellent source of neutral oxygen atoms in the ground state. While most reactive plasma particles recombine on the walls of the vacuum system, the lifetime of the neutral O atoms is very long, providing the pressure is low enough to prevent gas-phase recombination during three-body collision events (in practice it means below a few hundred Pa) and as long as the walls are made of materials with a low coefficient for heterogeneous surface recombination. A late afterglow of plasma created at moderately low pressure and in glass systems is therefore a suitable source of neutral oxygen atoms at room temperature. Such atoms do not cause substantial modification of the bulk

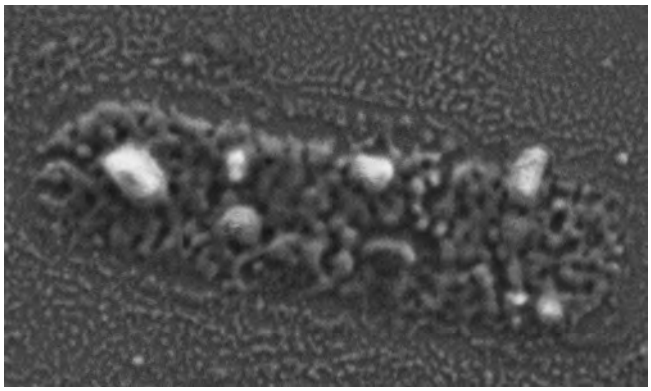

Figure 2: SEM image of bacillus stearothermophilus after treatment with oxygen atoms reveals the non-homogeneous structure of the bacterial cytoplasm.

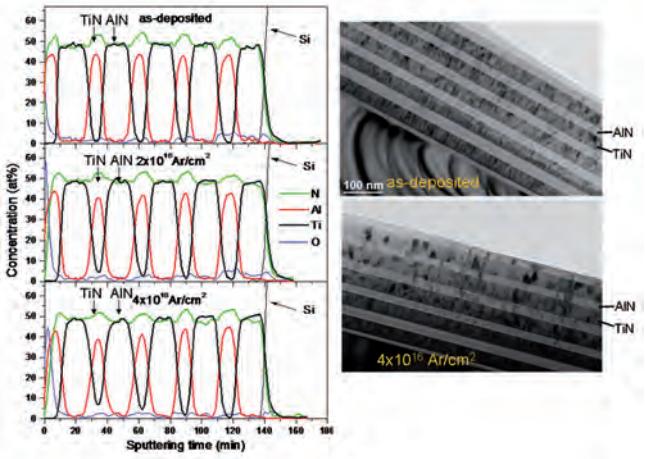

Figure 3: Very high ion radiation stability observed in the multilayered (AlN/TiN)x5/Si nanocomposites upon Ar ion irradiation at 200 keV. The AlN and TiN layers remain well separated, with sharp interfaces. XPS depth profiles are shown on left and TEM images on right. The work was performed in collaboration with the Institute for Nuclear Sciences Vinča, Serbia.

properties on organic materials, but do affect the surface properties. Numerous organic materials are treated by such an afterglow in order to obtain the required properties of polymer materials. The afterglow is also suitable for the slow and selective removal of organic materials from live biological cells, including bacteria. A treatment by neutral oxygen atoms at room temperature causes the removal of the outermost parts of the bacteria, revealing its internal structure.

The characterization of the surfaces and interfaces of bulk materials, layered structures and nanomaterials requires the application of modern surface-analytical techniques. X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES) and atomic force microscopy (AFM) have been used successfully, all for basic research and for the characterization of technological samples. Our research group is worldwide recognized for the depth profiling of thin films and multilayers at a high depth resolution. Applying the XPS method we investigated the structural changes in multilayered AlN/TiN nanocomposites upon Ar ion irradiation in collaboration with the Institute for Nuclear Sciences from Vinča, Serbia. Reactive sputtering was used to deposit (AlN/TiN) × 5 multilayers on a Si substrate with a thickness of the individual layer equal to 27 nm. Argon was implanted at 200 keV at doses of 5×10^{15} to 4×10^{16} ions/cm^2. It was found that this immiscible system exhibits a high ion radiation stability, the AlN and TiN layers remaining well separated with sharp interfaces. Ion irradiation induced small local density changes and only a slight increase in the size of individual grains. Due to these small structural changes, ion irradiation enhanced the mechanical strength of the multilayered nanocomposites.

The existence of ferromagnetism at room temperature in the Zn–Mn–O semiconductor samples and its dependence on the preparation conditions were investigated. We systematically examined the samples with a manganese concentration ranging from 0 to 10 at.%, prepared by a solid-state reaction route. The XPS surface composition, chemical analysis and depth profiling were successfully employed on powder, revealing the chemical composition at the surface of the grains and underneath. The present investigation shows that the physical properties and the observed room-temperature ferromagnetism is due to grain surface effects. It seems that the ferromagnetic phase is correlated with an oxygen build up at the surface.

A method for the suppression of tritium retention has been elaborated in collaboration within the EURATOM association.

Important results were obtained in collaboration with 15 partners of the European project PlasmaNice – Atmospheric plasmas for nanoscale industrial surface processing – funded under the EU's7th FP. The main objective of the PlasmaNice project is to develop equipment and technology for the industrial in-line atmospheric plasma deposition of functional nanocoatings on various fibre- and polymer-based substrates for packaging. The project aims at improving the recyclability of conventional fossil-fuel-based plastics and/or their replacement by renewable, bio-based and biodegradable materials. Our research group performs accurate surface characterizations of plasma-deposited sol-gel coatings using XPS, AFM and SEM methods. We determined the correlation between the plasma process parameters, the degree of surface fuctionalization and the thickness of the deposited coatings. Our second task is the development of a new method for the fast and in-line monitoring of the plasma-coating deposition process at a very high velocity. We tested different optical, electrical and spectroscopic methods and identified the most suitable one.

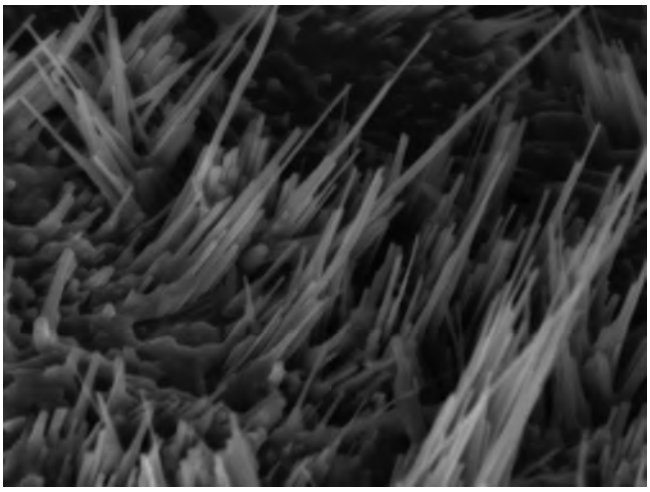

Figure 4: Single-crystalline nanowires of niobium pentoxide growing from the surface of polycrystalline niobium foil during exposure to a fully dissociated oxygen plasma.

An extremely sensitive method for the quantitative analysis of hydrogen in ultra-high-vacuum systems was developed. The system allows for an accurate quantitative analysis of gas compositions. We can determine the composition of a very small amount (10^{-10} mol) of gas which resides in the gas-accumulating vessel. Special attention was devoted to the suppression of the hydrogen background from the heated sample holder. This was achieved by a careful selection of materials and a pre-treatment procedure using an original construction. The quantitative analysis of the composition of a gas mixture using a mass spectrometer is the basic method giving a rough insight into the reactions in gases and on surfaces. Our improved setup was successfully applied in an investigation of the breakdown voltage drift with time in gas surge arresters. In the frame of Physics laboratory IV, the training

exercise on mass spectrometry of gas mixtures for students of physics at the Faculty of Mathematics and Physics, University of Ljubljana, was established.

Permeation measurements through coated Eurofer membranes were important activities related to an EU fusion project within Euratom and another EU project. It was found that 5-micrometer-thick TiAlN films (prepared at department F-3 at JSI) have the highest permeation barrier reduction factor (PRF) reported so far. In cooperation with Joanneum research centre in Leoben we found that silicon oxy-nitride and silicon nitride films can be prepared in the form that has also very high PRF, even at a thickness below 1 micrometer. No quantitative data on such films existed prior to our measurements. Beryllium and tungsten films on Eurofer were investigated in this context too. Both metals will be applied for the first wall in future large fusion reactors. Beryllium films (8 mm thick) were deposited in Dr. Cristian Lungu's lab at the National Institute for Laser, Plasma and Radiation Physics - NILPRP from Bucharest, Romania. We obtained results that were reproducible within relatively wide margins. However, they could not be compared to published data since these data do not exist. The unexpected kinetics could be well explained by our better model and respecting the fact that data on bulk beryllium are rather old and probably inaccurate. Similar conclusions could be drawn from experiments with tungsten films on Eurofer, although the reproducibility was much better than for beryllium. Tungsten films (10 mm thick) were deposited in dr. Cristian Ruset's lab at NILPRP, which also developed and successfully tested identical films in fusion reactors like JET.

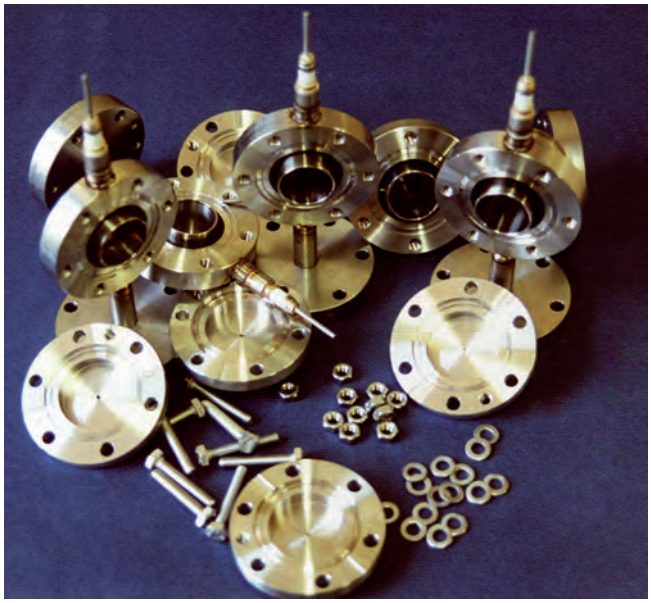

Figure 5: Ultra-high-vacuum pressure gauges in the development stage. The corresponding US patent has recently been granted.

The patent US7800376B2 entitled "Method and device for measuring ultrahigh vacuum" was granted in September 2010. The patent protects our original device for accurate pressure measurements in the range from 10^{-4} to 10^{-8} Pa.

Some outstanding publications in the past year

1. Francisco L. Tabarés, Jose Ferreira, G. van Rooij, J. Rapp, Aleksander Drenik, Miran Mozetič. Suppression of tritium retention in remote areas of ITER by nonperturbative reactive gas injection. Phys. rev. lett., 2010, vol. 105, no. 17, p. 175006-1-175006-4.
2. Kostya Ostrikov, Igor Levchenko, Uroš Cvelbar, Mahendra K. Sunkara, Miran Mozetič. From nucleation to nanowires : a single-step process in reactive plasmas. Nanoscale (Print), 2010, vol. 2, no. 10, p. 2012-2027.
3. Momir Milosavljević, Dalibor Peruško, Velimir Milinović, Zoran Stojanović, Janez Kovač, Chris Jeynes. Ion irradiation stability of multilayered AlN/TiN nanocomposites. J. phys., D, Appl. phys., 2010, vol. 43, no. 6, p. 065302-1-065302-6.

Patents granted

1. Method of treatment of biomedical polymeric prostheses for improvement of their antithrombogenous properties
   Ita Junkar, Miran Mozetič, Alenka Vesel, Uroš Cvelbar, Metka Krašna, Dragoslav Domanovič
   Patent No. SI 23021 (A)
2. Method and device for measuring ultrahigh vacuum
   Alenka Vesel, Miran Mozetič
   Patent No. US 7800376 (B2)

Organization of conferences, congress and meetings

1. 3rd International Conference on Advanced Plasma Technologies (ICAPT-III), Bohinj, Slovenia, 15.-18.6.2010

INTERNATIONAL PROJECTS

1. Atmospheric Plasmas for Nanoscale Industrial Surface Processing
   PlasmaNice
   7. FP
   EC; Dr. Johanna Lahti, Tampere University of Technology, Paper Converting and Packaging Technology, Tampere, Finland
   Asst. Prof. Janez Kovač
2. Removal of Deposits by Neutral Oxygen and Nitrogen Atoms - 1.4.2. – FU
   WP10-PWI-02-02/MHEST/PS; Detailed Characterization of Reaction Products from Removal of A-C:H with Mixed H2/N2 Plasmas
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Prof. Miran Mozetič

3. Deuterium Retention and Release from Metal Surfaces - 1.4.4. – FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Dr. Vincenc Nemanič
4. Plasma Sterilization and Decontamination of Water
   NATO CLG. REF.983580
   Dr. Fausto Pedrazziini, NATO - North Atlantic Treaty Organisation, Brussels, Belgium
   Asst. Prof. Uroš Cvelbar
5. Development of Bioactive Packaging
   BIOPACKAGING
   EUREKA
   Univerza v Mariboru, Inštitut za inženirske materiale in oblikovanje, Maribor, Slovenia
   Prof. Miran Mozetič
6. Vascular Graft Interfaces
   VaGrint
   MNT ERA NET, 3211-07-000024
   University of Maribor, Faculty of Mechanical Engineering, Maribor, Slovenia
   Prof. Miran Mozetič
7. Hydrogen Impermeable Nano-material Coatings for Steels
   Hy - Nano – IM
   MNT ERA NET
   Dr. Vincenc Nemanič, Dr. Paul McGuiness, Dr. Miha Čekada
8. Introduction Consulting to define Targets and Specify Methods; Measurement of Three Samples at Room Temperature
   Research Agreement
   Dr. Vincenc Nemanič
9. Characterization of Microorganism Structures by Advanced Analytical Techniques
   BI-ME/10-11-1
   Dr. Zoran Vratnica, Institute of Public Health, Podgorica, Montenegro
   Prof. Miran Mozetič
10. Sterilization of Medicine Materials with Gaseous Plasma
    BI-ME/10-11-3
    Dr. Danijela Vujošević, Institute of Public Health, Podgorica, Montenegro
    Asst. Prof. Uroš Cvelbar
11. Interaction of Highly Dissociated CO2 Plasma with Materials Suitable as Outer Protective Layers of Future Space Vehichles
    PROTEUS 2010 – 2011, BI-FR/10-11-PROTEUS-005
    Dr. Marianne Balat-Pichelin, Processes, Materials and Solar Energy Laboratory (PROMES-CNRS), Font-Romeu Odeillo, France
    Asst. Prof. Alenka Vesel
12. Improvement of Adhesive Properties of Biomedical Materials by Plasma Treatment
    BI-HR/10-11-020
    Dr. Morana Jaganjac, Ruđer Bošković Institute, Zagreb, Croatia
    Asst. Prof. Alenka Vesel
13. Modification of Cardiovascular Implants by Gaseous Plasma
    BI-HR/09-10-001
    Dr. Slobodan Milošević, Institut za fiziku - Institute of Physics, Zagreb, Croatia
    Prof. Miran Mozetič
14. Quantum Dots for Solar Cells
    BI-CN/09-11-003
    Dr. Xiaoxia Zhong, Shanghai Jiao Tong University, Shanghai, China
    Asst. Prof. Uroš Cvelbar
15. Study of Ion Mixing caused by FIB
    BI-HU/09-10-004
    Dr. Miklos Menyhard, Research Institute for Technical Physics and Materials Sciences, Budapest, Hungary
    Asst. Prof. Janez Kovač
16. Dissociation Kinetics in Technological Plasmas
    BI-SR/10-11-001
    Prof. Zoran Petrovič, Institute of Physics, Beograd - Zemun, Serbia
    Prof. Miran Mozetič
17. Thermoionic Energy Conversion
    BI-US/09-12-021
    Prof. Robert Nemanich, Arizona State University, (ASU), Tempe, Arizona, USA
    Dr. Vincenc Nemanič
18. Metal Oxide Nanowire/Nanotube Arrays for Electrochemical Energy Conversion Applications
    BI-US/08-10-030
    Prof. K. Mahendra Sukara, Oddelek za kemijsko inženirstvo, Univerza v Louisvillu, Louisville, KY, USA
    Asst. Prof. Uroš Cvelbar

R &D GRANTS AND CONTRACTS

1. Plasma Treatment of Vascular Grafts
   Prof. Miran Mozetič
2. Research and Development of Integrated Overvoltage Protection Devices Based on Gas Discharger Toward a Reliable Miniature Technical Solution
   Dr. Vincenc Nemanič
3. Study of Gaseous Deuterium Retention and Release from Metals Relevant to ITER
   Dr. Bojan Zajec
4. Investigation of Gaseous Diascharges for Introduction of New Enviromentally Friendly Technology for Functionalization of Semiproduct in Capacitor Production
   Prof. Miran Mozetič
5. Development of Treatments and Procedures for Improvement of Hemocompatibility of Polyethyleneterephtalate Surfaces
   Prof. Miran Mozetič
6. Synthesis and Functionalization of Composite Nanobeads for Early Diagnosis of Neurodegenerative Diseases
   Asst. Prof. Alenka Vesel
7. Superhydrophilicity of Surfaces and its Application in Technological Processes for Industrial Application
   Asst. Prof. Uroš Cvelbar
8. Printed Passive Electronic Components for Smart Packaging
   Asst. Prof. Alenka Vesel
9. Multifunctional Nanocomposite Coatings and Paints
   Asst. Prof. Janez Kovač, Asst. Prof. Alenka Vesel
10. Ignition and Eelf-extinguishing of arc in a Gas Surge Arrester at High Overvoltages
    Dr. Vincenc Nemanič

RESEARCH PROGRAMS

1. Vacuum Technique and Materials for Electronics
   Dr. Vincenc Nemanič
2. Thin Film Structures and Plasma Surface Engineering
   Prof. Miran Mozetič

MENTORING

Ph. D. Thesis

1. Ita Junkar, *Plasma treatment of polymers for biomedical applications* (mentor Miran Mozetič; co-mentor Uroš Cvelbar)

VISITORS FROM ABROAD

1. Dr. Slobodan Milošević, dr. Marijan Bišćan, Nikša Krstulović, Zlatko Kregar, Krešimir Salamon, Institute of Physics, Zagreb, Croatia, several times
2. Dr. Primož Eiselt, Plasmabull, Lebring, Austria, several times
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4. Dr. Nevena Puač, dr. Željka Nikitović, Institute of Physics, Belgrade, Serbia, several times
5. Dr. Momir Milosavljević, dr. Davor Peruško, Institute of nuclear sciences, Vinča, Belgrade, Serbia, 24. 5. – 28. 5 . 2010
6. Dr. Cristian Lungu, National Institute for Lasers, Bucharest, Romania, 13. 6. -15. 6. 2010
7. Dr. David Ruzic, University of Illinois, USA, 14. 6. – 20. 6. 2010
8. Prof. dr. Antony B. Murphy, CSIRO, Sydney, Australia, 14. 6. – 20. 6. 2010
9. Prof. dr. Giorgios Evangelakis, University of Ioannina, Ioannina, Greece, 14. 6. – 20. 6. 2010
10. Prof. dr. Tom Stara, J.P.Speed School of Engineering, University of Louisville, Louisville, Kentucky, USA, 14. 7. 2010 – 15. 7. 2010
11. Prof. Marian Lehocky and A/Prof. dr. Aleš Mraček, University Tomas Bata, Zlin, Czech Republic, 11. 11. 201 – 13. 11.2010
12. Dr. Iacono Jonathan, CNRS, Laboratory Promes, Odeillo, France, 7.12. 2010 – 14. 12.2010

STAFF

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18. Tatjana Filipič, B. Sc.
19. Janez Trtnik

BIBLIOGRAPHY

Original Articles

1. Andrew Das Arulsamy, Uroš Cvelbar, Miran Mozetič, Kostya Ostrikov, "Non-square-well potential profile and suppression of blinking in compositionally graded $Cd_{1-x}Zn_xSe/Cd_xZn_{1-x}Se$ nanocrystals", *Nanoscale (Print)*, vol. 2, no. 5, pp. 728-733, 2010.
2. Andrew Das Arulsamy, Kristina Eleršič, Martina Modic, Uroš Cvelbar, Miran Mozetič, "Reversible carrier-type transitions in gas-sensing oxides and nanostructures", *ChemPhysChem*, vol. 11, no. 17, pp. 3704-3712, 2010.
3. Ahmad Asadinezhad, Igor Novák, Marián Lehocký, František Bílek, Alenka Vesel, Ita Junkar, Petr Sáha, Anton Popelka, "Polysaccharides coatings on medical-grade PVC: a probe into surface characteristics and the extent of bacterial adhesion", *Molecules (Basel)*, vol. 15, no. 2, pp. 1007-1027, 2010.
4. Ahmad Asadinezhad, Igor Novák, Marián Lehocký, Vladimír Sedlarik, Alenka Vesel, Ita Junkar, Petr Sáha, Ivan Chodák, Ivan Chodák, "A physicochemical approach to render antibacterial surfaces on plasma-treated medical-grade PVC: irgasan coating", *Plasma processes polym. (Print)*, vol. 7, no. 6, pp. 504-514, 2010.
5. Ahmad Asadinezhad, Igor Novák, Marián Lehocký, Vladimír Sedlarik, Alenka Vesel, Petr Sáha, Ivan Chodák, "An in vitro bacterial adhesion assessment of surface-modified medical-grade PVC", *Colloids surf., B Biointerfaces*, vol. 77, no. 2, pp. 246-256, 2010.
6. Marianne Balat-Pichelin, Marc Passarelli, Alenka Vesel, "Recombination of atomic oxygen on sintered zirconia at high temperature in non-equilibrium air plasma", *Mater. chem. phys.*, vol. 123, no. 1, pp. 40-46, 2010.
7. Diana Ciolacu, Janez Kovač, Vanja Kokol, "The effect of the cellulose-binding domain from Clostridium cellulovorans on the supramolecular structure of cellulose fibres", *Carbohydr. res.*, vol. 345, iss. 5, pp. 621-630, Mar. 2010.
8. Miha Čekada, Matjaž Panjan, Darjan Cimprič, Janez Kovač, Peter Panjan, Janez Dolinšek, Anton Zalar, "Analysis of the diffusion processes in Al/Cr and Cr/Fe multilayer using the MRI model", In: *Proceedings of the 12th Joint Vacuum Conference, 10th European Vacuum Conference and 7th Annual Meeting of the German Vacuum Society (JVC-12/EVC-10/AMDVG-7), Balatonalmadi, Hungary, 22 - 26 September 2008*, (Vacuum, vol. 84, no. 1), Sándor Bohátka, ed., Béla Pécz, ed., András Berkó, ed., Oxford, New York, Pergamon Press, 2010, pp. 147-151.
9. Milan Čerček, Gregor Filipič, Tomaž Gyergyek, Jernej Kovačič, "Floating potentials in two-electron temperature plasma with two species of positive ions: kinetic model and PIC simulation", In: *CPP: contributions to plasma physics: special issue*, (Contributions to plasma physics (1985), vol. 50, no. 9), 8th International Workshop on Electric Probes in Magnetized Plasmas, September 21-23 2009, Innsbruck, Austria, Karl-Heinz Spatschek, ed., Roman Schrittwieser, ed., M. Laux, ed., Berlin, Akademie-Verlag, 2010, pp. 909-914.
10. Aleksander Drenik, Andrej Tomeljak, Miran Mozetič, Alenka Vesel, Dušan Babič, Marianne Balat-Pichelin, "Behaviour of neutral hydrogen atom density in the presence of a sample holder in a plasma reactor", In: *Proceedings of the 12th Joint Vacuum Conference, 10th European Vacuum Conference and 7th Annual Meeting of the German Vacuum Society (JVC-12/EVC-10/AMDVG-7), Balatonalmadi, Hungary, 22 - 26 September 2008*, (Vacuum, vol. 84, no. 1), Sándor Bohátka, ed., Béla Pécz, ed., András Berkó, ed., Oxford, New York, Pergamon Press, 2010, pp. 90-93.
11. Kristina Eleršič, Ita Junkar, Aleš Špes, Nina Hauptman, Marta Klanjšek Gunde, Alenka Vesel, "Degradation of bacteria Escherichia coli by treatment with Ar ion beam and neutral oxygen atoms", *Mater. tehnol.*, vol. 44, no. 3, pp. 153-156, 2010.
12. Kristina Eleršič, Janez Kovač, Martina Modic, Miran Mozetič, "ARXPS-analiza bakterij Escherichia coli, obdelanih v kisikovi plazmi", *Vakuumist*, vol. 30, no. 2, pp. 4-7, 2010.
13. Matjaž Finšgar, Janez Kovač, Ingrid Milošev, "Surface analysis of 1-hydroxybenzotriazole and benzotriazole adsorbed on Cu by X-ray photoelectron spectroscopy", *J. Electrochem. Soc.*, vol. 157, no. 2, pp. C52-C60, 2010.
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15. Marija Gorenšek, Marija Gorjanc, Vili Bukošek, Janez Kovač, P. Jovančić, Darka Mihailović, "Functionalization of PET fabrics by corona and nano silver", *Tex. res. j.*, vol. 80, no. 3, pp. 253-262, 2010.
16. Marija Gorenšek, Marija Gorjanc, Vili Bukošek, Janez Kovač, Zoran Lj. Petrović, Nevena Puač, "Functionalization of polyester fabric by Ar/N2 plasma and silver", *Tex. res. j.*, vol. 80, no. 16, pp. 1633-1642, 2010.
17. Marija Gorenšek, Marija Gorjanc, Janez Kovač, "Preiskava kemijskih sprememb na površini PET pletiva z rentgensko fotoelektronsko spektroskopijo po obdelavi s korona plazmo in po staranju pletiva", *Tekstilec*, vol. 53, no. 4/6, pp. 103-112, 2010.
18. Marija Gorjanc, Vili Bukošek, Marija Gorenšek, Miran Mozetič, "CF4 plasma and silver functionalized cotton", *Tex. res. j.*, vol. 80, no. 20, pp. 2204-2213, 2010.
19. Marija Gorjanc, Vili Bukošek, Marija Gorenšek, Alenka Vesel, "The influence of water vapor plasma treatment on specific properties of bleached and mercerized cotton fabric", *Tex. res. j.*, vol. 80, no. 6, pp. 557-567, 2010.
20. Marija Gorjanc, Janez Kovač, Marija Gorenšek, "Rentgenska fotoelektronska spektroskopija za določanje kemijskih sprememb na površini bombaža po obdelavi s korona in nizkotlačno plazmo", *Tekstilec*, vol. 53, no. 7/9, pp. 194-204, 2010.
21. Ivan Iskra, Andrej Detela, Marko Viršek, Vincenc Nemanič, Dejan Križaj, Damjan Golob, Johannes Teun van Elteren, Maja Remškar, "Capacitive-type counter of nanoparticles in air", *Appl. phys. lett.*, vol. 96, no. 9, pp. 093504-1-093504-3, 2010.
22. Ivan Jerman, Boris Orel, Angela Šurca Vuk, Matjaž Koželj, Janez Kovač, "A structural and corrosion study of triethoxysilyl and perfluorooctyl functionalized polyhedral silsesquioxane nanocomposite films on AA 2024 alloy", *Thin solid films*, vol. 518, no. 10, pp. 2710-2721, 2010.
23. Ita Junkar, Alenka Vesel, Uroš Cvelbar, Miran Mozetič, Simona Strnad, "Influence of oxygen and nitrogen plasma treatment on polyethylene terephthalate (PET) polymers", In: *Proceedings of the 12th Joint Vacuum Conference, 10th European Vacuum Conference and 7th Annual Meeting of the German Vacuum Society (JVC-12/EVC-10/AMDVG-7), Balatonalmadi, Hungary, 22 - 26 September 2008*, (Vacuum, vol. 84, no. 1), Sándor Bohátka, ed., Béla Pécz, ed., András Berkó, ed., Oxford, New York, Pergamon Press, 2010, pp. 83-85.
24. Grega Klančnik, Miro Zdovc, Uroš Kovšca, Borut Praček, Janez Kovač, Janez Rozman, "Osseointegration and rejection of a titanium screw", *Mater. tehnol.*, vol. 44, no. 5, pp. 261-264, 2010.
25. Andraž Kocjan, Paul J. McGuiness, Aleksander Rečnik, Janez Kovač, Spomenka Kobe, "Effect of composition on the i-phase cell parameter of Ti-(Zr,Cu)-Ni alloys", *J. non-cryst. solids*, vol. 356, issue 50-51, pp. 2769-2773, 2010.
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27. Pavel Lejček, Janez Kovač, Jaroslava Vaníčková, Jirí Děd, Zoran Samardžija, Anton Zalar, "Copper surface enrichment of Ag-Cu alloys", In: *Proceedings of the ECASIA'09, 13th European Conference on Applications of Surface and Interface Analysis, October 18-23, 2009, Antalya, Turkey*, (Surface and interface analysis, vol. 42, no. 6/7), London, Philadelphia, Heyden & Son, 2010, pp. 662-665.

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29. Oleg B. Malyshev, Bojan Zajec, A. Haase, L. Westerberg, M. Leandersson, M. Bender, A. Krämer, H. Kollmus, H. Reich-Sprenger, "Ar beam induced desorption from different materials at TSL", *Vacuum*, vol. 85, no. 2, pp. 338-343, 2010.
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31. Dušan Milivojević, Branka Babić-Stojić, Janez Kovač, "Surface of Zn-Mn-O and its role in room temperature ferromagnetism: an XPS analysis", *Appl. surf. sci.*, vol. 257, no. 3, pp. 937-943, 2010.
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36. Kostya Ostrikov, Igor Levchenko, Uroš Cvelbar, Mahendra K. Sunkara, Miran Mozetič, "From nucleation to nanowires: a single-step process in reactive plasmas", *Nanoscale (Print)*, vol. 2, no. 10, pp. 2012-2027, 2010.
37. Suzana Petrović, Biljana Gaković, Dalibor Peruško, Bojan Radak, Tara Desai, Janez Kovač, Peter Panjan, Milan Trtica, "Composition and structure modification of aWTi/Si system by short laser pulses", *Appl. phys., A, Mater. sci. process. (Print)*, vol. 98, no. 4, pp. 843-847, 2010.
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41. Alenka Vesel, "Modification of polystyrene with a highly reactive cold oxygen plasma", *Surf. coat. technol.*, vol. 205, no. 2, pp. 490-497, 2010.
42. Alenka Vesel, Aleksander Drenik, Miran Mozetič, Marianne Balat-Pichelin, "Hydrogen atom density in a solar plasma reactor", *Vacuum*, vol. 84, no. 7, pp. 969-974, 2010.
43. Alenka Vesel, Aleksander Drenik, Rok Zaplotnik, Miran Mozetič, Marianne Balat-Pichelin, "Reduction of thin oxide films on tungsten substrate with highly reactive cold hydrogen plasma", In: *Proceedings of the ECASIA'09, 13th European Conference on Applications of Surface and Interface Analysis, October 18-23, 2009, Antalya, Turkey*, (Surface and interface analysis, vol. 42, no. 6/7), London, Philadelphia, Heyden & Son, 2010, pp. 1168-1171.
44. Alenka Vesel, Miran Mozetič, "On the functionaliation of polypropylene with CF_4 plasma created in capacitively coupled RF discharge", *Inf. MIDEM*, vol. 40, no. 1, pp. 67-73, 2010.
45. Alenka Vesel, Miran Mozetič, Peter Panjan, Nina Hauptman, Marta Klanjšek Gunde, Marianne Balat-Pichelin, "Etching of carbon-tungsten composite with oxygen plasma", *Surf. coat. technol.*, vol. 204, no. 9/10, pp. 1503-1508, 2010.
46. Alenka Vesel, Miran Mozetič, Simona Strnad, Karin Stana-Kleinschek, Nina Hauptman, Zdenka Peršin, "Plasma modification of viscose textile", In: *Proceedings of the 12th Joint Vacuum Conference, 10th European Vacuum Conference and 7th Annual Meeting of the German Vacuum Society (JVC-12/EVC-10/AMDVG-7), Balatonalmadi, Hungary, 22 - 26 September 2008*, (Vacuum, vol. 84, no. 1), Sándor Bohátka, ed., Béla Pécz, ed., András Berkó, ed., Oxford, New York, Pergamon Press, 2010, pp. 79-82.
47. Danijela Vujošević, Boban Mugoša, Uroš Cvelbar, Miran Mozetič, Urška Repnik, Tina Zavašnik-Bergant, Danijela Rajković, Sanja Medenica, "Bactericidal effects of low-temperature oxygen plasma on Bacillus stearothermophilus and Staphylococcus aureus", *Nat. Monten.*, vol. 10, no. 1, pp. 57-70, 2010.
48. Rok Zaplotnik, Alenka Vesel, Miran Mozetič, "Razelektritveni parametri pri prehodu iz E- v H-način v kisikovi plazmi", *Vakuumist*, vol. 30, no. 4, pp. 4-8, 2010.
49. Kristina Žužek Rožman, Janez Kovač, Paul J. McGuiness, Zoran Samardžija, Boštjan Markoli, Spomenka Kobe, "Microstructural, compositional and magnetic characterization of electrodeposited and annealed Co-Pt-based thin films", *Thin solid films*, vol. 518, no. 6, pp. 1751-1755, 2010.

Review Articles and Chapters in Books

1. Martin Bizjak, Nikola Jelić, Vincenc Nemanič, Robert Rozman, Bojan Zajec, "Fizikalni pojavi pri vžigu in ugasnitvi razelektritve v plinskem odvodniku", In: *Plinski odvodnik za zaščito pred prenapetostjo pri udarih strele*, Martin Bizjak, Franc Brecelj, Nikola Jelić, Vincenc Nemanič, Andrej Pirih, Andrej Pregelj, Robert Rozman, Aleš Štagoj, Bojan Zajec, Martin Bizjak, ed., Ljubljana, Zavod Tehnološki center SEMTO, 2010, pp. 45-92.
2. Matjaž Finšgar, Janez Kovač, Ingrid Milošev, "Študij mehanizmov vezave molekul BTAH in BTAOH na baker z rentgensko fotoelektronsko spektroskopijo - XPS", *Vakuumist*, vol. 30, no. 3, pp. 4-11, 2010.
3. Miran Mozetič, "Surface modification of materials using an extremely non-equilibrium oxygen plasma", *Mater. tehnol.*, vol. 44, no. 4, pp. 165-171, 2010.

Published Conference Papers

Invited Paper

1. Ita Junkar, Uroš Cvelbar, Miran Mozetič, Barbara Šetina, Marjan Krašna, Dragoslav Domanovič, Marián Lehocký, "Improvement of polyethylene terephthalate biocompatibility through plasma treatment techniques", In: *Proceedings*, The 7th International Conference on Mechanics of Time-Dependent Materials, September 5-11, 2010, Portorož, Slovenia, Igor Emri, ed., 1st ed., Ljubljana, Center for Experimental Mechanics, Faculty of Mechanical Engineering, 2010, pp. 53-54.

Regular papers

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DEPARTMENT OF SOLID STATE PHYSICS F-5

Our research program is focused on the study of the structure and dynamics of disordered and partially ordered condensed matter at the atomic and molecular levels, with a special emphasis on phase transitions. The purpose of these investigations is to discover the basic laws of physics governing the behavior of these systems, which represent the link between perfectly ordered crystals, on one hand, and amorphous matter, soft condensed matter and living systems, on the other. Such knowledge provides the key to our understanding of the macroscopic properties of these systems and is an important condition for the discovery and development of new, multifunctional materials, nanomaterials and biomaterials for new applications. An important part of the research program is devoted to the development of new experimental methods and techniques in the field of magnetic resonance, magnetic resonance imaging, fluorescence microspectroscopy, scanning tunneling, electronic and atomic force microscopy, as well as dielectric relaxation spectroscopy and dynamic specific-heat measurements.

Head:
Prof. Igor Muševič

The experimental techniques used are:
- One (1D) and two (2D) dimensional nuclear magnetic resonance (NMR) and relaxation, as well as quadrupole (NQR) resonance and relaxation
- Multi-frequency NMR in superconducting magnets of 2T, 6T and 9T, as well as the dispersion of the spin–lattice relaxation time T_1 via field cycling
- Nuclear double resonance and quadrupole double resonance such as ^{17}O–H and ^{14}N-H
- Fast field cycling NMR relaxometry
- Frequency dependent electron paramagnetic resonance (EPR) and 1D and 2D pulsed EPR and relaxation
- MR imaging and micro-imaging
- Measurement of the electronic transport properties
- Magnetic measurements.
- Fluorescence microscopy and microspectroscopy
- Linear and non-linear dielectric spectroscopy in the range 10^{-2} Hz to 10^{9} Hz
- Electron microscopy and scanning tunneling microscopy
- Atomic force microscopy and force spectroscopy
- Dynamic specific-heat measurements.

The research program of the Department of Solid State Physics at the "Jožef Stefan Institute" is performed in close collaboration with the Department of Physics at the Faculty of Mathematics and Physics of the University of Ljubljana, the Institute of Mathematics, Physics and Mechanics and the J. Stefan International Postgraduate School. In 2010, the research was performed within three research programs:
- Magnetic resonance and dielectric spectroscopy of smart new materials
- Physics of Soft Matter, Surfaces and Nanostructures
- Experimental Biophysics of Complex Systems

I. Research programme "Magnetic resonance and dielectric spectroscopy of smart new materials"

The research of the program group **Magnetic Resonance and Dielectric Spectroscopy of Smart New Materials** has focused on a study of the structure and dynamics of disordered and partially ordered condensed matter at the atomic and molecular levels with a special emphasis on phase transitions. The purpose of the investigations was to discover the basic laws of physics governing the behavior of these systems, which represent a link between perfectly ordered crystals, on the one hand, and amorphous matter, soft condensed matter and living systems, on the other. This knowledge provides a key to the understanding of the macroscopic properties of these

The group has investigated important open issues in the physics of unconventional superconductivity in strongly correlated electron systems, the physics of magnetically frustrated systems and transport phenomena in the heavy-fermion conductors. The group has also discovered novel multiferroic-, relaxor- and liquid-crystalline materials and developed optimized techniques for the detection of explosives, drugs and pharmaceutical substances by magnetic resonance methods.

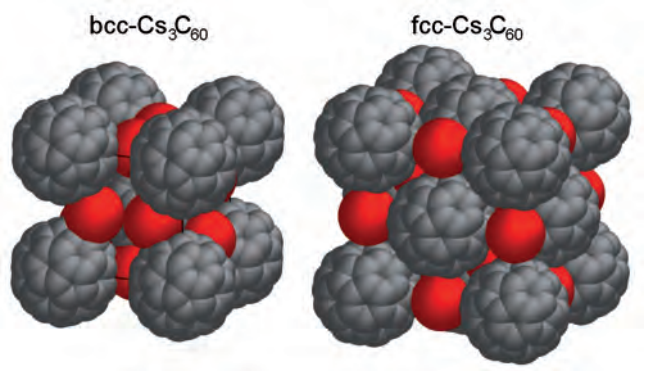

Figure 1: Comparison of Cs_3C_{60} structures for (a) face centered cubic (fcc) and (b) body centered cubic (bcc) polymorphs.

systems and is an important condition for the discovery and development of new multifunctional materials and nanomaterials for new applications. In our research, we used the following experimental techniques:

- Nuclear magnetic resonance (NMR), electron paramagnetic resonance (EPR) and nuclear quadrupole resonance (NQR),
- Nuclear double resonance ^{17}O–H and ^{14}N-H,
- Fast field cycling NMR relaxometry,
- Linear and non-linear dielectric spectroscopy in the range 10^{-2} Hz to 10^{9} Hz,
- Frequency-dependent ac calorimetry,
- Measurement of the electronic transport coefficients,
- Magnetic measurements.

In 2010, investigations were focussed on the following research fields:

Superconductivity in strongly correlated electron systems

On July 8th 2010 we published in the journal *Nature* 466: 221-225 (2010) an article entitled "Polymorphism control of superconductivity and magnetism in Cs_3C_{60} close to Mott transition" by P. Jeglič, D. Arčon, A. Potočnik et al. With the help of nuclear magnetic resonance experiments we demonstrated that both known Cs_3C_{60} polymorphs have an insulating ground state under ambient pressure conditions. However, both magnetic ground states are strikingly different. The body-centered cubic lattice (bcc) orders antiferromagnetically below 46 K. On the other hand, the face-centered cubic lattice (fcc) only shows signs of short-range magnetic ordering. The key factor in magnetic ordering suppression in the fcc lattice is the magnetic frustration that is present in the fcc lattice only. Despite that it seems that the superconductivity, which emerges under high-pressure conditions, has the same basis. Namely, just like in the bcc Cs_3C_{60} structure, where the superconducting critical temperature increases with increasing pressure and reaches a maximum at T_C = 38 K at around 8 kbar, also in the fcc structure superconductivity emerges only for pressures exceeding a critical pressure of 2.2 kbar and then reaches a maximum at T_C = 35 K at 7 kbar. We showed that both critical temperatures follow the universal parameter that depends on the electron correlation energy.

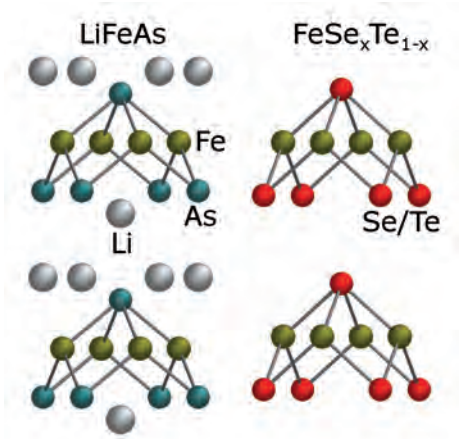

Figure 2: Comparison of LiFeAs (left) and $FeSe_xTe_{1-x}$ (right) structures.

In an article published in the journal *Physical Review Letters* (A. Omerzu, D. Arčon et al., *Phys. Rev. Lett.* **104**, 156804 (2010) we used different spectroscopic techniques on the first example of a chemically electron-doped metal- DNA complex. The doped unpaired electrons occupy the lowest unoccupied molecular orbital levels of the nucleobases, as detected with electron spin resonance and x-ray absorption near edge structure measurements. Delocalization and strong correlations between the unpaired electrons are evident from a temperature-independent spin susceptibility and a microwave conductivity above 100 K.

Superconductivity in iron pnictides. Superconductivity in iron-pnictides has attracted a great deal of attention in the research community ever since its discovery in 2008. Our group also joined these activities from the beginning and in 2010 we focused on the simplest pnictide structures shown in Fig. 2. In particular we were interested in the LiFeAs and $FeSe_xTe_{1-x}$ compounds. In the first case we presented a detailed study of ^{75}As nuclear magnetic resonance Knight shift and spin-lattice relaxation rate in the normal state of stoichiometric polycrystalline LiFeAs. Our analysis of the Korringa relation suggested that LiFeAs exhibits strong antiferromagnetic fluctuations, if transferred hyperfine coupling is the dominant interaction between the ^{75}As nuclei and the Fe electronic spins, whereas for an on-site hyperfine coupling scenario, these are weaker, but one still present to account for our experimental observations. We continue to work on these structures by extending the research also to NaFeAs. Extremely intriguing results emerged on $FeSe_xTe_{1-x}$, where combined electron paramagnetic and nuclear magnetic resonance data provided indications for the coexistence of intrinsic localized and itinerant electronic states.

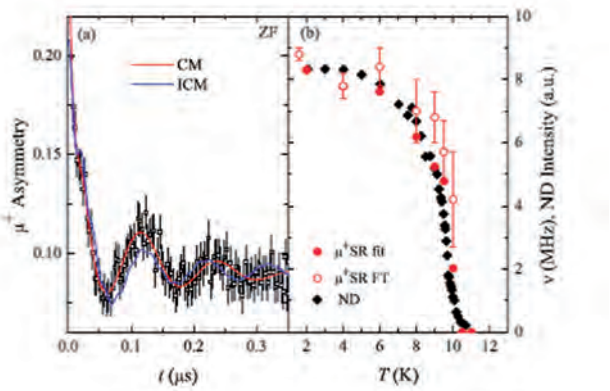

Figure 3: (a) Comparison of incommensurate model and multicomponent commensurate model with recorded ZF muon relaxation at 2 K. (b) Temperature dependence of μ+ spin precession frequency obtained from ZF relaxation fits (solid circles) and FT (open circles), compared to the intensity of magnetic peaks measured by neutron diffraction (diamonds).

Strongly frustrated magnetic systems. We continued to work on a two-dimensional strongly frustrated magnetoelectric system $FeTe_2O_5Br$ (M. Pregelj, O. Zaharko, A. Zorko, Z. Kutnjak, P. Jeglic, P. J. Brown, M. Jagodic, Z.

Jaglicic, H. Berger, D. Arcon. Phys. Rev. Lett. 103, 147202 (2009)) and we now managed to determine a complete phase diagram. Using numerous experimental techniques we showed that this system develops a very complex phase diagram as a function of temperature and magnetic field. First, we used the muon spin relaxation technique to determine the temperature dependence of the magnetic order parameter (Fig. 3). Next, the low-temperature magnetic phase diagram down to 300 mK and up to 9 T was presented in our extensive work where we discovered the existence of additional incommensurate phase that is not also ferroelectric. We also proposed a theoretical model to describe this phase diagram.

Heavy fermions. We developed an analytical model of the temperature-dependent electrical resistivity $\rho(T)$ and the thermoelectric power $S(T)$ of heavy-fermion systems that reproduces the maximum in $\rho(T)$ and the minimum in $S(T)$. The model is based on the quantum transport theory of slow charge carriers, where the velocity of heavy electrons is low due to their large effective mass m^*. The theory is applied to the experimental $\rho(T)$ and $S(T)$ data of the recently discovered heavy-fermion system $YbCu_{4.25}$, belonging to the class of giant-unit-cell complex metallic alloys.

Spin ladders. M. Klanjšek with colleagues from the international collaboration group (IJS, LNCMI Grenoble, Dresden High Magnetic Field Laboratory etc.) have studied $CuBr_4(C_5H_{12}N)_2$ by means of high-resolution multifrequency electron spin resonance (ESR). Magnetic Cu^{2+} atoms in $CuBr_4(C_5H_{12}N)_2$ are coupled into spin-1/2 dimers, which are stacked along one of the crystal axes to form parallel ladders. The magnon Bose-Einstein condensation (BEC) formalism is a powerful way to describe the low-temperature field-induced magnetic order in spin-1/2 dimer systems. However, in order for this formalism to apply a spin Hamiltonian of the system should be isotropic. A presented ESR study completes the full determination of the spin Hamiltonian and reveals the presence of a small but sizeable exchange anisotropy, which should be taken into account in a possible BEC description.

Ground state of the frustrated kagomé lattice. Members of the Langasite family, $RE_3Ga_5SiO_{14}$ (RE – rare earth), represent the first realization of the kagomé spin lattice in the limit of classical spins, based on large rare-earth moments. Due to the strong geometrical frustration of this lattice, unusual ground states have been theoretically predicted. A. Zorko and his collaborators from the Laboratoire de Physique des Solides, Université Paris - Sud 11 have been investigating this issue via local-probe techniques, including nuclear magnetic resonance and muon spin relaxation. They have shown that for Kramers ions (Nd^{3+}) a ground state with spin-liquid characteristics occurs. This state is highly susceptible to moderate magnetic fields, which drastically suppress the magnetic fluctuations. In contrast, for non-Kramers ions (Pr^{3+}), they showed that the ground state is a non-magnetic crystal-field singlet with anomalously enhanced nuclear magnetism. Their findings were published in two Physical Review Letters papers, the latest in A. Zorko et al., *Phys. Rev. Lett.* **104**, 057202 (2010).

Magnetic structures of fluoride magnetoelectrics. The majority of known oxide magnetoelectrics and multiferroics are not very well suited for practical applications, as the polarization-magnetization coupling is weak. This is the result of the fact that the requirements for ferroelectricity and ferromagnetism in one-component oxide systems are mutually exclusive. In view of this we started to investigate other multiferroic families where these restrictions do not apply. With the help of electron spin resonance and muon spin rotation we determined the magnetic structure of $K_3Fe_5F_{15}$, $K_3Cr_2Fe_3F_{15}$ and $K_3Cu_3Fe_2F_{15}$. We also determined the transition temperatures, the internal magnetic fields and other magnetic fields as well as the electronic configurations of the iron ions. This shows that fluoride multiferroics could be useful for memory elements and in spintronics.

Surface-induced breaking of macrospocic symmetry in nanowires. Our investigations have shown that paraelectric insulating crystals may become ferroelectric if the radius of the corresponding nanoparticles is small enough. This is the result of a surface symmetry that is lower than the bulk symmetry and which becomes dominant over the bulk symmetry for small enough particles. An example of that is ferroelectricity in BaO as well as $SrTiO_3$ nanoparticles below a critical size. We have also shown that diamagnetic nanoparticles may become ferromagnetic or antiferromagnetic as a result of the interaction between surface defects, impurities or vacancies. An example of this are small enough TiO_2 nanoparticles.

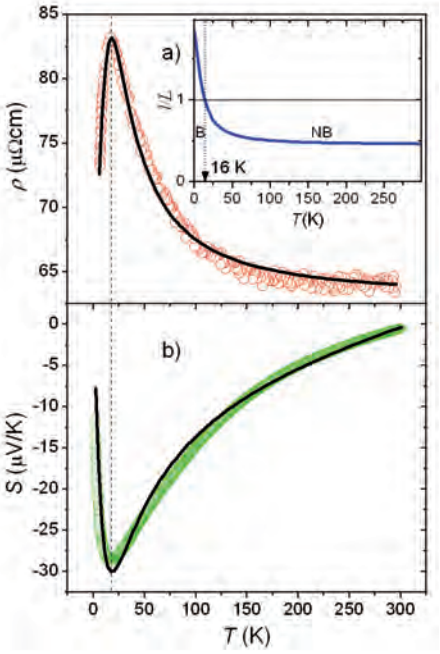

Figure 4: (a) Temperature-dependent electrical resistivity of $YbCu_{4.25}$. Solid curve is the theoretical fit. The inset shows the temperature-dependent normalized mean free path, where "B" denotes the Boltzmann and "NB" the non-Boltzmann conductivity regimes. The crossover between the two regimes occurs at T = 16 K (indicated by a dashed arrow). (b) Temperature-dependent thermoelectric power. Solid curve is the fit. The vertical dashed line at T = 16 K indicates that the maximum and the minimum occur at the same temperature.

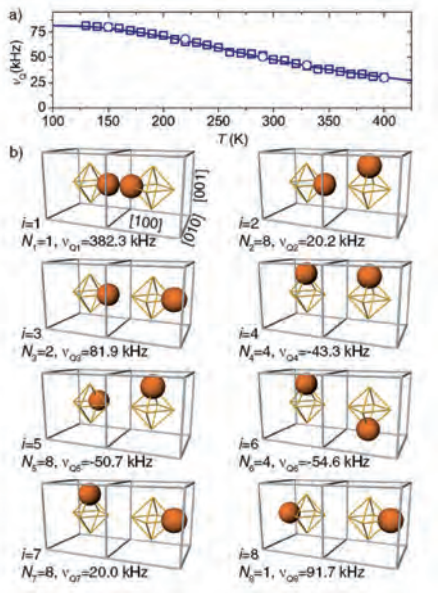

Figure 5: (a) Temperature dependence of the ^7Li quadrupole frequency in KTL x=0.01 (circles) and x=0.04 (squares). The solid line is the theoretical fit obtained with the values of the quadrupole frequencies listed in panel b. (b) Basic Li-Li pair configurations along the [100] crystallographic axis. Also stated is the number of possible states in a multiplet (N_i) and the effective quadrupole frequency (ν_{Qi}).

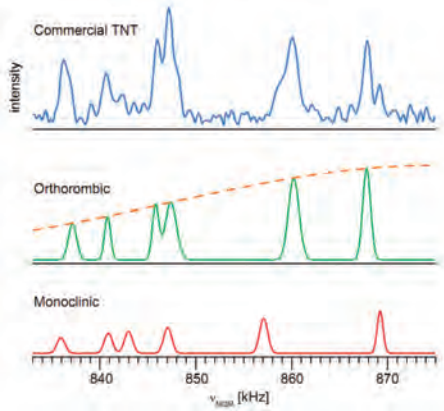

Figure 6: The ^{14}N NQR spectrum is composed of orthorhombic and monoclinic phases. To reduce the detection time, we are developing a multiple-echo acquisition technique, which takes into account the effects of off-resonance effects on the intensity of individual lines.

Phase diagram of UV-controlled binary-confined liquid crystals. We have investigated the binary phase diagram of azobenzene-based liquid crystals in a cylindrical confinement geometry using quadrupole perturbed deuteron NMR. By comparing theoretically predicted and experimentally determined phase boundaries separating the isotropic and nematic phase, we demonstrated the existence of linear isonematic lines in the temperature-concentration phase diagram.

Proof of the existence of correlated Li-Li dipoles in the paraelectric phase of weakly substitutionally disordered KTL. Breaking of the average cubic symmetry was detected via the quadrupole-perturbed NMR of ^{7}Li nuclei in a perovskite system KTL, at temperatures 150 K-400 K, high above the nominal glass-transition temperature at about 50 K (Figure 5). The splitting of the satellite transitions, the presence of which signifies the broken symmetry, strongly depends on temperature. This is consistent with a conjecture of energetically inequivalent Li-Li pair configurations. A comparison of the results of point-charge and LDA theoretical models and the temperature dependences of the satellite splitting provides for a determination of the preferential Li-Li configurations. B. Zalar, A. Lebar, D. C. Ailion, R. O. Kuzian, I. V. Kondakova, and V. V. Laguta, *^{7}Li NMR investigation of Li-Li pair ordering in the paraelectric phase of weakly substitutionally disordered $K_{(1-x)}Li_xTaO_3$, Phys. Rev. Lett.* **105**, 226402 (2010).

Optimization of the ^{14}N NQR method for the detection of explosives. We are solving the problem of the detection of explosives, hidden either in buried landmines or concealed in passenger baggage, by developing a 14N nuclear quadrupole resonance (NQR) based detector of solid explosives. The technique is based on the detection of transitions between split levels of nitrogen nuclei in the field of the surrounding electrons. The set of these transitions represents a unique "fingerprint" of every nitrogen-based solid material. The technique is good at sensing plastic explosives (C5, RDX), but is unfortunately less sensitive to the most common explosive TNT. We are solving these problems by the detection of multiple "spin-echo signals" and taking into account the theoretically predicted off-resonance effects.

Molecular dynamics in twisted grain-boundary liquid crystalline phases. Liquid crystal HZL 7/* has a very rich phase diagram. We used fast-field cycling relaxometry to investigate the molecular dynamics in the isotropic, chiral nematic, TGBA* and two TGBC* phases. The analysis of the spin-lattice relaxation rate dispersions in the frequency range from 5 kHz to 300 MHz we were able to determine the contributions from different molecular motions: Rotations/Reorientations (R), Translational Self-Diffusion (SD), Rotations Mediated by Translational Displacements along the Helical Axis (RMTD), Order Director Fluctuations (ODF) and Layer Undulations (LU).

Capacitor as a detector of nuclear magnetization. The basic element for the detection of nuclear magnetic resonance (NMR) is a coil. Its role is to transform the precession of nuclear magnetization into voltage, which is then amplified and finally digitized. The coil is used since the very first NMR experiments due to its versatility and simple use, but unfortunately it is not ideal. So far, there are few cases where alternative technologies are more sensitive, and one of them is being also developed at the IJS: the NMR capacitor-based detection of thin samples. Due to their geometry, thin samples are a notorious problem for coil based detection, whereas a capacitor is built simply by sandwiching the sample between two conducting plates. The physical processes taking place during excitation and detection are shown in the figure. We have verified experimentally the technique with nuclear quadrupole resonance on a sample of a few centimetres in size but with a thickness of only a few hundred micrometers.

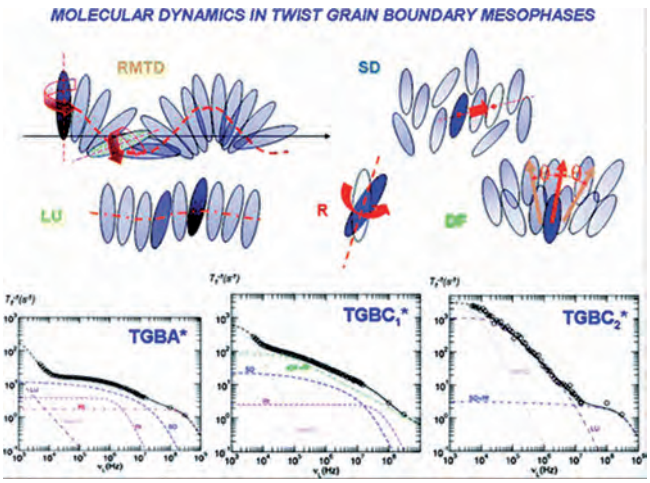

Figure 7: Schematic representation of the main molecular motions, detectable by fast-field cycling NMR relaxometry. The lower part of the figures shows the dispersions of the proton spin-lattice relaxation rate in various mesophases, and the contributions of various types of molecular motions.

Development of new double-resonance methods. We developed a new three-frequency double-resonance method for the measurement of the dipolar structure of the 17O NQR lines. The new method is more sensitive than the two-frequency method, which is usually used for this purpose. In particular the edges of the NQR lines are better resolved by the new method, which allows a more precise determination of the O-H distance.

Study of phase transitions in organic ferroelectrics and pharmaceutical substances. In the organic ferroelectric $(H_2\text{-TPPZ})(Hca)_2$ we studied

the position and dynamics of protons in the N-H...N hydrogen bonds in the ferroelectric and paraelectric phase using 14N NQR. The measurements show that in the paraelectric phase a simultaneous jump of two protons in a H_2-TPPZ^{2+} ion changes the type of the two hydrogen bonds. These two-proton jumps freeze in the ferroelectric phase. Combining the ^{14}N NQR measurements and DFT calculations we studied crystal polymorphism and hydrogen bonding in selected thiadiazoles, benzimidazoles and piroxicam.

Proton position and proton transfer in hydrogen bonds. ^{14}N NQR has been used for the study of very short N...H-O hydrogen bonds in molecular complex isonicotinamide-oxalic acid (2:1) in two polymorphic phases. The principal values of the quadrupole coupling tensor in the studied compound deviate from the correlation dependence found for the hydrogen-bonded pyridine nitrogen even in case of the proton transfer. The deviation is found to be the result of an excess electric charge on the nitrogen atom.

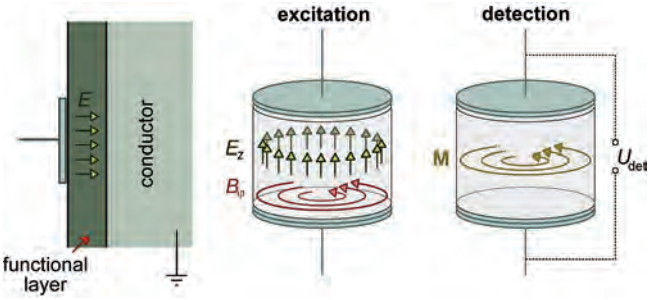

Figure 8: (left) A proposed application for the observation of protecting surfaces on metallic objects. (middle) The geometry of the magnetic field during excitation. (right) The geometry of the magnetization during detection and the associated induced voltage.

Study of nanostructural materials and materials with large electrocaloric and thermomechanical effect. By utilizing a high-resolution calorimeter we show via direct measurements the existence of the large electrocaloric effect in perovskite and polymeric ferroelectric materials (Figure 9). We show that the nature of the thermomechanical response in the main-chain liquid-crystal elastomers can be controlled by the crosslinking temperature. We successfully stabilized the liquid-crystal third blue phase in a broad temperature range exceeding 20 K by adding the CdSe nanoparticles with a functionalized surface. The studies have been published in 14 articles in international scientific journals.

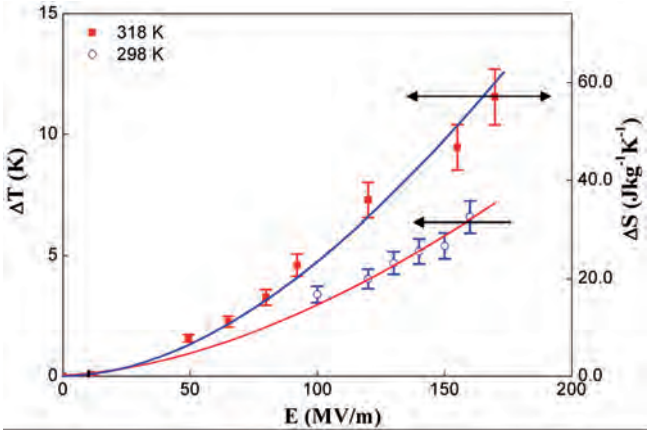

Figure 9: Electric-field dependence of the electrocaloric temperature change at two different temperatures.

High-temperature dielectric investigations of inorganic relaxor systems. High-temperature dielectric investigations of classical inorganic relaxors, PMN single crystal, PMN-PT ceramics, and PLZT ceramics revealed astonishing results – they contradict the widely accepted beliefs on relaxor properties. The results clearly reveal that polar nanoregions do not form at the so-called Burns temperature (approx. 600 K), but are continuously formed in a broad temperature range, starting well above 800 K. Furthermore, a detailed analysis of the intrinsic dielectric response revealed that relaxors adopt critical behaviour associated with the universality classes typically found in 3D spin glasses, while the mean-field results can be rejected on a high confidence level.

Investigations of a new type of relaxor polymer system. In collaboration with researchers from Nanjing University, China, investigations of a new type of relaxor polymer system have started – these systems are, due to their giant electromechanical response, very promising for various applications. Dielectric investigations of the reduced P(VDF-TrFE) copolymer have revealed that two similar types of dynamics coexist in the system – the glassy transition in the amorphous matrix and relaxor behaviour in the crystalline parts, the latter being almost identical to the behaviour detected in classical inorganic relaxors.

Ordering of polarons in $Pr_{0.5}Ca_{0.5}MnO_3$. We reported a detailed dielectric investigation of $Pr_{1-x}Ca_xMnO_3$ (PCMO, x = 0.5) ceramics, a member of the perovskites manganite family that exhibits a colossal magnetoresistance. Analysis of the ac electrical conductivity and dielectric constant data revealed that in the low-temperature phase, below 42 K, small polarons are responsible for the charge transport in the system. This provides a new understanding of the phase diagrams in PCMO systems.

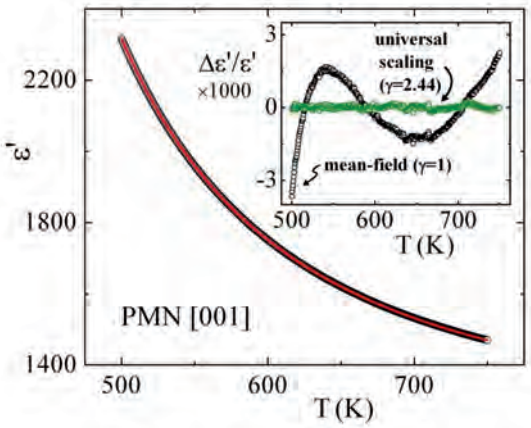

Figure 10: High-resolution, high-temperature dielectric investigations have revealed that relaxors adopt universal scaling behavior and that within the resolution of 10^{-4} no anomaly around 600 K exists which would indicate the sudden formation of polar nanoregions.

NMR in Biophysics. ^{1}H NMR spin-lattice and spin-spin relaxation times of isotropic solutions of n-octylammonium n-octadecanoate in deuterochlorform containing ca. 0.1 – 0.2 % tetramethylsilane (v/v) at ca.

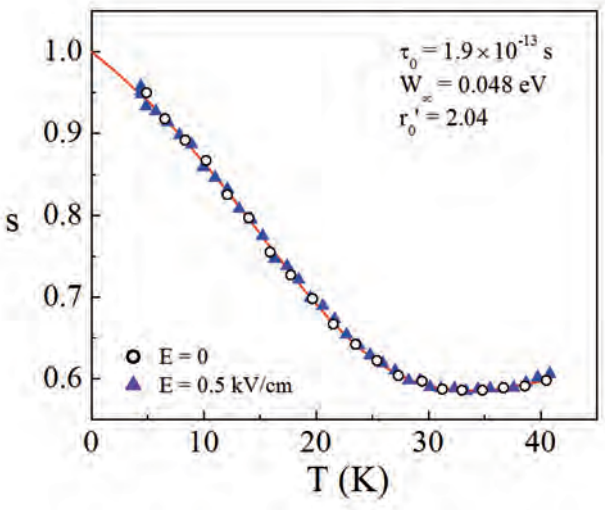

Figure 11: The temperature dependence of the UDR parameter s for $E_{dc} = 0$ in $E_{dc} = 0.5$ kV/cm in $Pr_{0.5}Ca_{0.5}MnO_3$. The solid line is a fit to a model for the small polaron tunnelling.

292 K are observed to vary with the position of the functional group in the amphiphile ion-pair, and with solute concentration. The latter dependence can be satisfactorily described using either single or multiple equilibria models of the association complex formation of the reverse micelle type above a critical concentration (ca. 0.13 mol/kg). Transverse relaxation is accounted for predominantly via the reorientation/rotational diffusion of monomers and micellar aggregates, and is analyzed in terms of two component times, while longitudinal relaxation principally involves motions of different size segments around covalent bonds. Picosecond correlation times are attributed to intramolecular and monomer rotations, whereas multimer reorientation/tumbling processes are an order of magnitude longer. Results are analyzed for the size of the reorienting species in terms of theoretical calculations for rotational diffusion of model cylindrical and elipsoidal volumes of revolution, which above the critical micelle concentration correspond to association complexes of 2–4 monomers. The dilution shifts of the proton NMR peak positions also comply with the model of reverse micelle formation.

Sodium nitroprusside (SNP) is a nitric oxide (*NO) donor "in vitro" and "in vivo". The time variation of the intracellular water proton nuclear magnetic resonance (NMR) effective relaxation time T'2a in SNP-treated human erythrocyte suspensions, containing a 10 mM membrane impermeable paramagnetic MnCl2, has been measured. The observed T'2a time-course was analyzed in terms of the two mechanisms by which the released *NO affects T'2a. These are, respectively, the enhancement of the intracellular water proton intrinsic NMR relaxation rate 1/T2a by the paramagnetism of the *NO subsequently bonded to the iron atoms of intracellular deoxyhemoglobin, and the suppression of the diffusional water permeability Pd as a consequence of the nitrosylation of aquaporin-1 (AQP1) channel Cys189, either by a direct reaction with *NO or with one of the *NO oxidation products, such as N_2O_3. The bound *NO on the Cys189 thiol residue appears to impose a less effective barrier to water permeation through the AQP1 than does the larger carboxyphenylmerucryl residue from the p-chloromercuribenzoate. The effect of *NO on Pd is discussed in terms of the NO-induced vasodilation.

Magnetoelectric materials. Last year we have paid the most interest to researching new magnetoelectric materials belonging to the fluoride family. We have been interested in the correlation between the electric and magnetic properties as well as the potential application of these new materials.

II. Research programme "Physics of Soft Matter, Surfaces and Nanostructures"

The investigations of the research program "Physics of Soft Matter, Surfaces and Nanostructures" are focused on novel complex soft matter systems and surfaces with specific functional properties. We investigated in particular liquid-crystalline elastomers and dendrimers as novel multifunctional materials, nematic colloids, molecular motors, soft-matter photonic crystals and novel synthetic or self-assembled micro- and nano-structures. The aim of the program is to understand the structural and dynamical properties of these systems, their interactions, their function at the molecular level, and self-assembly mechanisms in soft matter. The underlying idea is that it is possible to understand complex mechanisms, such as self-assembly, on a macroscopic level, using a simplified physical picture and models. In order to provide a comprehensive approach to the problem, the program combines both experimental and theoretical investigations, supported by modelling and simulations. Special emphasis is given to the possible electro-optic and medical applications.

The group members have invented the first 3D microlaser based on cholesteric liquid crystals. The microlaser emits monochromatic and coherent light in all directions. The news on the invention was released in a special press release by the Optical Society of America on December 8, 2010, that had a readership of more than 30 million on internet forums, blogs, magazines and newspapers.

Soft Matter Photonics. In recent years, there has been intense development of new photonic crystal structures and laser sources based on them. Especially interesting are the 3D structures that strongly confine light in all three dimensions. However, they are usually difficult to manufacture using standard lithographic methods. Therefore, we used the soft-matter approach that is based on self-assembly to produce such structures. By mixing a dye-doped cholesteric liquid crystal with a carrier fluid we were able to produce millions of cholesteric droplets in a matter of seconds. The droplets have an onion-shell structure that has a radial modulation of the refractive index and

can confine light in the center. By pumping a droplet with a pulsed source of light the droplet starts to emit laser light from its center. The emission is isotropic in all directions, like it would be emitted from a true point source of light. As such, this kind of light source is the first practical 3D microlaser. Furthermore, by changing the temperature we can tune the laser wavelength as much as 50 nm. The production of such laser sources is straightforward, cheap and scalable, so that they could be used in a number of applications such as displays, telecommunications, sensing and imaging. The invention was published in *Optics Express* **18**, 26995-27003 (2010) and received an outstanding promotion via the Press Release of the Optical Society of America on December 8, 2010, reaching in total an estimated number of 30 million readers.

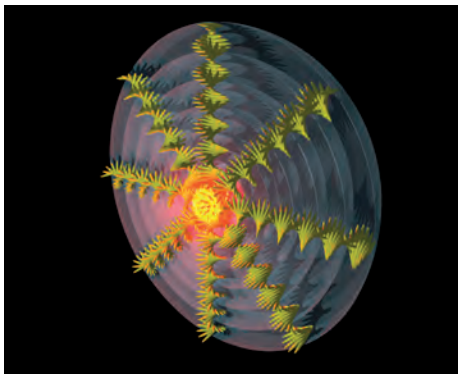

Figure 12: Liquid-crystalline microlaser. Artist's impression of the molecular organization inside a small microdroplet of a cholesteric liquid crystal in an isotropic fluid. Fluorescent molecules are added into the interior, providing light, whereas chiral organization of the cholesteric liquid provides a self-assembled onion-like microresonator.

Liquid-crystal colloids. The first 3D colloidal crystal in a nematic liquid crystal was built. It has been assembled from glass microspheres, which behave in the homogenous liquid crystal as topological dipoles. The optical properties of such a photonic crystal have been analyzed and the response on the external electric field has been measured. In addition, the interactions between spherical colloidal particles with normal and tangential surface director alignment in a nematic liquid crystal, which are inducing elastic quadrupoles of opposite signs, have been analyzed. We have shown that these colloids are attracted along or perpendicular to the nematic director, and we have used this property to build 2D colloidal crystals with square lattices. We have also studied the dynamical properties of colloidal structures, in particular we have studied light-driven oscillations of a chain of entangled colloidal particles in the nematic liquid crystal. The collective motion of the colloids is highly damped due to the high viscosity of the liquid crystal. The results were explained with an effective bead-spring model, where the motion of elastically coupled particles is hindered by viscous damping and hydrodynamic coupling. The topological properties of nano-colloids in the nematic have been also analyzed. We have found that even 100 nm colloids behave like topological dipoles accompanied by a clearly resolvable hyperbolic point defect and behave hydrodynamically as much bigger particles because of the elastic distortion around them. This has a surprising consequence that the pair-binding energy of the dipolar nanocolloids is as high as 700 k_BT for 125 nm colloids and is practically size-independent in the range from 125 nm to 500 nm.

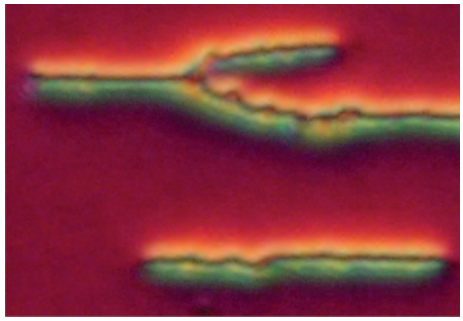

Figure 13: Self-assembled dipolar chains from 320 nm colloids.

Nematic and Chiral Nematic Defect and Colloidal Structures. Colloidal crystals formed by trapping particles in blue phase disclination networks are predicted by simulations. It has been shown that the interaction potential of a single, nano-sized colloidal particle with a -1/2 disclination line is very strong, and the disclination line represents a strong trap for nanoparticles within the cholesteric blue phases. The interaction potential is shown to be highly anisotropic and have threefold rotational symmetry. We discuss the equilibration of the colloidal texture with respect to particle positions and the unit-cell size of the blue phase.

By numerical calculations, we showed that a chiral liquid crystal confined in a thin cell can exhibit various exotic ordered structures not found in bulk liquid-crystalline systems (Fukuda and Zumer, *Phys. Rev. Lett.* **104**, 017801 (2010). Such structures include pairs of disclination lines with double-helix shape (figure), sets of parallel undulating disclination lines, and inchworm-like fragmented defects in contact with the confining surfaces. Within a two-dimensional Landau–de Gennes tensorial formalism, as well as using large-scale lattice Monte Carlo simulations, we have studied the equilibrium configurations of nematic shells, thin films of nematic liquid crystal deposited on the boundary of colloidal particles of arbitrary shape enforcing a degenerate tangential anchoring on the nematic molecules. In this formalism, defects appear wherever a scalar order parameter vanishes. Their total number is the colloidal valence, as this is the number of molecular bridges that can bind every colloid to its peers. We have shown how the defect organization on a colloidal particle is affected by the Gaussian curvature of the colloidal boundary, to the point of changing its valence.

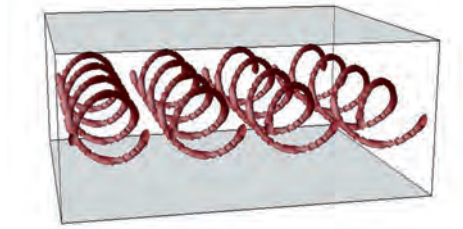

Figure 14: Visualization of topological defects in a "double-helix" configuration of a blue phase I confined to a thin layer. A 2 × 2 unit cells are shown (Fukuda & Žumer, Phys. rev. lett. 104, 2010).

Nanotubes and Nanoparticles. We determined the time evolution of the sulphurization of MoS_2 nanotubes. We have evidenced that the concentration of defects in MoS_2 nanotubes influences their optical and electrical properties. In collaboration with the Complex Matter Dept., JSI, we reported the synthesis of MoS_2 nanotubes with controlled sizes. We evidenced the metallic behaviour of the electrical conductivity of a single MoS_2 nanotube, 100 nm in diameter, although bulk MoS_2 is known to be a semiconductor. In cooperation with the Faculty for Mechanical

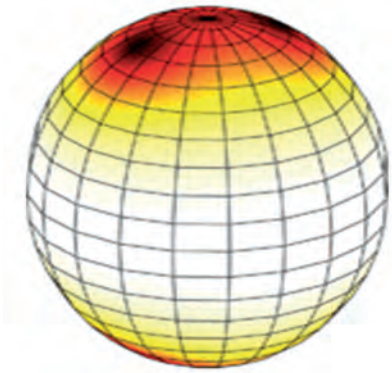

Figure 15: Nematic shell. Black spots correspons to defects in the nematic

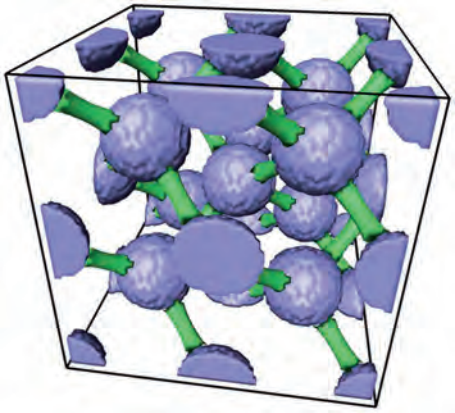

Figure 16: Three-dimensional blue phase colloidal crystal. Stable crystalline configuration based on a blue phase II defect network with two 150nm particles per body-centered cubic unit cell with a 350nm lattice constant. S. Žumer et al., SPIE NewsRoom, November 3, 2010.

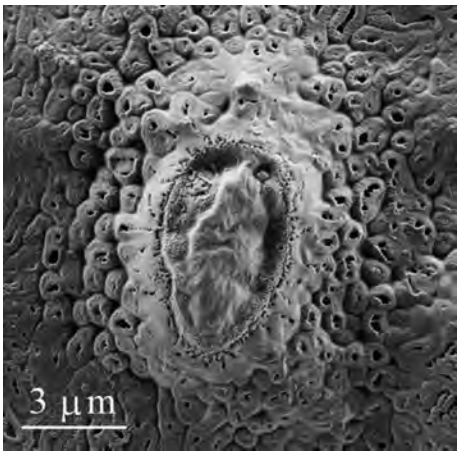

Figure 17: Nanoparticle from the ash erupted from volcano Eyjafjallajökull and brought by air flow to Krvavec in Slovenia It contained metal sulphides and fluorides, which at a presence of humidity caused its corrosion. The image was taken by scanning electron microscope at national Institute of Chemistry. Author: G. Kapun

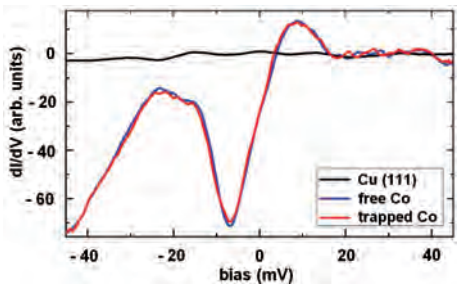

Figure 18: STS spectra at 7K, measured by positioning the STM tip above the Cu(111) surface and above a free and a pinned Co adatom.

Engineering, UL, and the company OLMA, we continued testing the lubrication properties of MoS_2 nanotubes as additives in oils, greases and cooling cutting fluids. We have made the first polymer composites containing MoS_2 coaxial nanotubes with improved mechanical properties of the polymers and for application as self-lubricating coatings. We continued with the synthesis of sub-stoichiometric tungsten oxides. The corresponding EU patent was granted. In the field of detecting nanoparticles in air, we have published a new method for counting nanoparticles and performed a simulation of the process in collaboration with the Faculty of Electrical Engineering, UL. A national patent application was upgraded by a PCT application. In the field of nanosafety, we continued our collaboration with the Ministry of Health and with The Institute for Public Health. At the Slovenian Days of Chemistry we reported together with the Dept. of Environmental Sciences, JSI, on the influence of traffic on the number of nanoparticles in air (measured in the area of the JSI). At the meeting Chemical Safety and at The 21st Fair of Furniture we gave talks on safety recommendations for work with nanomaterials. In collaboration with National Institute for Chemistry and the company Aerosol Ltd. we measured volcanic ash on Krvavec. The Beauty of Nanoworld we have shown in the Slovenian Parliament with an exhibition entitled "Nanoworlds of the Jožef Stefan Institute Illuminated by Light of Art".

Magnetic Adatoms on Conducting Surfaces & Sliding Charge Density Waves. We show that naturally occurring Ag impurities, embedded into a Cu (111) surface, act as pinning centres for deposited magnetic Co adatoms. Without being accompanied by electronic standing-wave patterns and with electronic structures and sizes very similar to those of the remaining surface Cu atoms, these defects are nevertheless clearly detected in the topographic STM images. The superb STM resolution enables a determination of the binding sites for single Co atoms and their pairs relative to the Ag defects. STS experiments show that the embedded Ag impurities do not affect the electron-exchange coupling of the Co adsorbate with the substrate and show no difference in the Kondo temperatures of the pinned and the free Co adatoms. The embedded Ag defects support atomic-scale nanostructuring of the Co adatoms with improved stability at higher temperatures, without significantly affecting their electronic and magnetic properties (E. Zupanič et al., *Phys. Rev. Lett.* **104**, 196102 (2010)).

Charge density wave modulation in low-dimensional systems and hydrogen storage. By reconsidering some recently published low-temperature STM images we confirmed our earlier assertions that the sliding of the charge density waves in $NbSe_3$ is a consequence of unstable layered nanodomains with two types of incommensurate. With ab-initio density functional theory calculations and with maximally localized Wannier functions we studied the stability of H atoms at different interstitial sites in different $ZrCr_2$ Laves phases and the structural and electronic properties of certain hydrated compounds based on the $ZrCr_2$ structure.

Molecular motors. In the field of molecular motors we have produced in collaboration with the F7 department and the Department of Physics the first working system of artificial cilia assembled from superparamagnetic particles. We have tested their performance against the predictions of theoretical calculations. The results were published in *Proc. Natl. Acad. Sci. USA* and have also been reported by *Nature Physics*. We continued with studying in more detail the flows and hydrodynamic coupling between cilia, as well as the ways how to optimize the efficiency of fluid pumping. In collaboration with a group from Dresden we studied the helical motion of microtubules driven by kinesin motors. We have shown that by measuring the rotational motion we can characterize the conformational changes that were not accessible with previous techniques.

Application of Liquid Crystals. EU Patent EP 1883854 has been granted to the Institute for its patent application on "variable LCD light filter". The Slovenian Patent office submitted this patent to the EU Patent Office as the Slovenian proposal for the yearly award of EU Patent Office. Technical solutions from this patent have been introduced in the regular production in the IJS spin-off company Balder. On the basis of the excellent performance International Standard Organization invited IJS and Balder to participate in the ISO expert group that has prepared a draft for the new world standard on Eye Protection.

III. Research programme "Experimental Biophysics of Complex Systems"

Within the program "**Experimental Biophysics of Complex Systems**" we explore the processes and structures of various complex systems (from model systems to the structures in living

cells, tissues and even small animals) including the effects of various bioactive molecules on these systems. One of the aims is the investigation of the structural properties of different membrane structures such as membrane domains, membrane proteins and glycosaccharide matrix as well as their interactions with other cell parts at different pathogenic states. These activities will improve our understanding of cell signalling and signal transduction in biomembranes, which in turn will enable a better insight into complex cell responses. We also started to explore the interaction between new materials and cells, especially from the point of view of bioactivity and biocompatibility. In addition, research is expanded to the field of **interactions between novel materials and cells**, especially from the bioactivity and biocompatibility points of view. We also focused on the optimization of medical treatment in tumour therapies, magnetic resonance imaging techniques and the mathematical modelling of thrombolysis, magnetic resonance microscopy for application in forestry and wood science, studies of constrained diffusion as well as food processing by magnetic resonance imaging. The recent developments of fluorescence microspectroscopy aim at resolving fluorescent spectra from very small volume elements of a sample. This would enable the characterization of the local molecular environment of fluorophore molecules. The latter will unravel localized information about the interaction between membrane domains of model and real cell membranes as well as bioactive molecules and new materials such as new medical materials and nanomaterials that more and more often enter our environment.

Figure 19. New model of the welding helmet, which enables a flow of the fresh air to the user.

Within the research of the structure of the biological systems we developed a new algorithm for **colour coding of the fluorescent microspectroscopy images**, where the colour components of the individual pixels reflect the properties of the fluorescent emission spectrum like maximum shift or intensity change originating from this particular volume element. With this approach we want to localize the nanomaterials inside the living cells, detect the reorganization of the biomembranes as well as characterize the time-dependent phenomena in membranes, like lipid domain restructuring in model and real membranes. In addition, we also optimized labelling and partitioning of fluorescent probes to increase the sensitivity to the local molecular environment. Fluorescent microspectroscopy has been applied to the structural research of the hydrogels as artificial tissue scaffolds, to the structural studies of the dentin channels in the teeth of various animal species to determine the connection between the tooth structure and the resistance to the environmental stress.

On the segment of the **development of double labels** (nitroxide group and fluoprophore in the same molecule) we made significant progress. In 2010 we designed amfiphilic structures which had in its lipophilic part nitroxide moiety (a doxyl group) and in its polar part (amino sugar) a fluoprophor of NBD type. We have already synthesized some compounds which bound into the upper half of the lipid bilayer with its lipophilic alkyl chain bearing a paramagnetic doxyl group, while the NBD group which is on the surface of the biological membrane and is far from doxyl group if it is bound to the cell membrane. The mentioned double label enables the localization of the spectroscopic information. Such a new molecular tool will enable a new, combined exploration of the same sample with fluorescence microspectroscopy and electron paramagnetic resonance spectroscopy at the same time.

Within the research of the membrane structure and the **interaction between** biologically active materials and cells we focused on an investigation of **cancerostatic alkylphospholid** (perifosine, OPP) and **antidepressant clomipramine (CLO)** with **model and real membranes** using EPR spectroscopy and a home-developed computer program for the simulation of the EPR spectra (EPRSIM). OPP belongs to a new class of anticancer agents, directly targeting the cell membrane but not the DNA. It shows a selective apoptotic response in tumour cells, sparing normal cells. In order to understand the interaction of OPP with cellular membranes and to find the optimal liposomal formulation for cancer therapy spin labelled OPP (SL-OPP) was synthesized and incorporated into the OPP liposomes with different concentrations of cholesterol. It was found that the transfer of OPP from liposomes to cells is a fast process (within the time of 1–5 min) and did not depend on the cholesterol concentration in liposomes, irrespective of the significantly different fluidity. Due to the amphiphilic character of the OPP and charge its transport into the cell is slow. With respect to the properties of SL-OPP we suppose that it could be used as a good alternative spin probe for cell membrane investigations by EPR (presented at the VIIIth international workshop on EPR in biology and medicine, Krakow, October 2010). The influence of the antidepresive drug CLO was investigated on liposomes of different composition and with different spin probes. CLO decreases the phase-transition temperature and decreases the ordering of liposome membranes. A computer simulation of the EPR spectra enabled us to detect a unique anomalous increase in the diffusion of the spin probe in the temperature region where the liposome membrane without cholesterol experiences the phase transitions from solid-ordered to liquid-disordered phase. Since the changes in the central part of the membrane were even more pronounced than in the upper part of the membrane, it could be concluded that CLO incorporates into the membrane with its hydrophobic ring parallel to the phospholipid chains. (J. Liposome Res.).

In collaboration with Veterinary Faculty of Ljubljana, a method for **trapping and detecting the very reactive nitric oxide** (NO radical) by EPR was developed. It was found that after oral infection with different bacteria NO

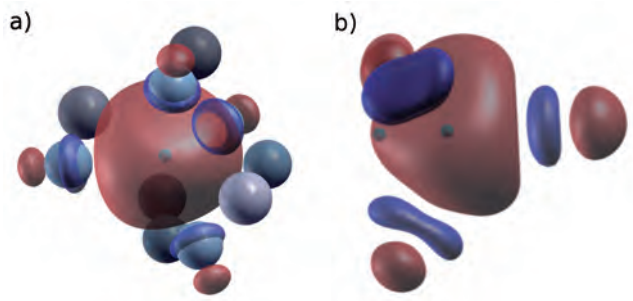

Figure 20: Maximally localized Wannier functions of $ZrCr_2$ with a) one H atom in the 4Cr coordination and b) two H atoms in neighboring 4Cr coordinations. Zr atoms are gray, Cr atoms are large and blue and H atoms are small and blue. Transparent red and blue surfaces represent positive and negative amplitude iso-surfaces.

radicals were formed in almost all organs. NO production was found to be inhibited by selective inhibitor of inducible nitric oxide synthase (iNOS), while by the non-selective iNOS inhibitor in some cases NO radical production can in some cases even be enhanced. (Arch. Oral Biol.)

One of the problems that we have studied in the framework of our activities in the research of structured membranes has been the influence of **ceramide accumulation during apoptosis on the structure and properties of membranes**. The accumulation occurs due to enzymatic conversion of sphingomyelin, a lipid with a high proportion in cell membranes, into ceramide. In the experiment the accumulation in model membranes has been simulated by increasing the proportion of ceramide with respect to sphingomyelin. The method of attenuated total reflection Fourier-transform infrared spectroscopy (ATR-FTIR) was used to study the influence of the addition of ceramide on the lipid ordering and on the intermolecular interactions between the lipids via hydrogen bonds. From the temperature dependence of the shapes of different absorption lines we could make conclusions on the phase properties of lipid mixtures as a function of the concentration of ceramide.

To improve **protein structure determination** based on the conformational space modelling of the protein side chains (CSM), we explore the conformational spaces (CS) with the methods of molecular dynamics (MD). On our computer cluster we ran the comparative study to determine the effect of lipids and the various physico-chemical properties of the spin-probe on the creation and anisotropy of the CS. MD was used to empirically calibrate the CSM, which appeared to be several orders of magnitude faster in protein structure determination than the MD methods.

Titanate nanomaterials generate short-lived free radicals in the processes of photocatalysis, thus preventing bacterial growth. We synthesised titanate nanomaterials, which have good adhesion properties due to their high specific surface area and a significant antimicrobial activity on the basis of the photocatalytic process. We determined the antimicrobial activity of titanate nanomaterials on bacteria of the genus Listeria in the laboratory as well as in real conditions in the meat-processing industry. On the basis of bioassays, we showed that titanate nanomaterials doped with small amounts of copper, that have the greatest effect on the inhibition of microbial growth and are suitable for a stable coating on the surface of polyethylene terephthalate (PET500), reduced the number of bacteria such as Listeria innocua by at least 90%, which is practically in accordance with the standards required for the effective disinfection (CFU reduction below 10^5). This could potentially provide continuous biosecurity in the production of raw meat, to ensure consumer safety and the possibility to reduce the environmental impact of chemicals, since this form of disinfection does not leach chemicals into the environment. We also showed that the most effective titanate nanomaterials with a very small addition of copper exhibit photocatalytic properties even when exposed to ordinary fluorescent lamps.

Thrombolysis as biochemo-mechanical process. We confirmed our assumption that thrombolysis is not just a biochemical process in which there is a complete degradation of fibrin, but under the influence of rapid blood flow it leads to the formation of strong mechanical forces to the surface of a blood clot that result from blood viscosity. These forces cause the breakage of large parts of the clot formed by the fibrin network and blood cells (primarily erythrocytes). These torn pieces may range in size from individual cells, to clusters of several hundred cells. With optical microscopy experiments, we also showed that the size of these clusters largely depends on the blood flow. In a slow stream of blood only small clusters were formed, while at a higher speed significantly larger pieces of the clot were torn. These results also explain why the thrombolysis is much faster in a faster flow than in a slow flow. The promotion of thrombolysis in the rapid blood flow is greater than expected due to the better permeation of the clot with the thrombolytic agent and significantly larger forces of the streaming blood to the surface of the clot. Based on the results of this study a computer simulation of the microscopic processes of thrombolysis was developed. Its results are in a good agreement with our measurements.

MRI study of the dynamics of food freezing. Using MRI, we monitored the freezing dynamics of different types of vegetables and showed the differences between rapid and slow freezing. We have shown that MR imaging is an efficient tool for monitoring the freezing process, because it can very clearly distinguish between fresh and frozen food areas. MRI also reflects the differences in NMR relaxation times and the diffusion characteristics of food before and after freezing.

Controlled drug-delivery systems are widely used in the pharmaceutical industry because of their numerous advantages. For hydrophilic polymers, it is generally accepted that, once in contact with body fluids, they hydrate and swell, forming a gel layer that regulates the penetration of body fluids into the tablet and the dissolution of the incorporated drug. Therefore, a knowledge of the gel-layer characteristics is of crucial importance for the use of controlled drug-delivery systems. A Combination of different MRI methods enables an accurate determination of the

medium penetration into the tablet as well as the hydrogel formation *in situ*. This approach has been used to determine the influence of the incorporated drug in matrix tablets of xanthan on the kinetics of medium penetration and hydrogel formation. The drug influences the hydrogel thickness. Its effect depends on the amount of the incorporated drug and on the drug's solubility in the medium.

The aggregation of nanoparticles in cells was identified with fluorescence microspectroscopy. A new MRI contrast agent was tested based on ferrous nanoparticles. A 200-times better antimicrobial protection of polyethylene surfaces was achieved using UV-activated titanate nanoparticles compared to the protection by UV-light alone.

The MRI contrast properties of a **new contrast agent based on ferrite nanoparticles** were tested. Most of the MR contrast agents based on the ferrite nanoparticles have very large r2 relaxivities, i.e., the T2 significantly shortens already at low nanoparticles concentrations, while the r1 relaxivity (the contrast agent shortens the spin-lattice (T1) relaxation time) is much lower and can therefore only be used as a negative (T2) MR contrast agent. T2 MR contrast agents enhance the T2 relaxation leading to lowering the MR signal and consequently darkening the contrast media-containing structures on the MR image. The use of such nanoparticles in targeted drug delivery systems should enable simultaneous non-invasive monitoring of the targeting efficiency and with that drug delivery to the desired position by MRI detection. This was confirmed by MR imaging of mice-bearing tumours and the administered nanoparticles encapsulated in lipid shell comprising magneto-liposomes. We were able to detect the shortening of T2 relaxation in tumours targeted by a magnetic field. This confirms a major advance in the application of nanotechnologies in medicine that has opened up new possibilities for the diagnosis and treatment of important human diseases such as cancer.

The above research has been supported by a number of international projects financed by the European Union within the Fifth and Sixth Frameworks, as well as a number of NATO projects. It was also supported within the bilateral Slovenian–USA, Slovenian–German and Slovenian–Greek and other scientific cooperations. International cooperations with

- The high magnetic field centres in Grenoble, France, and Nijmegen, The Netherlands
- The high magnetic field center at the University Florida, Tallahassee, Florida, USA
- The ETH, Zürich, Switzerland
- The Ioffe Institute in St. Petersburg, Russia
- The University of Duisburg, the University of Mainz and the University of Saarbrucken in Germany
- The University of California, the University of Utah and the Liquid Crystal Institute, Kent, Ohio, USA,
- National Institute for Research in Inorganic Materials, Tsukuba, Japan
- NCSR Demokritos, Greece
- Institut für Biophysik und Nanosystemforschung OAW, Graz, Austria
- Bioénergétique et Ingénierie des Protéines, CNRS Marseille, France
- Architecture et Fonction des Macromolécules Biologiques, CNRS Marseille, France
- The Max Delbruck Center for Molecular Medicine in Berlin
- The Dartmouth Medical School, Hanover, NH, USA
- The Mayo Clinic, Rochester, USA

made the above studies possible.

Some outstanding publications in the past year

1. A.Y.Ganin, Y. Takabayashi, P. Jeglič, D. Arčon, A. Potočnik, P.J. Baker, Y. Ohishi, M.T. McDonald, M.D. Tzirakis, A. McLennan, G.R. Darling, M. Takata, M.J. Rosseinsky, K. Prassides. Polymorphism control of superconductivity and magnetism in Cs_3C_{60} close to the Mott transition. *Nature (London)* **466**, 221-225(2010).
2. A. Zorko, B. Fabris, P. Mendels, K. Marty, P. Bordet. Ground state of the easy-axis rare-earth kagome langasite $Pr_3Ga_5SiO_{14}$. *Phys. Rev. Lett.* **104**, 057202-1-057202-4(2010).
3. B. Zalar, A. Lebar, D.C. Ailion, R.O. Kuzian, I. Kondakova, V.V. Laguta. ^{7}Li NMR Investigation of Li-Li pair ordering in the paraelectric phase of weakly substitutionally disordered $K_{(1-x)}LixTaO_3$. *Phys. Rev. Lett.* **105**, 226402-1-226402(2010).
4. E. Zupanič, R. Žitko, H. J. P. van Midden, I. Muševič, A. Prodan. Pinning of adsorbed cobalt atoms by defects embedded in copper (111) surface. *Phys. Rev. Lett.* **104**, 196102-1-196102-4(2010).
5. A. Omerzu, B. Anželak, I. Turel, J. Štrancar, A. Potočnik, D. Arčon, I. Arčon, D. Mihailovič, H. Matsui. Strong correlations in highly electron-doped Zn(II)-DNA complexes. *Phys. Rev. Lett.* **104**, 156804-1-156804-4(2010).
6. Jun-ichi Fukuda, S. Žumer. Novel defect structures in a strongly confined liquid-crystalline blue phase. *Phys. Rev. Lett.* **104**, 017801-1-017801-4(2010).
7. M. Humar, I. Muševič. 3D microlasers from self-assembled cholesteric liquid-crystal microdroplets. *Opt. Express* **18**, 26995-27003(2010).

8. Vilfan, A. Potočnik, B. Kavčič, N. Osterman, I. Poberaj, A. Vilfan, D. Babič. Self-assembled artificial cilia. *Proc. Natl. Acad. Sci. U. S. A.* **107**, 1844-1847(2010).
9. A. Kavalenka, I. Urbančič, S. Kure, J. Štrancar. Conformational analysis of the partially disordered measles virus $N_{(TAIL)}$-XD complex by SDSL EPR spectroscopy. *Biophys. J.* **98**, 1055-1064(2010).

Patents granted

1. Variable contrast, wide viewing angle LCD light-switching filter
   Janez Pirš, Andrej Vrečko, Silvija Pirš, Bojan Marin
   Patent No. EP 1883854 (B1)
2. A method and a device for an immediate wood moisture determination
   Igor Serša, Urška Mikac, Maks Merela, Primož Oven
   Patent No. SI 23011 (A)

Awards and appointments

1. Janez Dolinšek: Zois Award for great achievements 2010, Ministry of Higher Education, Science and Technology
2. Simon Jazbec: Prešeren Award of the Faculty of Mathematics and Physics for B.Sc. Thesis, Ljubljana, University of Ljubljana, Faculty of Mathematics and Physics
3. Andreja Jelen: Promoters of inventions 2010, Ministry of Higher Education, Science and Technology, Slovenian Research Agency and The society of young researchers Slovenia, Microstructures of various natural and high-tech synthetic materials
4. Dalija Jesenek: Perlach Award of the Faculty of Natural Sciences and Mathematics for B.Sc. Thesis Influence of temperature and confinement on liquid crystals smectic layer spacing, Faculty of Natural Sciences and Mathematics, University of Maribor
5. Slavko Pečar: Award for the contribution to the development of university education of pharmacy in Slovenia, Faculty of Pharmacy, University in Ljubljana
6. Brigita Rožič: Recognition for the effective presentation of research findings in terms of scientific quality and their usability (1st Prize - Best conference paper), Jožef Stefan International Postgraduate School, The giant electrocaloric effect: phenomenon for application and cooling and heating devices of new generation

Organization of conferences, congress and meetings

1. International Conference Magnetic resonance in highly frustrated magnetic systems HFMR 2010, Hotel Špik, Kranjska Gora, Feb. 1 – Feb. 4, 2010
2. Fifth European School in Material Science: Mechanical Properties of Complex Metallic Alloys, Mons, Ljubljana, Slovenia, May 23 – May 29, 2010
3. Scientific Meeting of Solid State Physics Department, Technical Museum, Bistra, June 4, 2010
4. International Conference Confined Liquid Crystals: Landmarks and Perspectives, Museum of Modern Art, Ljubljana, July 19 – July 20, 2010
5. SLONANO 2010, International Conference, National Institute of Chemistry, Ljubljana, Oct. 20 – Oct. 22, 2010
6. 7^{th} Physicists Conference in Basic Research, Hotel Slovenia, Portorož, Nov. 5, 2010

INTERNATIONAL PROJECTS

1. Underwater Coastal Sea Surveyor
   UNCOSS
   7. FP, 218148
   EC; Dominique Vilbois, Patrick Peras, ECA SA, Toulon, France
   Prof. Robert Blinc, Prof. Aleksander Zidanšek
2. Development of Wear Resistant Coatings based on Complex Metallic Alloys for Functional Applications
   appliCMA
   7. FP, 214407
   EC; Andreas Merstallinger, Aerospace & Advanced Composites GmbH, Wiener Neustadt, Austria
   Prof. Janez Dolinšek, Asst. Prof. Miha Čekada, Dr. Kristoffer Krnel, Dr. Srečo D. Škapin
3. Hierarchical Assembly in Controllable Matrices
   HIERARCHY
   7. FP, 215851, PITN-GA-2008-215851
   EC; Paul Kouwer, Harry Rullmann, Radboud University Nijmegen, Faculty of Science, Finance and Economic Affairs, Nijmegen, The Netherlands
   Prof. Igor Muševič
4. Multifunctional Ceramic Layers with High Electromagnetoelastic Coupling in Complex Geometries
   MULTICERAL
   6. FP, NMP3-CT-2006-032616
   EC; Prof. Andrei Kholkin, University of Aveiro, Department of Ceramics & Glass Engineering, Aveiro, Portugal
   Prof. Robert Blinc, Prof. Marija Kosec, Dr. Janez Holc, Prof. Raša Pirc
5. Complex Metallic Alloys
   CMA
   6. FP, NoE, NMP3-CT-2005-500140
   EC; Centre National de la Recherche Scientifique, Paris, France
   Prof. Janez Dolinšek, Dr. Peter Panjan, Prof. Spomenka Kobe
6. Safe Production and Use of Nanomaterials
   NANOSAFE2
   6. FP, NMP2-CT-2005-515843
   EC; Frederic Schuster, Commissariat a l"Energie Atomique, Grenoble, France
   Asst. Prof. Maja Remškar
7. Fullerene-based Opportunities for Robust Engineering: Making Optimised Surfaces for Tribology
   FOREMOST
   6. FP, 515840-2
   EC; Alberto Alberdi, Fundacion Tekniker, Eibar, Spain
   Asst. Prof. Maja Remškar, Marko Žumer, B. Sc.
8. Designing Novel Materials for Nanodevices: From Theory to Practise (NanoTP)
   COST MP0901
   EC
   Dr. Polona Umek
9. Optical Micro-manipulation by Nonlinear Photonics
   COST MP0604
   EC
   Prof. Igor Muševič
10. Advanced Paramagnetic Resonance Methods in Molecular Biophysics
    COST P15
    EC
    Asst. Prof. Janez Štrancar
11. Structure and Mechanism of Cytoplasmic Dynein
    HFSP RGP0009/2008-C
    HFSPO - International Human Frontier Science Program Organisation, Strasbourg, France; University of Leeds, IMSB FBS, Leeds, Great Britain
    Asst. Prof. Andrej Vilfan
12. Workshop "Magnetna resonanca močno frustriranih magnetnih sistemov" 1.-4. 2. 2010, Kranjska Gora
    ESF-European Science Foundation, Strasbourg, France
    Asst. Prof. Denis Arčon
13. Field - induced Phenomena in Quantum Spin Systems
    PROTEUS
    BI-FR/09-10-PROTEUS-017
    Dr. Claude Berthier, Grenoble High Magnetic Field Laboratory, CNRS, Grenoble, France
    Dr. Martin Klanjšek
14. Self-assembly of Molecular Nanomagnets in Nanotube
    PROTEUS
    BI-FR/09-10-PROTEUS-007
    Dr. Christopher Paul Ewels, Institut des Matèriaux Jean Rouxel (IMN), CNRS UMR6502, Nantes, France
    Asst. Prof. Denis Arčon
15. Supermolecular Organization of Polisaharides in Marine Gel Networks
    BI-HR/10-11-011
    Dr. Vesna Svetličić, Ruder Bošković Institute, Zagreb, Croatia
    Asst. Prof. Janez Štrancar
16. Manifestation of Gigantic Electrical/magnetic Response Near the Phase Boundary in Complex Oxides
    BI-JP/08-10-001
    Prof. Mitsuru Itoh, Tokyo Institue of Tehnology, Materials and Structures Laboratory, Tokyo Institute of Technology, Nagatsuta, Midori, Yokohama, Japan
    Prof. Robert Blinc
17. Method and Measuring Device Agreement
    Dr. Bernhard Schmitz, ECS GmbH, Aalen, Germany
    Dr. Janez Pirš
18. Multidrug Resistance in Cancer and Membrane Domain Structures
    BI-PL/10-11-009
    Dr. Rochala Wojceich, The University of Warsaw, Warsaw, Poland
    Asst. Prof. Janez Štrancar
19. Molecular Dynamics Studies in Chiral Nematic and Smectic Phases by Proton NMR
    BI-PT/10-11-011
    Prof. Pedro Sebastiao, Cenro de Fisica da Meteria Condensada da Universidade de Lisboa, Lisbon, Portugal
    Asst. Prof. Tomaž Apih
20. Liquid Crystals Superstructures for Advanced Photonic Applications (SUPERNET)
    BI-UA/09-10-012
    Dr. Andriy Nych, Institute of Physics, National Academy of Science of Ukraine, Kiev, Ukraine
    Dr. Miha Škarabot
21. High Throughput-Low Cost Biologically Based Triage for Radiation Exposure Based on EPR
    Measurements of Radiation-Induced Changes in Fingernails and Toenails
    Fingernail Dosimetry Project
    412, Modification 1 (Fingernails), HR0011-08-C-0022
    Shelagh Eastridge, Nancy Archibald, Shea McGovern, Dartmounth College, Hanover, USA
    Dr. Pavel Cevc
22. Dielectric and Electocaloric Properties of Advanced Relaxor Polymer Films and Nanotubes
    BI-US/09-12-039
    Prof. Zhang Qiming, Office of Sponsored Programs, The Pennsylvania State University, PA, USA
    Asst. Prof. Vid Bobnar
23. Geometrically Frustrated Quantum Magnetism
    BI-US/09-12-040
    Dr. Johan van Tol, National High Magnetic Field Laboratory, Florida State University, Tallahasse, FL, USA
    Dr. Andrej Zorko
24. Spintronics in Artificially Grown Nanostructures
    BI-US/08-10-017
    Prof. Saw-Wai Hla, Department of Physics and Astronomy, Ohio University, Athens, OH, USA
    Prof. Igor Muševič
25. Optical and Electrical Properties of MoS2 and WS2 Hybrid Nanomaterials
    BI-US/08-10-016
    Prof. Alan Seabaugh, University of Notre Dame, Electrical Engineering, Notre Dame, IN, USA
    Asst. Prof. Maja Remškar

R &D GRANTS AND CONTRACTS

1. Biotechnological Processes of Treatment of Lignocellulosic Materials
   Prof. Janez Štrancar
2. Wireless Networks with Radio over Optical Fiber
   Prof. Jurij Franc Tasič
3. Hybrid Nanomaterials for Low-friction Polymer Composites and Energy Conversion
   Prof. Maja Remškar
4. Formulation and Characterization of BF Fuzogenic Nanoparticles for Efficient Drug Delivery into Cells
   Dr. Marjeta Šentjurc
5. NQR - Nondestructive Method for Study of Polymorphism in Heterogeneous Pharmaceutical Systems
   Asst. Prof. Tomaž Apih
6. Applications of Nanoparticle - Macromolecule Complexes for the Formulation of Biological Drugs
   Prof. Igor Muševič
7. Molecular Motors
   Asst. Prof. Andrej Vilfan
8. Advanced Ferroelectric Polymeric and Inorganic Materials: Giant Electrocaloric Effect and Transport Properties
   Prof. Zdravko Kutnjak
9. Novel Ground States and Quantum Critical Points in Low-dimensional Quantum Spin Systems
   Dr. Andrej Zorko
10. New Methods for the Detection of N-14 Nuclear Quadrupole Resonance
    Asst. Prof. Tomaž Apih
11. Novel Nanostructured Materials with Giant Electromechanical Response, Soft Elasticity and Unusual Physical Properties: Thermal, Dielectric, Transport and Self-organization Studies
    Prof. Zdravko Kutnjak

12. Optical Microresonators Based on Liquid Crystals
    Prof. Igor Muševič
13. Single Magnetic Atoms and Magnetic Nanostructures on Metal Surfaces
    Dr. Rok Žitko
14. Antimicrobial Surfaces for Safe Production of Food
    Prof. Janez Štrancar
15. Study of Food Processing and Preparation by Magnetic Resonance Imaging and Spectroscopy Methods
    Asst. Prof. Igor Serša
16. Study of the Structure and the Dynamics of Blood Clot Dissolution: Mathematical Modelling Supported by Magnetic Resonance Experiments
    Asst. Prof. Igor Serša
17. Hydrogen Storage in Zr-based Metallic Glasses
    Prof. Janez Dolinšek
18. Dentin Evolution Detected by Spectroscopic Means
    Prof. Janez Štrancar
19. Three Dimensional Assembling of Colloidal Structures in Mesophases
    Prof. Slobodan Žumer
20. Eye Protection
    Dr. Janez Pirš
21. Patterns, Structural Self-assemly and Multiferroic States in Mixtures of Nanoparticles and Liquid Crystals
    Prof. Samo Kralj
22. Physicochemical Processes Involved in Formation of Radioactive Nanoaerosols
    Asst. Prof. Janja Vaupotič, Prof. Maja Remškar
23. Use of Nanoparticles as Additives in Lubricants and in Tribology
    Prof. Maja Remškar
24. Textured Ceramic Films for Sensors and Actuators
    Prof. Marija Kosec, Prof. Zdravko Kutnjak
25. Ecotechnological 1D Nanomaterials: Synthesis and Characterization of 1D Titanate Nanomaterials Doped with Transition Metal Ions
    Dr. Polona Umek

RESEARCH PROGRAMS

1. Experimental Biophysics of Complex Systems
   Prof. Janez Štrancar
2. Physics of Soft Matter, Surfaces and Nanostructures
   Prof. Slobodan Žumer
3. NMR and Dielectric Spectroscopy Condensed Matter; Smart New Materials and Translational Symmetry Breaking
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NEW CONTRACTS

1. E-STAR: Explosive detection-Spectroscopy, Terahertz technology And Radar
   Jožef Stefan International Postgraduate School
   Prof. Robert Blinc
2. The services of MR imaging of samples
   Krka, pharmaceutical company
   Asst. Prof. Igor Serša

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Ph. D. Theses

1. Špela Irman, *Effects of subsets of antiphospholipid antibodies on annexin A5 crystallization on phospholipid bilayers* (mentor Borut Božič; co-mentor Miha Škarabot)
2. Matjaž Panjan, *Physical and chemical properties of nanolayered metal-nitride coatings prepared by sputtering* (mentor Janez Dolinšek)
3. Matej Pregelj, *Magnetic properties of two-dimensional systems of magnetic clusters with triangular geometry* (mentor Denis Arčon)
4. Uroš Tkalec, *Colloidal interactions and novel colloidal structures in thin nematic layers*, (mentor Igor Muševič)
5. Jernej Vidmar, *Role of MRI in the analysis and prognosis of thrombolysis with thrombolytic agents,* (mentor Igor Serša; co-mentor Aleš Blinc)
6. Marko Viršek, *Structural, electrical and optical properties of low dimensional crystals of molybdenum and tungsten compounds,* (mentor Maja Remškar)
7. Stanislav Vrtnik, *Electrical and magnetic properties of Al-based quasicrystals and giant-unit-cell intermetallics* (mentor Janez Dolinšek)
8. Blaž Zupančič *NMR study of photoisomerization in bulk and confined liquid crystals* (mentor Boštjan Zalar)
9. Erik Zupanič, *Low-temperature STM study and manipulation of single atoms and nanostructures*, (mentor Albert Prodan; co-mentor Miha Škarabot)

M. Sc. Thesis

1. Janez Podobnik, *The use of magnetic resonance imaging in monitoring effects of enviroment on respiratory organs*, (mentor Igor Serša; co-mentor Igor Kocijančič)

Specialization thesis

1. Mateja Tršan, *Dobra proizvodna praksa sterilnih izdelkov v bolnišnični lekarni s poudarkom na testiranju bakterijskih endotoksinov* (mentor Slavko Pečar)

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BIBLIOGRAPHY

ORIGINAL ARTICLES

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6. Robert Blinc, Pavel Cevc, Aleš Mrzel, Denis Arčon, Maja Remškar, Fani Milia, Valentin V. Laguta, "EPR spectra of MoS_2/C_{60}", In: *Proceedigs of the IWEPNM 2009, XXIIIrd International Winterschool on Electronic Properties of Novel Materials, 7-14 March, 2009, Kirchnerg, Tirol, Austria*, (Physica status solidi, B), Berlin, Akademie-Verlag, 2010, pp. 3033-3034.
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DEPARTMENT FOR COMPLEX MATTER F-7

The research within the Department of Complex Matter encompasses a variety of research fields, ranging from the synthesis of new material to fundamental investigations of elementary excitations in complex systems. These include anything from nano-biosystems and biomolecules to superconductors and nanowires. The experimental methods used are suitably diverse, from synthetic chemistry to biomedicine and femtosecond laser spectroscopy and magnetometry. Last year's research achievements are thus quite diverse, but we are able to report on breakthroughs in a number of areas.

Head:
Prof. Dragan D. Mihailović

The activities in the department can be grouped together into a number of thematically inter-related research areas. Nanomaterials research is focused on investigations into the fundamental properties and applications of MoSI molecular wires, crossing into physics and the nanoscience of macromolecular biological systems such as DNA and cilia, and venturing into quantum molecular electronics and nanoelectronics. These and other materials, such as strongly correlated systems, electronically ordered systems and superconductors, were investigated using advanced femtosecond spectroscopy techniques. In many areas we have introduced new materials, technologies and techniques. An exciting new area which developed rapidly this year was 'cosmology in the laboratory', where ultrafast laser systems are used to simulate cosmological transitions, such as the Big Bang on the nanoscale.

Ultrafast system dynamics.

It is a fundamental principle of physics that there is a unified system of laws governing all scales from subatomic particles to the Cosmos. It is believed that the Universe, evolving from the initial hot Big Bang, would have undergone a series of symmetry-breaking phase transitions with observationally significant consequences such as the formation of topological defects. Direct experimental tests of these ideas are infeasible, but transitions described by very similar equations occur in experimentally accessible condensed-matter systems at low temperatures.

The aim of our experimental real-time studies is to exploit this analogy through studies of exemplary phase transitions in condensed matter physics in order to establish the validity of the analogy and explore the diverse behaviour of elementary fermionic and bosonic excitations through the transition.

Following the suggestion by Zurek in 1985 of a possible "laboratory cosmology experiment" to test Kibble's cosmological model, we report on a high-resolution, real-time study of the non-equilibrium evolution of both bosonic and fermionic excitations through a second-order, charge-ordering transition in electronic crystals. Using a new, multi-pulse, femtosecond, spectroscopy technique, we quench the model system into the high-symmetry state, and then detect coherent aperiodic undulations of the order parameter, critically slowing down of the collective mode, and the evolution of the particle-hole gap which appears through the Peierls-BCS mechanism (akin to the Higgs mechanism) as it evolves through the transition. Numerical modeling convincingly reproduces the observations, including the spatio-temporal distortions caused by Higgs waves arising from the spontaneous annihilation of topological defects, providing new data on hitherto unexplored dynamics of both single particle and collective excitations through symmetry-breaking transitions. In the systems showing a second-order CDW transition we detected coherent aperiodic undulations of the order parameter (OP), critical slowing down of the collective mode, and evolution of the particle-hole gap which appears through the Peierls-BCS mechanism (akin to the Higgs mechanism) as it evolves through the transition we quenched the system into the high symmetry state. The results were published in *Nature Physics 6, 681 (2010).*

By means of the three-pulse method we also investigated the excitation region below the CDW destruction threshold in 1*T*-TaS_2 and $TbTe_3$. We observed remarkable anharmonic effects hitherto undetected in the systems exhibiting collective charge ordering. Upon strong coherent excitation we observed the self-modulation of the amplitude mode intensity. A similar effect was also observed for some other phonons, where the cross-modulation at

- **Following the suggestion by Zurek in 1985 of a possible "laboratory cosmology experiment" to test Kibble's cosmological model, we report on a high-resolution, real-time study of the non-equilibrium evolution of both bosonic and fermionic excitations through a second-order, charge-ordering transition in electronic crystals.**
- **We found that the primary relaxation process in cuprate superconductors is the electron-phonon interaction and extracted a measure of its strength, the second moment of the Eliashberg function.**
- **By studying structural dynamics with femtosecond electron diffraction we were able, for the first time, to observe electronically driven melting of the structural order.**

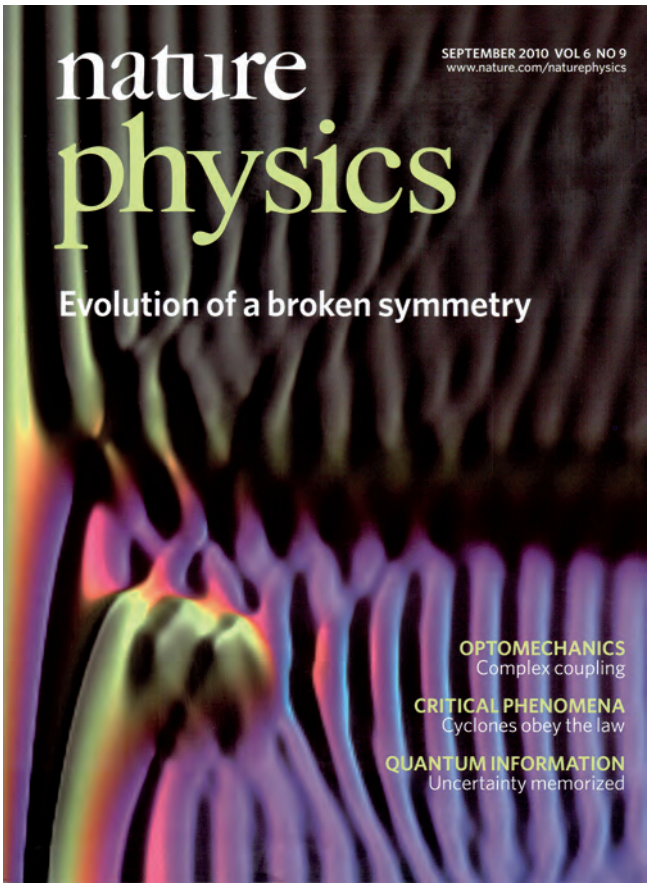

Figure 1: The trajectories of systems undergoing symmetry-breaking transitions can now be investigated in real time with femtosecond resolution. A recent paper in Nature Physics describes the behavior of charge-density wave systems. Of particular interest is the observation of Higgs waves (shown on the cover picture) emitted upon the annihilation of topological defects.

the amplitude-mode frequency indicates the anharmonic interaction of those phonons with the amplitude mode. By analyzing the observed phenomena in the framework of time-dependent Ginzburg-Landau theory we attribute the effects to the anharmonicity of the mode potentials inherent in the broken symmetry state of the CDW systems. The results were accepted for publication in *Physical Review B.*

Correlated electron dynamics

The field of research of relaxation processes of photo-excited electrons in correlated electron systems remains one of our main research topics. Several experimental studies of carrier relaxation phenomena in correlated electron systems with various degrees of correlation have been performed using femtosecond time-resolved techniques. The aim of the ongoing research is to gain additional information about the nature of the low-lying excitations in these materials, and to explore the nature and strength of the interactions of electrons with other low-lying excitations. Femtosecond spectroscopy has been instrumental in elucidating the nature of the electronic excitations in superconductors, since it allows us to distinguish different components by their lifetimes. Moreover, the relaxation kinetics can yield valuable information on the mechanism for superconductivity.

The electron-phonon interaction (EPI) is one of the most important processes which determine the functional properties of materials. It is a main scattering process in electron conduction and is vital for the formation of ordered electronic states such as superconductivity and charge-density waves. One of the most reliable and straightforward ways to determine its strength is from the electron-energy relaxation rate k, provided that the time resolution is sufficient and the appropriate analytic expression that links the EPI strength to k is used.

By means of an upgraded broad-band, non-collinear, optical parametric amplifier, with the time resolution below 20 fs, we systematically investigated electron phonon coupling in different superconductors and charge density wave compounds. We found that the primary relaxation process in the cuprate superconductors is the electron-phonon interaction and extracted a measure of its strength, the second moment of the Eliashberg function. Part of the results on the two high-temperature superconductors $YBa_2Cu_3O_{6.5}$ and $La_{1.85}Sr_{0.15}CuO_4$ was published in *Phys. Rev. Lett. 105, 257001 (2010).* The fast relaxation and hence strong EPI point to an important role of phonons in the mechanism of high-temperature superconductivity.

We continued our research on the relaxation of quasiparticles in pnictide superconductors. The main focus was on the undoped parent materials which show a spin-density wave (SDW) ground state. A single relaxation process is observed in SDW SmFeAsO and $SrFe_2As_2$, showing a remarkable critical slowing down of the QP relaxation dynamics at the SDW transition temperature due to the opening of a charge gap concurrent with SDW formation. From the high-temperature data the second moment of the Eliashberg function was also determined, indicating a rather moderate electron-phonon coupling. The results were published in two papers: *Phys. Rev. B82, 012505 (2010)* and *Phys. Rev. B81, 224504 (2010).*

We also measured (by means of optical time-resolved spectroscopy) the optical energy density which is required to destroy various types of condensates. The main focus was on the superconducting condensate in the prototypical $YBa_2Cu_3O_7$-δ system. Results show that the energy density required to destroy the superconducting condensate increases systematically with the critical temperature and that as in $(La,Sr)CuO_4$ a major part of the optical energy is transferred to phonons on a sub-ps timescale, indicating a strong electron-phonon coupling. The manuscript describing the results is in the final stage of preparation.

Utilizing an optimized system for a time-resolved reflectivity study with an extremely high signal/noise ratio we have studied the temperature dependence of the photo-induced reflectivity dynamics in a prototype quasi one-dimensional CDW system: $K_{0.3}MoO_3$. The vastly improved sensitivity and stability of the set-up enabled us to measure the temperature dependence of a series of phonon modes (15 modes up to 150 cm^{-1}) with unprecedented sensitivity and energy resolution (< 0.1 cm^{-1}). We have shown that most of the modes, which are present only below Tc, are a result of the linear coupling of phonon modes at the charge-density wave modulation vector $2k_F$ with the electronic part of the order parameter, while the ultrafast component, showing divergence near the critical temperature, cor-

responds to an overdamped purely electronic mode (amplitude mode of the electronic part of the order parameter).The paper was published in *Physical Review Letters 105, 066402 (2010).*

We have performed the first studies of the dynamics of the lattice part of the order parameter in a low-dimensional Charge Density Wave 1*T*-TaS_2, aiming at a better understanding of the interplay between electronic density modulation and the periodic lattice deformation. By studying structural dynamics with femtosecond electron diffraction we were able, for the first time, to observe electronically driven melting of the structural order. These results, combined with optical time-resolved measurements, give the first direct evidence of de-coupling of the electronic and lattice parts of the order parameter in these systems on a timescale shorter than the characteristic phonon frequencies. The paper was published in *Nature 468, 799 (2010).*

We have studied the anisotropic mid-infrared response of electrons and phonons in bulk $YBa_2Cu_3O_7$after femtosecond photoexcitation. A line shape analysis of the specific lattice modes revealed their transient occupation and coupling to the superconducting condensate. The apex oxygen vibration is strongly excited within 150 fs, demonstrating that the lattice absorbs a major portion of the pump energy before the quasiparticles are thermalized. These results imply ultrafast electron-phonon energy transfer and introduce a powerful concept probing electron-lattice interactions in a variety of complex materials. This paper was published in *Phys. Rev. Lett. 105, 067001 (2010).*

The dynamics of the depletion and recovery of the superconducting state in $La_{2-x}Sr_xCuO_4$ thin films was investigated utilizing optical pump-probe and optical pump - THz probe techniques as a function of temperature and excitation fluence. The absorbed energy density required to suppress superconductivity is found to be about 8 times higher than the thermodynamically determined condensation energy density and nearly temperature independent between 4 and 25 K. These findings indicate that during the time when superconducting state suppression takes place (≈0.7 ps), a large part (nearly 90%) of the energy is transferred to the phonons with energy lower than twice the maximum value of the SC gap and only 10 % is spent on Cooper-pair breaking. This manuscript has been submitted to *Phys. Rev. B.*

- **Recently, it has been shown that the solution-processed attachment of gold nanoparticles (GNPs) to MoSI NWs produces self-assembled, inorganic networks in a scale-free self-organized critical state. This gives a great opportunity for exploring the novel properties of MoSI materials for the fabrication of nanodevices and foresees the possibility to make these nanonets candidates for sophisticated data-processing systems such as the human brain.**
- **In 2010 we have continued our research on the electronic properties of M-DNA – a complex that DNA forms with divalent transition-metal cations. We have published our results of the spectroscopic measurements, which proved that we could effectively produce a strong electron doping in M-DNA**
- **We demonstrated that such a composite holographic grating having a thickness of only 200 micrometers acts as a "50:50 beam splitter" for a neutron beam with a wavelength of 2 nm.**

Theoretical studies on the nanoscale.

We consider flux penetration into a 2D superconducting cylinder. We show that in the low field limit the kinetics is deterministic and governed by kinematic vortices. In the strong field limit the dynamics becomes stochastic and is determined by the Kibble-Zurek mechanism. Surprisingly, the inhomogeneity in the cylinder reduces the level of stochasticity because of the predominance of ordered vortices which are similar to Kelvin-Helmholtz vortices in classical hydrodynamics. *(Physical Review Letters, 105, 157005 (2010)).*

Utilizing the time-dependent Ginzburg-Landau theory we show that modes below Tc result from linear coupling of the electronic part of the order parameter to the phonon modes at the wave-vector of the transition. The electronic CDW amplitude mode is overdamped in agreement with experimental data in blue bronze. *(Physical Review Letters, 105, 066402 (2010)).*

We have performed extensive Monte-Carlo simulations of a polaron and bipolaron transport in a charge-segregated state of doped strongly correlated 2D semiconductor. We have shown that at small dopings and low temperatures bi-particle dominates the hopping conductivity *(Submitted for publication in Physical Review B)*

Nanomaterials

Inorganic molecular wires – particularly molybdenum halide or chalcogenide cluster polymers – have emerged as a new type of one-dimensional material with remarkable molecular-scale functionality. Their one-dimensional polymer structure gives rise to some very unusual physical properties. Anionic bridges which bind Mo clusters together into one-dimensional chains are extraordinarily strong, yet highly deformable, giving rise to an exceptionally high Young's moduli and nonlinear mechanical properties respectively. The very weak interaction between individual polymer chains within crystalline bundles leads to an observation of the extreme one-dimensional electronic and magnetic character, on the one hand, and also to easy dispersion in common polar solvents and ultralow shear moduli, on the other. The sulfur atoms within the structure facilitate diverse functionalization chemistry to thiol-containing molecules, such as proteins.

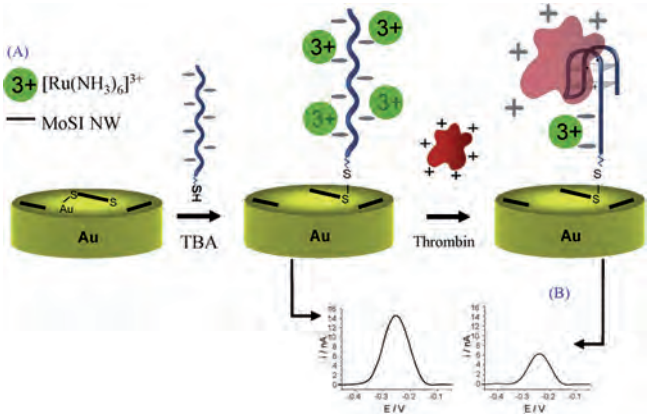

Figure 2: We have demonstrated the use of a novel electrochemical sensing platform based on aptamer conjugated $Mo_6S_{9-x}I_x$ nanowires (MoSI NWs) for the highly sensitive detection of the blood-clotting enzyme thrombin. (Biosensors and Bioelectronics, in print)

Recently, it has been shown that the solution-processed attachment of gold nanoparticles (GNPs) to MoSI NWs produces self-assembled inorganic networks in a scale-free self-organized critical state. This gives a great opportunity for exploring the novel properties of MoSI materials for the fabrication of nanodevices and foresees the possibility to make these nanonets candidates for sophisticated data-processing systems such as the human brain. In the frame of a possible application of GNPs-MoSI nanonets in molecular-scale devices, we have studied the nature of bonds between GNPs and MoSI bundles after the network formation process. As a first consideration, we observed that the chemical interaction between the nanowires' structure and the metal nanoparticles is much heavier than that suggested a by simple microscopic recognition. Besides the formation of oxidized species with the partial degradation of the nanowires, we observed a peculiar interaction with sulfur and iodine, which could be of crucial importance for the correct use of the networks in applications where the electronic system plays a crucial role. This work has been published in *The Journal of Physical Chemistry Letters 1, 393 (2010).*

In a single-step, premixing method we directly deposited gold nanoparticles on MoSI NW bundles. Gold nanoparticles with different sizes and densities were coated on the MoSI by changing the concentration of the gold-containing salt, $HAuCl_4$. TEM, SEM, and EDS characterization showed the deposition of gold nanoparticles on the MoSI NW surface. The electrical resistance of these MoSI–Au composites was more than 100 times lower than that for pure MoSI, and was mainly dependent on the density of the deposited gold nanoparticles. Furthermore, we immobilized thiol group-labeled oligonucleotide on the composites and then hybridized with a fully matched sequence. The resistance of the MoSI–Au composites increased during the thiol step, while it decreased by hybridizing, due to the conductance difference between single- and double-stranded DNA chains. These results indicate that this new kind of MoSI–Au composite could be used as a platform for different applications, including biosensors. This work has been published in *Journal of Colloid and Interface Science 348, 299 (2010).*

For functional nanodevices it is necessary to control the assembly process of the individual building blocks, thus paving the way for a pre-determined recognition of molecular species at specific postitions. This can only be accomplished by means of uniform and efficient chemical functionalisation of the nanowires. Full and uniform decoration of the nanowires with Hg has been obtained in solution using a common organic mercury salt as a source of single Hg atoms. The degree of mercury coverage appears to be strongly time dependent, with an average network formation time of two weeks in solution. A liquid Hg coating both on the walls and the ends of the NWs ultimately leads to the self-assembly of the NWs into structured networks. Mercury allows the interaction of the NWs with many molecular species and to connect them to the outside world. This work has been published in *New Journal of Chemistry 34, 2241 (2010).*

Nanoelectromechanical systems (NEMS) have recently attracted much attention because their unique properties and possible applications. We investigated the properties of single MoSI NW based two-terminal NEMS devices by *in-situ* TEM testing. It was shown that a single MoSI nanowire exhibits inherent bistability and can be effectively used in applications such as NEMS switches and memory elements. While properties are similar to those reported for CNTs, the devices exhibit low friction coefficients at contact and higher operation voltages. The low adhesion leads to smaller differences in driving potentials for on–off switching, which leads to a lower energy consumption in high-speed, high-density devices. From the investigation of the failure parameters we deduce that the MoSI-based NEMS exhibit very robust operating behavior and their high current failure is related to the Joule heating of the bulk nanowire rather than defects or contact failure. This work has been published in *Nanotechnology 21, 125706 (2010).*

We studied the vibrational properties and the thermal stability of $Mo_6S_3I_6$ (MoSI) nanowires (NWs) using Raman spectroscopy. The MoSI nanowires decompose at temperatures between 573 and 673 K when the mode characteristic for the MoO_3 phase appears. The intensity of the MoO_3 mode rises with increasing temperature followed by the appearance of additional molybdenum oxide modes, pointing at the structural instability of these systems at higher temperatures. Phonon–phonon interactions investigated for the case of the two most intense Raman internal and external modes in the temperature range 5–300 K showed that the anharmonic coupling of phonons is almost 5 times stronger for the breathing (internal) modes than for the torsional (external) ones. These vibrational properties may provide a stimulus for better understanding of the lattice dynamics of MoSI nanowires. This study has been published in *Journal of Raman Spectroscopy 41, 978 (2010).*

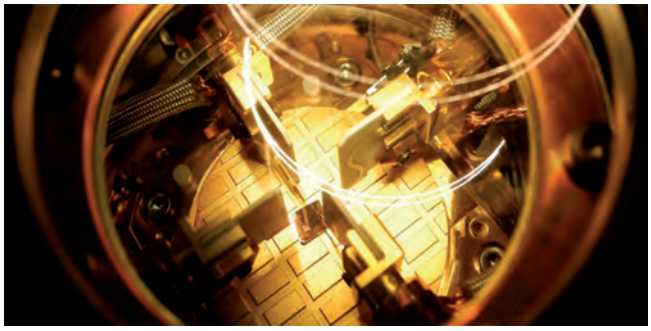

Figure 3: Four-probe measurements on nanoscale electronic circuits can now be made without wire contacts using the new LakeShore probestation at the Nanocenter.

Driving a high current through a nanowire leads to an increased temperature due to Joule heating. This current-induced heating could lead to the failure of nanowires, however, heat could also be used to remove the imperfections in the wires by annealing. *In-situ* transmission electron microscope (TEM) probing is one method to study these phenomena for the direct correlation of electrical properties with the microstructure of the nanowires during Joule heating. Straight metallic molybdenum nanowires were non-reversibly transformed from MoSI bundles by Joule heating via thermal decomposition, as consistently observed by the conductivity increase, reduction in diameter, TEM imaging, and electron diffraction. The annealing of the Mo nanowires, with the observed grain growth as a result, suggests that Joule heating might be a general way to anneal or transform nanowires, pointing to applications such as *in-situ* improvement of field emitters, metal nanowire fabrication, or novel memory elements based on material transformation. This work has been published in *Nanotechnology 21, 165704 (2010).*

Sedimentation studies have shown that bundles can be separated by dilution and that aggregation in dense dispersions causes the formation of 100nm bundles which sediment out after a period of days, while the thinner bundles (below 20nm diameter) form stable dispersions of uniform atomic structure. Until now, the only method of determining the bundle diameter during the processing has been by a combination of high-resolution electron microscopy and atomic force microscopy. A systematic study of the optical absorption spectra of MoSI NW dispersions in ethanol, fractionated into different bundle diameter populations, shows that electronic transitions shift significantly as a function of bundle diameter. Two electronic transitions show significant shifts: the Mo–S charge transfer peak shifts from 1.8 to 1.5 eV and the next inter-band transition shifts from 2.7 to 2.4 eV with increasing bundle diameter in the range 5–100 nm. Hence, the diameter distribution can now be obtained from a simple optical transmission measurement instead of time-consuming TEM, AFM or STM imaging. This reduces the time for bundle diameter characterization in the dispersion by approximately two orders of magnitude and will prove extremely beneficial for further research on these materials. This work has been published in *Synthetic Metals 160, 2389 (2010).*

Nanomaterials prepared by the sulfurization of $Mo_6S_2I_8$ nanowires and the time and temperature dependence of the transformation process are investigated by high-resolution transmission electron microscopy, X-ray powder diffraction, and wavelength-dependent Raman spectroscopy. Depending on the temperature, coaxial MoS_2 nanotubes or MoS_2 "mama"-tubes are formed after 2 h of sulfurization. Using a few minutes of sulfurization time, core–shell nanowires composed of well-ordered MoS_2 layers covering a $Mo_6S_2I_8$ core are formed, proving an outside-to-inside transformation process. The crystallinity of the three MoS_2 nanostructures increases with increasing transformation temperature, i.e., in the sequence from $MoS_2/Mo_6S_2I_8$ core–shell structures via coaxial MoS_2 tubes to the MoS_2 "mama"-tubes. The analysis indicates a different nature of the defects in the MoS_2-based nanomaterials, originating from the sulfurization of the $Mo_6S_2I_8$ than in the conventional MoS_2 plate-like crystals. A correlation between the Raman spectroscopic parameters and the defect density in MoS_2 is identified. This work has been published in The Journal of *Physical Chemistry C, 114, 6458 (2010).*

Using passive microrheology we measured the microrheological properties of a magnetic fluid as a function of direction and the magnitude of the external magnetic field. The effective microviscosity strongly depends on the magnitude of the external field, while it is almost independent of its direction. The measured effective storage modulus varies significantly within the sample and depends both on the direction and the magnitude of the external magnetic field. It vanishes in zero field, while in non-zero field it is by a factor of 2 to 4 larger in the direction along the field than perpendicular to it. The non-zero value of the storage modulus, which indicates the formation of a viscoelastic fluid, appears at magnetic fields at which the dynamic light scattering experiments reveal the formation of elongated structures. The results are reported in *Soft Matter, 7, 125-131 (2011).*

Electron dynamics in biological macromolecules

In 2010 we have continued our research on the electronic properties of M-DNA – a complex which DNA forms with divalent transition metal cations. We have published our results of the spectroscopic measurements, which proved that we could effectively produce a strong electron doping in M-DNA, in the article "Strong Correlations in Highly Electron-Doped Zn(II)-DNA Complexes" , A. Omerzu, B. Anželak, I. Turel, J. Štrancar, A. Potočnik, D. Arčon, I. Arčon, D. Mihailović, H. Matsui. *Phys. Rev. Lett. 104, 156804 (2010)*. We plan to make the next step forward in the research of the transport properties of M-DNA by turning to single molecule measurements. For that purpose, we have started a comprehensive study of M-DNA adsorption and ordering on suitable substrates (mica, SiO_2, etc). This study includes a determination of the optimal conditions for a controlled deposition of M-DNA macromolecules on

- **We completed a comparative study of the aggregation properties of lipophilic derivatives with one, two and three hydrocarbon tails. Langmuir films of these derivatives on water subphase and Langmuir-Blodgett (LB) films transferred to a mica surface were analysed. AFM imaging of the structure of LB films showed that surface-adsorption features of the three derivativatives are very different.**
- **We study new concepts of compact light sources on the basis of the nonlinear optical conversion of existing lasers into the spectral regions where lasers are not yet available**
- **We used combined magneto-optical tweezers to study biomimetic systems. Superparamagnetic spheres were assembled into long chains that were attached to a glass surface on one end. This created an array of artificial cilia and we investigated the hydrodynamics around them.**

the substrate: DNA and transition-metal cation concentrations, buffer ionic strength, pre-conditioning and drying methods of the substrate, etc. In the course of our experiments we have found that at higher cation concentrations M-DNA starts to aggregate into bundles. The effect of aggregation is well-known and well-documented for the cases of tri- and tetra-valent cations, but it is quite unexplored in the case of divalent metal cations. Because in our case the aggregation is unwanted, we have thoroughly explored the effect. We found that for each transition-metal cation there exist a narrow interval of concentrations which allow for the undoped DNA to doped M-DNA transition while they are still low enough not to induce the aggregation. Thus, we have resolved the first pre-condition for a successful future research on the conductivity of single M-DNA molecules.

Soft Matter

In cooperation with the Faculty of Physics at the University of Vienna we continued with our investigations of holographically structured materials that can be used as diffractive elements for the manipulation of cold neutron beams. We analysed a series of diffraction gratings fabricated from photopolymer composites with SiO_2 and ZrO_2 nanoparticles. We demonstrated that such a composite holographic grating having a thickness of only 200 micrometers acts as a "50:50 beam splitter" for a neutron beam with a wavelength of 2 nm. This result was reported in the paper: *Phys. Rev. Lett. 105, 123904 (2010)*. In the second part of the year we started with investigations of holographic patterning in composite materials from photopolymer and superparamagnetic nanoparticles. Preliminary investigations of the effect of a magnetic field on neutron diffraction from structures with a homogeneous distribution of nanopaticles were performed. The aim of these investigations is to develop neutron-optical elements that can be used for the manipulation of the polarization state of the neutron beam.

We also continued with our investigations of 2D composite photonic structures from polymers and liquid crystals. We investigated the effect of Nematic-Isotropic phase transition and the effect of the external electric field on the structural and diffraction properties of different types of photonic lattices. We performed a comprehensive study of the temperature dependence of the switching properties for the 2D square lattice. The results of this work are reported in the paper: *J. Opt. 12, 015196 (2010).*

Investigations of optical holographic patterning in light-sensitive liquid crystal elastomers (LCEs) were, in 2010, focused on various details of the holographic recording process. We studied the unusual phenomenon of a strong increase of diffraction efficiency after the termination of the recording stage, which is observed in the vicinity of phase transition from the nematic to the isotropic phase. We also analyzed the effect of the polarization state of the recording and of the probe beams on the diffraction properties. We showed that, due to the decrease of absorption coefficient related to photoizomerization process, the depth of the holographic recording increases with the increasing recording time. This finding is reported in a manuscript submitted to *Phys. Rev. E.*

We continued investigations of the self-assembling properties of guanosine derivatives in aqueous solutions and on various surfaces. We analysed the results of an investigation of the dissociation of G-quadruplex structures in water performed by small-angle x-ray scattering (SAXS), which were reported in *J. Nucleic Acids 2010, 472478 (2010)*. We completed a comparative study of the aggregation properties of lipophilic derivatives with one, two and three hydrocarbon tails. Langmuir films of these derivatives on water subphase and Langmuir-Blodgett (LB) films transferred to a mica surface were analysed. AFM imaging of the structure of LB films showed that surface-adsorption features of the three derivativatives are very different. This observation demonstrates that the self-assembling properties of guanosine molecules can be effectively manipulated by appropriate chemical modification of the molecule. The results of these investigations are reported in the paper: *Appl. Surf. Sci. 256, 2038 (2010)*. In the second part of the year the investigations were extended to the analogous derivatives of adenosine. The results show that adenosine derivatives transfered to the mica surface always tend to fom micellar structures, despite the number of attached hydrocarbon tails. In cooperation with the group from Ulster University we continued investigations of the self-assembling properties of guanosine-rich DNA oligonucleotides (6-30 bp) in solution and on surfaces. Dynamic light scattering (DLS) was used to probe the self-assembly of 6 different oligonucleotides in aqueous solution. The measurements showed that, in contrast to the expectations, the derivatives with and without the "sticky CG ends" form very similar one-dimensional structures. The results of this study were published in *J. Nucleic Acids 2010, 431651 (2010).*

Our cooperation with the laser company Fotona d.d. from Ljubljana was focused on the further development of computer-simulation methods for the determination of the optical field in unstable laser resonators. The main part of the work was devoted to an investigation of the so-called population-lensing effect in Ruby lasers. The obtained results are reported in *IEEE J. Quantum. El. 46, 361 (2010).* We also analysed the effect of astigmatic thermal lensing on the output laser beam of the Nd:YAG and rubin laser systems with an unstable resonator. The results of this investigationare are reported in a manuscript submitted for publication to *Applied Physics B.*

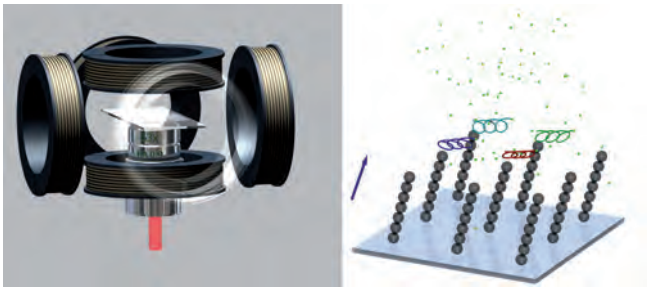

Figure 4: Artificial cilia were assembled in an external magnetic field. (A) Detail of the experimental setup, which was used for creating and manipulating the artificial cilia. Three orthogonal pairs of coils that generated a homogeneous magnetic field of arbitrary direction and varying magnitude were integrated into an optical microscope (not shown) equipped with optical tweezers.(B) Schematic view of the numerical simulation that was made for exactly the same configuration as in the experiment and for the same parameter values. Tracer particles were randomly distributed through the sample and their average velocity was calculated. The arrow denotes the direction of the external magnetic field

Nonlinear optics.

In the Nonlinear Optics Laboratory we study new materials and their interaction with laser light. Integrated optics is a promising technology; however, better materials will increase its potential. In cooperation with the National Institute for Materials Science in Tsukuba, Japan, ($LiTaO_3$) and North Carolina State University in Raleigh, USA, (GaAlN) we study new concepts of compact light sources on the basis of the nonlinear optical conversion of existing lasers into the spectral regions where lasers are not yet available. In cooperation with ETH Zurich, a new topic is THz generation with difference frequency mixing. In an optical parametric oscillator we produce pulses with two frequency components of prescribed frequency difference. These pulses are then sent to a nonlinear optical crystal where they generate a pulse of THz waves.

Biomedical optics.

We have investigated the potential of pulsed photo-thermal radiometry (PPTR) for noncontact measurements of laser-induced temperature profiles in strongly scattering samples, such as biological tissue. Systematic measurements in laboratory tissue models, compared with high-resolution magnetic resonance imaging and supported by detailed numerical simulation, have demonstrated a high accuracy of depth determination of subsurface absorbing layers and unprecedented spatial resolution of temperature profiling when explicitly accounting for the variation of the sample IR absorption coefficient within the acquisition spectral band.

Using the described PPTR technique, we have been measuring laser-induced temperature profiles in the skin of human volunteers, e.g., over the course of a laser treatment for unwanted tattoos (collaboration with Fotona d.d., Ljubljana). The aim of this study is to optimize the measurement technique, study the pecifics of laser-tissue interactions, and assess the potential of PPTR for monitoring the therapeutic efficacy and possibly predict the optimal treatment parameters on an individual patient basis. As part of this study, objective evaluation of therapeutic efficacy was also attempted by measurements of skin color with a tri-stimulus colorimeter, supported by a custom PC application. Seasonal, daily, and acute variations of the measured skin color, potentially interfering with the above aim, were analyzed in a separate study.

We have developed a three-dimensional Monte Carlo model of optical transport in skin, which allows treatment of skin inclusions with complex geometries and arbitrary irradiation patterns. With this model we have performed a parametric study of blood-vessel photocoagulation and collateral tissue damage in a novel treatment of port wine stain (PWS) lesions using sequential laser irradiation and intermittent cryogen spray cooling (collaboration with Beckman Laser Institute, University of California at Irvine).

Biological systems.

In collaboration with the Laboratory for Experimental Soft Matter at the Faculty of Mathematics and Physics, University of Ljubljana, we used combined magneto-optical tweezers to study biomimetic systems. Superparamagnetic spheres were assembled into long chains that were attached to a glass surface at one end. This created an array of artificial cilia and we investigated the hydrodynamics around them. By using an external magnetic field, we rotated the cilia and the assymetry of rotation resulted in a fluid flow.

We measured the velocity profile of the flow as a function of height above the ciliated surface and studied its dependence on the rotation parameters (degree of asymmetry and rotational frequency). In collaboration with the Department of Condensed Matter Physics (F5) a theoretical model was proposed and an excellent agreement between the experimental data and the model was obtained. The paper was published in the Proceedings of the National Academy of Sciences (PNAS) and summarized in Nature Physics.

We also performed experiments that would finally prove the hypothesis that the metachronal waves on a cell surface appear as a result of the hydrodynamic coupling between individual cilia. We created special, non-magnetic cilia, which do not respond to an external magnetic field. Their motion is therefore determined by the motion of other cilia based on the hydrodynamic coupling. The results were presented at the 2nd European Conference on Microfluidics Microfluidics 2010.

Some outstanding publications in the past year

1. Roman V. Yusupov, Tomaž Mertelj, Viktor V. Kabanov, Serguei Brazovskii, Primož Kušar, Jiun-Haw Chu, Ian R. Fisher, Dragan Mihailović. Coherent dynamics of macroscopic electronic order through a symmetry breaking transition. Nature physics, 2010, vol. 6, no. 9, p. 681-684.
2. Christoph Gadermaier, Alexandre Sasha Alexandrov, Viktor V. Kabanov, Primož Kušar, Tomaž Mertelj, Xin Yao, C. Manzoni, Daniele Brida, G. Cerullo, Dragan Mihailović. Electron-phonon coupling in high-temperature cuprate superconductors determined from electron relaxation rates. Phys. rev. lett., 2010, vol. 105, no. 25, p. 257001-1-257001-4.
3. Tomaž Mertelj, Primož Kušar, Viktor V. Kabanov, Ljupka Stojchevska, N. D. Zhigadlo, S. Katrych, Z. Bukowski, J. Karpinski, S. Weyeneth, Dragan Mihailović. Quasiparticle relaxation dynamics in spin-density-wave and superconducting $SmFeAsO_{1-x}F_x$ single crystals. Phys. rev., B, Condens. matter mater. phys., 2010, vol. 81, no. 22, p. 224504-1-224504-9.
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5. Mojca Vilfan, Anton Potočnik, Blaž Kavčič, Natan Osterman, Igor Poberaj, Andrej Vilfan, Dušan Babič. Self-assembled artificial cilia. Proc. Natl. Acad. Sci. U. S. A., 2010, vol. 107, no. 5, p. 1844-1847, doi: 10.1073/pnas.0906819106.
6. A. Omerzu, B. Anželak, I. Turel, J. Štrancar, A. Potočnik, D. Arčon, I. Arčon, D. Mihailović, H. Matsui. "Strong Correlations in Highly Electron-Doped Zn(II)-DNA Complexes" . Phys. Rev. Lett. 104, 156804 (2010).
7. H. Schäfer, Viktor V. Kabanov, M. Beyer, K. Biljaković, Jure Demšar. Disentanglement of the electronic and lattice parts of the order parameter in a 1d charge density wave system probed by femtosecond spectroscopy. Phys. rev. lett., 2010, vol. 105, no. 6, p. 066402-1-066402-4.

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2. Verner K. Thorsmølle, Jure Demšar. Morphology effectively controls singlet-triplet exciton relaxation and charge transport in organic semiconductors. Phys. rev. lett., 2009, vol. 102, 017401-1-017401-4.
3. Tomaž Mertelj, Anderej Ošlak, Janez Dolinšek, I. R. Fisher, Viktor V. Kabanov, Dragan Mihailović. Fine structure in the electronic density of states near the Fermi energy of Al-Ni-Co decagonal quasicrystal from ultrafast time-resolved optical reflectivity. Phys. rev. lett., 2009, vol. 102, 086405-1-086405-4.
4. Tomaž Mertelj, Viktor V. Kabanov, Christoph Gadermaier, N. D. Zhigadlo, S. Katrych, J. Karpinski, Dragan Mihailović. Distinct pseudogap and quasiparticle relaxation dynamics in the superconducting state of nearly optimally doped $SmFeAsO_{0.8}F_{0.2}$ single crystals. Phys. rev. lett., 2009, vol. 102, 117002-1-117002-4.
5. Andrej Petelin, Martin Čopič. Observation of a soft mode of elastic instability in liquid crystal elastomers. Phys. rev. lett., 2009, vol. 103, 077801-1-077801-4.
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1. Roman.V. Yusupov, Tomaz Mertelj, J.-H. Chu, I.R. Fisher, Dragan Mihailović. Single-particle and collective mode couplings associated with 1- and 2-directional electronic ordering in metallic RTe_3 (R =Ho, Dy, Tb). Phys. rev. lett., 2008, 101, issue 24, 246402.
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3. Primož Kušar, Viktor V. Kabanov, Jure Demšar, Tomaž Mertelj, Sunji Sugai, Dragan Mihailović. Controlled vaporization of the superconducting condensate in cuprate superconductors by femtosecond photoexcitation. Phys. rev. lett., 2008, vol. 101, 227001-1-22700-4.

Patents granted

1. Marko Marinček, Marko Čenčič, Laser system: US7778306 (B2), [S. l.], United States Patent and Trademark Office, 17. avg. 2010.

Organization of conferences, congress and meetings

1. SLONANO 2010, Ljubljana, Slovenia, coorganizers, 20 – 22 October 2010.

INTERNATIONAL PROJECTS

1. Electronic Response of Single Inorganic Nanowires
   ERESIN
   7. FP, 230975, PERG03-GA-2008-230975
   EC
   Prof. Dragan Mihailović
2. Composites of Inorganic Nanotubes and Polymers
   COINAPO, COST MP0902
   EC; COST Office, Brussels, Belgium
   Prof. Dragan Mihailović
3. Self-assembled Guanosine Structures for Molecular Electronic Devices
   COST MP0802
   COST-Workshop-MP0802-01830
   CGA-MP0802-1
   EC; Dr. Caroline Whelan, Milena Stoyanova, Kent Hung, COST Office, Brussels, Belgium
   Prof. Martin Čopič, Asst. Prof. Lea Spindler
4. Dynamic Properties of Light-sensitive Liquid Crystalline Elastomers
   Dynamsche Eigenschften lichtempfindlicher Flüssigkristall-Elastomere
   BI-AT/09-10-009
   Prof. Wilfried Schranz, University of Vienna, Institut für Experimentalphysik, Vienna, Austria
   Prof. Irena Drevenšek Olenik
5. Light-Sensitive Nanocomposite Media for Tunable Photonic Devices
   BI-CN/09-11-016
   Prof. Xinzheng Zhang, Teda Applied Physics School, Nankai University, Tianjin, China
   Prof. Irena Drevenšek Olenik
6. Experimental Search for Collective Excitations in the Peierls Conductors by Optical Methods
   BI-RU/10-11-003
   Dr. Sergei Zaitsev-Zotov, Kotelnikov Institute of Radioengineering and Electronics of RAS, Moscow, Russia
   Asst. Prof. Viktor Kabanov
7. Ultrafast Pump-probe Spectroscopy of Complex Matter
   e-GAP
   Royal Society International Joint Projects 2009/R2
   Prof. Sasha Alexandrov, Loughborough University, Physics Department, Loughborough, Great Britain
   Prof. Dragan Mihailović
8. Laser Therapy of Cutaneous Vascular Lesions using Repetitive Irradiation and Intermittent Cryogen Cooling
   BI-US/09-12-044
   Dr. John Stuart Nelson, Beckman Laser Institute and Medical Clinic, University of California at Irvine, Irvine CA, USA
   Asst. Prof. Boris Majaron
9. Structure and Dynamics of Confined Bent-core Liquid Crystals
   BI-US/08-10-029
   Noel A. Clark, Department of Physics, University of Colorado, CO, USA
   Prof. Martin Čopič

R &D GRANTS AND CONTRACTS

1. Biomimetic Systems in Microfluidics
   Dr. Mojca Vilfan
2. Dynamics of Complex Functional States
   Prof. Dragan Dragoljub Mihailović
3. Molecular Elecronics with MoSI Nanowires
   Prof. Dragan Dragoljub Mihailović
4. Synthesis and Characterization of Novel Nanostructures on the Basis of Transition Metals
   Dr. Aleš Mrzel
5. Ultrafast Electron Dynamics in Metals and Determination of Electron-Phonon Coupling Constant in Metals and Superconductors
   Prof. Viktor Kabanov

RESEARCH PROGRAMS

1. Dynamics of Complex Nanosystems
   Prof. Dragan Dragoljub Mihailović
2. Light and Matter
   Prof. Martin Čopič

NEW CONTRACT

1. Feasibilty study of pulsed photothermal radiometry (PPTR) application in dermatologic laser surgery
   Asst. Prof. Boris Majaron
   FOTONA d.d.

MENTORING

Ph. D. Theses

1. Joaquin Gabriel Miranda Mena, *Phase separation in a 2D charged system* (mentor Viktor V. Kabanov; co-mentor Tomaž Mertelj)
2. Dejan Škrabelj, *Optical field generation in Q-switched unstable laser resonators* (mentor Irena Drevenšek Olenik; co-mentor Marko Marinček)

M. Sc. Thesis

1. Jerneja Milavec, *Electrooptic properties of holographic polymer - dispersed liquid crystals* (mentor Irena Drevenšek Olenik)
2. Danica Radmanovac, *Distribution of nanoparticles of fullerenol in human serum in presence of doxorubicin* (mentor Svjetlana Trivic; co-mentor Alenka Mertelj)

VISITORS FROM ABROAD

1. Li Hui, TEDA Applied Physics School, Nankai University, China. 14 March – 10 April 2010
2. Dr. Romano Rupp, TEDA Applied Physics School, Nankai University, China. 02 April 2010
3. Prof. Hans Kuzmany, University of Vienna, Faculty for Physics, Austria. 12- 13 May 2010
4. Dr. Raavi Sai Santosh Kumar, Politehnična univerza v Milanu, Italy. 13 – 19 May 2010
5. Dr. Marta Mróz, Politehnična univerza v Milanu, Italy, 16 – 19 May 2010
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14. Prof. Miagku Oda, Department of Applied Physics, Hokkaido University, Sapporo, Japan. 15 – 16 July 2010
15. Prof. Sergey Zaytsev-Zotov, Kotel'nikov Institute of Radio Engineering and Electronics of RAS, Moskva, Russia. 01 – 06 September 2010
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17. Prof. Hiroyuki Shima, Tokyo Institute of Technology, Department of Nuclear Engineering and Research Laboratory for Nuclear Reactors, Japan. 16 – 19 September 2010
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21. Asst. prof. Elbert Chia, Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore. 19 - 21 October 2010
22. Prof. Christos Pnagopoulous, Division of Physics & Applied Physics Department, Nanyang Technological University, Singapore. 20 – 23 October 2010
23. Dr. Igor Nikolaevich Dyuzhikov, Kotel'nikov Istitute of Radioengineering and Electronics of RAS, Moscow, Russia. 31 October – 13 November 2010
24. Dr. Venera Nasretdinova, Kotel'nikov Istitute of Radioengineering and Electronics of RAS, Moscow, Russia. 30 November – 20 December 2010
25. Prof. Aleksandar Djordjević, Prirodno matematički fakultet, Departman za hemiju, University of Novi Sad, Serbia. 13 – 17 December 2010
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23. Miha Devetak, B. Sc.
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25. Andrej Kovič, B. Sc.
26. Mathieu Lu-Dac, B. Sc.
27. Andrej Petelin, B. Sc.
28. Ljupka Stojchevska, B. Sc.
29. Jure Strle, B. Sc.
30. Martin Strojnik, B. Sc.

Technical officers
31. Boštjan Berčič, B. Sc., left 01.06.10
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33. Damjan Vengust, B. Sc.

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34. Smiljana Golja, left 22.09.10
35. Martina Knavs, B. Sc.
36. Nataša Zupančič, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

1. Alexandre Sasha Alexandrov, Carlo Di Castro, Igor Mazin, Dragan Mihailović, "Phonons and electron correlations in high-temperature and other novel superconductors: editorial", *Adv. Condens. Matter Phys.*, vol. 2010, pp. 206012-1-206012-2, 2010.
2. J. Andzane, J. Prikulis, Damjan Dvoršek, Dragan Mihailović, D. Erts, "Two-terminal nanoelectromechanical bistable switches based on molybdenum-sulfur-iodine molecular wire bundles", *Nanotechnology (Bristol)*, vol. 21, no. 12, pp. 125706-1-125706-6, 20102010.
3. M. Beck, H, Schäfer, G. Klatt, Jure Demšar, S. Winnerl, M. Helm, Thomas Dekorsy, "Impulsive terahertz radiation with high electric fields from an amplifier-driven large-area photoconductive antenna", *Opt. express*, vol. 18, no. 9, pp. 9251-9257, 2010.
4. Robert Blinc, Pavel Cevc, Aleš Mrzel, Denis Arčon, Maja Remškar, Fani Milia, Valentin V. Laguta, "EPR spectra of MoS_2/C_{60}", In: *Proceedigs of the IWEPNM 2009, XXIIIrd International Winterschool on Electronic Properties of Novel Materials, 7-14 March, 2009, Kirchnerg, Tirol, Austria*, (Physica status solidi, B, vol 247, no. 11/12), Berlin, Akademie-Verlag, 2010, pp. 3033-3034.
5. Boris Cenčič, Matjaž Lukač, Janez Žabkar, Marko Marinček, Zdenko Vižintin, "High fluence, high beam quality Q-switched Nd:YAG laser with optoflex delivery system for treating benign pigmented lesions and tattoos", *LAHA*, vol. 1, no. 1, pp. 9-18, 2010.
6. Giuseppe Compagnini, Giacomo Patanè, Marco Sinatra, Orazio Puglisi, Valeria Nicolosi, Dragan Mihailović, Damjan Vengust, Jure Strle, "Bonding states in molecular-scale MoSI nanowire-gold nanoparticle networks", *J. phys. chem. lett.*, vol. 1, no. 1, pp. 393-397, 2010.
7. Miha Devetak, Stefano Masiero, Silvia Pieraccini, Gian Piero Spada, Martin Čopič, Irena Drevenšek Olenik, "Surface structure of Langmuir-Blodgett films of lipophilic guanosine derivatives", *Appl. surf. sci.*, vol. 256, no. 7, pp. 2038-2043, 2010.
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9. Martin Fally, Irena Drevenšek Olenik, (13 authors), "Neutron optical beam splitter from holographically structured nanoparticle-polymer composites", *Phys. rev. lett.*, vol. 105, no. 12, pp. 123904-1-123904-4, 2010.
10. Christoph Gadermaier, Alexandre Sasha Alexandrov, Viktor V. Kabanov, Primož Kušar, Tomaž Mertelj, Xin Yao, C. Manzoni, Daniele Brida, G. Cerullo, Dragan Mihailović, "Electron-phonon coupling in high-temperature cuprate superconductors determined from electron relaxation rates", *Phys. rev. lett.*, vol. 105, no. 25, pp. 257001-1-257001-4, 2010.
11. Christoph Gadermaier, Jure Strle, Marko Uplaznik, Damjan Vengust, Boštjan Berčič, Dragan Mihailović, "$Mo_6S_3I_6$ molecular wires: from a one-dimensional quantum fluid to self-organized critical self-assembled networks", In: *Proceedigs of the IWEPNM 2009, XXIIIrd International Winterschool on Electronic Properties of Novel Materials, 7-14 March, 2009, Kirchnerg, Tirol, Austria*, (Physica status solidi, B, vol. 247, no. 11/12), Berlin, Akademie-Verlag, 2010, pp. 3014-3017.
12. Martin Gorjan, Marko Marinček, Martin Čopič, "Spectral dynamics of pulsed diode-pumped erbium-doped fluoride fiber lasers", *J. Opt. Soc. Am., B, Opt. phys.*, vol. 27, no. 12, pp. 2874-2793, 2010.
13. Sašo Gyergyek, Darko Makovec, Alenka Mertelj, Miroslav Huskić, Mihael Drofenik, "Superparamagnetic nanocomposite particles

synthesized using the mini-emulsion technique", *Colloids surf., A Physicochem. eng. asp.*, issue 1-3, vol.366, pp. 113-119, 2010.
14. Magnus Hummelgård, Renyun Zhang, Torbjörn Carlberg, Damjan Vengust, Damjan Dvoršek, Dragan Mihailović, Håkan Olin, "Nanowire transformation and annealing by Joule heating", *Nanotechnology (Bristol)*, vol. 21, no. 16, pp. 165704-1-165704-6, 2010.
15. Pil-Joo Kim, O-Pil Kwon, Mojca Jazbinšek, Hoseop Yun, Peter Günter, "The influence of pyrrole linked to the π-conjugated polyene on crystal characteristics and polymorphism", *Dyes pigm.*, vol. 86, no. 2, pp. 149-154, 2010.
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17. Seong-Ji Kwon, Mojca Jazbinšek, O-Pil Kwon, Peter Günter, "Crystal growth and morphology control of OH1 organic electrooptic crystals", *Cryst. growth des.*, vol. 10, no. 4, 2010, pp. 1552-1558.
18. Mathieu Lu-Dac, Viktor V. Kabanov, "Phase slip phenomena in superconductors: from ordered to chaotic dynamics", *Phys. rev. lett.*, vol. 105, no. 15, pp. 157005-1-157005-4, 2010.
19. Mathieu Lu-Dac, Viktor V. Kabanov, "Dynamics in mesoscopic superconducting rings: multiple phase-slips and vortex-antivortex pairs", In: *Proceedigs of the VORTEX VI, Sixth International Conference in School Format on Vortex Matter in Nanostructured Superconductors, Rhodes, Greece, 17-24 September, 2009*, (Physica, C, Superconductivity and its applications, vol. 470, no. 19), J. Herczeg, ed., Amsterdam, North-Holland, 2010, pp. 942-945.
20. Matjaž Lukač, Martin Gorjan, Janez Žabkar, Ladislav Grad, Zdenko Vižintin, "Beyond customary paradigm FRAC3 Nd:YAG laser hair removal", *LAHA*, vol. 1, no. 1, pp. 35-46, 2010.
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23. Matjaž Lukač, Zdenko Vižintin, Janez Žabkar, Samo Pirnat, "QCW Pulsed Nd:YAG 1064 nm laser lipolysis", *LAHA*, vol. 1, no. 1, pp. 24-34, 2010.
24. Paolo Mariani, Francesco Spinozzi, Francesco Federiconi, M. G. Ortore, Heinz Amenitsch, Lea Spindler, Irena Drevenšek Olenik, "Guanosine quadruplexes in solution: a small-angle X-ray scattering analysis of temperature effects on self-assembling of deoxyguanosine monophosphate", *J. nucleic acids (Online)*, vol. 2010, pp. 472478-1-472478-10, 2010.
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Published Conference Papers

Invited Papers

1. Mojca Jazbinšek, Harry Figi, Christoph Hunziker, Blanca Ruiz, Seong-Ji Kwon, O-Pil Kwon, Zhou Yang, Peter Günter, "Organic electro-optic single crystalline films for integrated optics", In: *Linear and nonlinear optics of organic materials X: 1-2 and 4 August 2010, San Diego, California, United States*, (Proceedings of SPIE, vol. 7774), Manfred Eich, ed., Bellingham, SPIE, cop. 2010, pp. 77740Q-1-77740Q-10.
2. Mojca Jazbinšek, Christoph Hunziker, Seong-Ji Kwon, Harry Figi, O-Pil Kwon, Peter Günter, "Hybrid organic crystal/silicon-on-insulator integrated electro-optic modulators", In: *Organic photonic materials and devices XII: 26-28 January 2010, San Francisco, California, United States*, (Proceedings of SPIE, vol. 7599), Robert L. Nelson, ed., François

Kajzar, ed., Toshikuni Kaino, ed., Bellingham, SPIE, cop. 2010, vol. 7599, pp. 7599OK-1-7599OK-14, 2010.
3. Boris Majaron, Matija Milanič, "Pulsed photothermal profiling of water-based samples using a spectrally composite reconstruction approach", In: *15th International Conference on Photoacoustic and Photothermal Phenomena (ICPPP15) 19-23 July 2009, Leuven, Belgium*, (Journal of physics, Vol. 214), Christ Glorieux, ed., Jan Thoen, Bristol, IOP Publishing, 2010, vol. 214, no. 1, pp. 012007-1-012007-5, 2010.

Regular papers

1. Valentina Domenici, Marjetka Conradi, Maja Remškar, Aleš Mrzel, Boštjan Zalar, "MoO_3 − x nanowires as inorganic components of liquid crysralline elastomer composites", In: *Proceedings of the 12th International Ceramics Congress, CIMTEC 2010 International Conferences on Modern Materials & Technologies, Montecatini Terme, Tuscany, Italy, June 6-11, 2010*, (Advances in science and technology, vol. 71), Stäfa, Trans Tech Publications, 2010, pp. 40-44.
2. Harry Figi, Mojca Jazbinšek, Christoph Hunziker, Manuel Koechlin, Peter Günter, "Integrated electro-optic devices of melt-processable single-crystalline organic films", In: *Organic photonic materials and devices XII: 26-28 January 2010, San Francisco, California, United States*, (Proceedings of SPIE, vol. 7599), Robert L. Nelson, ed., François Kajzar, ed., Toshikuni Kaino, ed., Bellingham, SPIE, cop. 2010, vol. 7599, pp. 75991N-1-75991N-6, 2010.
3. Christoph Gadermaier, Jure Strle, Marko Uplaznik, Damjan Vengust, Boštjan Berčič, Dragan Mihailović, "$Mo_6S_3I_6$ molecular wires: from a one-dimensional electron fluid to self-organized critical self-assembled network", In: *Proceedigs of the International Conference on Theoretical Physics, Dubna-Nano 2010 5-10 July, 2010, Dubna, Russia*, (Journal of physics, Conference series, vol. 248), Bristol, Institute of Physics Publishing, 2010 pp. 012032-1-012032-6.
4. Blaž Kavčič, Dušan Babič, Natan Osterman, Boštjan Podobnik, Igor Poberaj, "Rapid prototyping system with sub-micrometer resolution for microfluidic applications", In: *Proceedings*, 2nd European Conference on Microfluidics Microfluidics 2010 (MicroFlu'10), December 8-10, 2010, Toulouse, France, Stéphane Colin, ed., Gian Luca Morini, ed., Paris, Societe Hydrotechnique dee France, 2010, 9 pp.
5. Gašper Kokot, Mojca Vilfan, Natan Osterman, Andrej Vilfan, Blaž Kavčič, Igor Poberaj, Dušan Babič, "Measurement of fluid flow generated by artificial cilia", In: *Proceedings*, 2nd European Conference on Microfluidics Microfluidics 2010 (MicroFlu'10), December 8-10, 2010, Toulouse, France, Stéphane Colin, ed., Gian Luca Morini, ed., Paris, Societe Hydrotechnique dee France, 2010, 9 pp.
6. Boris Majaron, Matija Milanič, Wangeun Jia, J. Stuart Nelson, "3D Monte Carlo model of optical transport in laser-irradiated cutaneous vascular malformations", In: *Laser applications in life sciences: 9-11 June 2010, Oulu, Finland*, (Proceedings of SPIE, vol. 7376), Matti Kinnunen, ed., Risto Myllylä, ed., Bellingham, SPIE, 2010, pp. 737608-1-737608-10.
7. Matija Milanič, Vojko Jazbinšek, Rok Hren, "Assessment of regularization techniques used in electrocardiographic imaging", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniske konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, pp. B: 319-322.
8. Maja Remškar, Marko Viršek, Aleš Mrzel, J. P. Canejo, Helena M. Godinho Godinho, "The MoS_2 nanohybrids grown in a confined geometry of nanotube reactors", In: *The proceedings of the Twentieth (2010) International Offshore and Polar Engineering Conference: Beijing, China, June 20-25, 2010: ISOPE-2010 Beijing*, Cupertino, International Society of Offshore and Polar Engineers, cop. 2010, pp. 510-513.
9. Andrej Vilfan, Anton Potočnik, Blaž Kavčič, Natan Osterman, Gašper Kokot, Mojca Vilfan, Igor Poberaj, Dušan Babič, "Magnetically driven self-assembled artificial cilia", In: *Proceedings*, 2nd European Conference on Microfluidics Microfluidics 2010 (MicroFlu'10), December 8-10, 2010, Toulouse, France, Stéphane Colin, ed., Gian Luca Morini, ed., Paris, Societe Hydrotechnique dee France, 2010, 9 pp.

Textbooks and Lecture Notes

1. Martin Čopič, *Fizika II*, Ljubljana, Fakulteta za matematiko in fiziko, Oddelek za fiziko, 2007-.
2. Viktor V. Kabanov, *Polarons: from single polaron to short scale phase separation: lecture notes for the subjets of "Theory of nanomaterials"*, Ljubljana, Jozef Stefan International Postgraduate School, 2010.
3. Boris Majaron, Marko Mikuž, Anton Ramšak, *Kolokvijske naloge iz fizike I*, (Zbirka izbranih poglavij iz fizike, 32), 4. popravljena izd., Ljubljana, DMFA - založništvo, 2010.
4. Marko Zgonik, Martin Horvat, *Praktikum II*, Ljubljana, Fakulteta za matematiko in fiziko, Oddelek za fiziko, 2008-.

Patent

1. Marko Marinček, Marko Čenčič, *Laser system: US7778306 (B2)*, [S. l.], United States Patent and Trademark Office, 17. avg. 2010.

Patent Application

1. Aljaž Drnovšek, Dragan D. Mihailović, *An array smell sensor based on the measurement of the junction resistence of nanowires with different metals: P-201000461,* Ljubljana, Urad RS za intelektualno lastnino, 2010.

DEPARTMENT OF REACTOR PHYSICS
F-8

During the past year we have been working mainly on:

- ***theoretical, experimental and applied reactor physics***
- ***plasma physics***
- ***neutron-transport calculations***
- ***physics of semiconductors***
- ***medical physics***

Head (since 8. 11. 2010):
Asst. Prof. Andrej Trkov

Head (until 7. 11. 2010):
Prof. Bogdan Glumac

Our research in the field of **reactor physics** was continued with the development of new methods for the analysis of research and power reactors. Special attention was devoted to the experiments for the validation of the computational model of the TRIGA reactor benchmark, which is unique due to its high sensitivity to the nuclear data of zirconium and zirconium hydride. In this way we combined theoretical and experimental reactor physics within the scope of an international effort under OECD/NEA and coordinated by the Idaho National Laboratory. We also studied the effects of self-shielding in samples irradiated in a reactor, which is important for analysing reactor experiments and for routine sample analyses by the neutron-activation method. Through international collaboration we also continued work on evaluations of nuclear data and their covariance information, including studies of their impact on the uncertainties in the calculated integral parameters. The results of our studies will have important implications on how the covariances of the resonance parameters are stored in evaluated nuclear data files.

In the field of **plasma physics** studies were made of the potential formation in front of an electron-emitting electrode immersed in a plasma that contains an additional energetic electron population. Previous investigations, where the energetic electron population was modelled by a high-temperature Maxwellian, have been continued in the direction, where the energetic electron population has the form of a mono-energetic electron beam. Two cases have been studied: a one-dimensional beam perpendicular to the electrode and an isotropic, mono-energetic beam. Main attention was focused on the transition between the space-charge-limited and temperature-limited emission. The results were published in two papers. We prepared a simulation model for emissive surfaces in edge plasmas of small/middle-sized tokamaks and used it with success for simulating a planar emissive probe. Partice-in-cell codes were also used for the calculation of the polytropic coefficient in edge plasma with an oblique magnetic field applied. It was noticed that the magnetic field has a strong effect on the formation of the coefficient profile due to additional drifts. We also started developing a two-electron-temperature plasma model with oblique magnetic field and emitted electrons. We have also investigated the potential formation in front of a floating electrode that is immersed in plasma that contains two species of positive ions. Using a kinetic model and a PIC simulation we confirmed that at the sheath edge each ion species reaches its own Bohm velocity.

In the field of **neutron-transport calculations** we continued our collaboration with JET – Joint European Torus, the largest fusion reactor in the world. Co-workers of the Reactor physics division have performed longer visits to JET in order to analyze the differences due to the planned change of the torus first wall to beryllium in view of the change in the neutron field. The IJS staff is co-responsible for the maintenance of the JET model for transport calculations with the Monte Carlo method and in 2010 our model has been improved and harmonized with the condition after the present shut-down. The new model delivered a good insight into the expected changes due to future constructional changes. It was proven that the introduction of larger quantities of beryllium, known to have a large (n,2n) reaction cross-section, does not significantly affect the neutron multiplication in the torus.

We also collaborate on the project of neutron detector calibration. Our tasks are transport calculations for the determination of the calibration uncertainties and the determination of corrections, arising from the operating conditions, which differ from the conditions during calibration, e.g., in-vessel structures, neutron spectra, neutron source shape, etc.

Additionally, we have calculated the neutron detector response and its dependence on the change of particular torus structures and predicted stable detection, independent of torus configuration changes. The work on the JET gamma camera was continued with a calculation of the radiation field at the position of the KN3 detectors and its response per source neutron. The activation of the torus first wall components due to neutron interaction was calculated by coupling the neutron transport and activation codes.

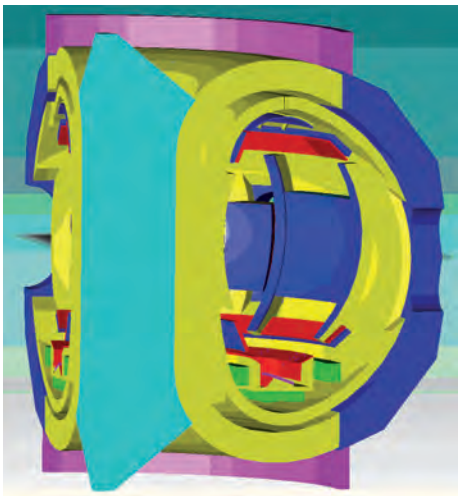

Figure 1: Display of the MCNP model for the fusion reactor JET (Abingdon, UK), maintained and upbraded by co-workers of the Reactor physics division – JSI. MCNP is widely used program for transport calculations based on the Monte Carlo method

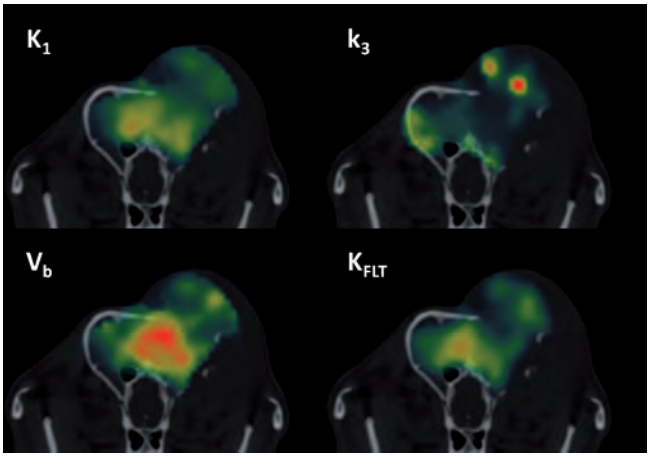

Figure 2: Axial view on CT image of laboratory animal (canine) with overlay of parametric images that were acquired with kinetic analysis of dynamic FLT PET images. Four parametric images show perfusion (K_1), cellular proliferation (k_3), vasculature fraction (V_b) and FLT tumor uptake (K_{FLT}). Presented laboratory animal is included in study of dose painting, based on FLT PET images.

In the area of **particle radiation effects on the trap density in organic semiconductors** the two, in the literature, well-established models of current-voltage characteristics of single layer metal/organic structures were re-examined. In the article entitled "The elimination of interface charge density singularity in single layer organic semiconductor structures" the arguments are presented that the assumption of a zero electric field at the charge carrier injection electrode/organic interface, as assumed by the current-voltage model of shallow traps occupying a single energy level within the organic semiconductor charge transport band, as well as by the model of traps exponentially distributed in energy, is invalid in principle. A set of published room-temperature current-voltage data of a single layer, electron-only, metal/organic semiconductor structure is used in order to show explicitly that the singularity of free (or total) electron charge carriers at the injecting interface and the associated space charge limited current characteristics reflects an unrealistic assumption of the above two models. It is also shown that the drift-diffusion electron transport interpreted in terms of the single energy level shallow trap model is incompatible with the published measurements.

Our research in the field of **medical physics** is directed towards image-guided cancer therapy. Within this general area, our research is grouped into five focused areas. The first area is the quantitative imaging of cancer, which includes a comprehensive assessment of PET imaging uncertainties, the impact of patient set-up and motion on the quantification of PET images, the modelling of radiopharmaceuticals uptake into the tumours and the quantification of vasculature imaging. The second area is imaging for biological target definition, which covers multimodality imaging for comprehensive determination of tumour biology, the characterization of tumour heterogeneity, the dose prescription function for dose painting, the delivery of dose painting with helical tomotherapy and robust target definition. The third focus area is imaging for treatment assessment, which covers robust treatment assessment of a molecular-targeted therapies, treatment assessment in metastatic bone diseases, assessment of normal tissue response to therapies and deformable registration. The fourth area is modelling of tumour growth and response to therapies, which includes the modelling of tumour growth and response to therapy, modelling vasculature growth and the response to anti-angiogenic therapies and combination of external beam and targeted radionuclide therapy. The fifth area is open-source medical devices that covers the development of an open-source small-animal imaging/therapy device.

Some outstanding publications in the past year

1. Bruno Cvikl. The drift-diffusion interpretation of the electron current within the organic semiconductor characterized by the bulk single energy trap level. J. Appl. Phys., 2010, vol. 107, p. 023710-1-023710-9.
2. T. Gyergyek, J. Kovačič, M. Čerček. A fluid model of the sheath formation in front of an electron emitting electrode with space charge limited emission immersed in a plasma that contains a one-dimensional mono-energetic electron beam, Contributions to Plasma Physics, 50, p. 121-134, (2010).
3. T. Gyergyek, J. Kovačič, M. Čerček. Potential formation in front of an electron emitting electrode immersed in a plasma that contains a monoenergetic electron beam, Physics of Plasmas, 17, 083504, (2010).
4. R. Jeraj, Y. Cao, R.K. Ten Haken, et al. Imaging for assessment of radiation-induced normal tissue effects. Int J Radiat Oncol Biol Phys 2010;76:S140-4.
5. U. Simončič and R. Jeraj. Cumulative input function method for linear compartmental models and spectral analysis in PET. J Cereb Blood Flow Metab 2010.

Organization of conferences, congress and meetings

1. International Conference »Nuclear Energy for New Europe 2010, Portorož, Slovenia, 6. 9. – 9. 9. 2010 (160 participants from 22 countries and International Atomic Energy Agency, 106 contributions)
2. International Criticality Safety Benchmark Evaluation Project (ICSBEP) Working Group Meeting, Hotel Union and Reactor Centre IJS, Ljubljana, Slovenia, 3. 5. – 7. 5. 2010 (50 participants from 8 countries) (co-organization)

INTERNATIONAL PROJECTS

1. Fusion Expo Activities under an EFDA
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   WP10-PIN-FUSEX
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Igor Lengar, Melita Lenošek Kavčič, B. Sc., Asst. Prof. Saša Novak Krmpotič
2. Accurate Nuclear Data for Nuclear Energy Sustainability
   ANDES
   7. FP – EURATOM, 249671
   EC; Dr. Enrique Miguel Gonzalez Romero, Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas-CIEMAT, Madrid, Spain
   Asst. Prof. Andrej Trkov
3. Improvement of Diagnostics in Edge Plasmas of Fusion Devices - 1.2.1.-FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Tomaž Gyergyek
4. Upgrade of Gamma-Ray Cameras: Neutron Attenuators - J1/b - 2.2.1. FU EURATOM-MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065, JW6-TA-EP2-GRC-02, JW8-NEP-MHST-02, JW9-NEP-MHST-02
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Igor Lengar
5. Neutron Calculation for Fusion Reactor – Neutron Source - 3.4.2.-FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Dr. Luka Snoj
6. Neutron Calculation for Fusion Reactor - JET MCNP Model - 3.4.1. – FU10
   JET MCNP Model 3.4.1., TA JW10-FT-JET-5.34/JW10-NFT-MHST-04
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Igor Lengar
7. Research Unit - Administration and Services - RU-FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Prof. Milan Čerček, Asst. Prof. Saša Novak Krmpotič
8. Fusion Expo Activities under an EFDA
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Igor Lengar, Melita Lenošek Kavčič, B. Sc., Sabina Markelj, B. Sc., Asst. Prof. Saša Novak Krmpotič, Štefan Kolenko
9. F4E - Action 2 - Nuclear Data Experiments and Techniques ACTION F4E-GRT-056 (ES-AC)
   ACTION 2
   Dr. Paola Batistoni, ENEA - Agenzia nazionale per le nuove tecnologie l´energia e lo sviluppo economico sostenibile, Frascati (Rome), Italy
   Dr. Ivan Aleksander Kodeli
10. F4E - Nuclear Data, Studies/Experiments in Support of TBM Activities (NUDATA_Exper), Task 5
    F4E-2008-GRT-014-02 (ES-AC)
    Fusion for Energy, The European Joint Undertaking for ITER and the Development of Fusion Energy, Barcelona, Spain; Paola Bastioni, Enter per le Nuove Technologie, l´Energia e l´Ambiente - ENEA, Rome, Italy
    Dr. Ivan Aleksander Kodeli
11. F4E - Improvement of Nuclear Data, Development of Tools and Experiments/Validation in Support of ITER Activities (NUDATA_Files) - A1/T7 - 1.1. FU
    F4E-2008-GRT-014-01 (ES-AC)
    Fusion for Energy, The European Joint Undertaking for ITER and the Development of Fusion Energy, Barcelona, Spain; Dr. Jean-Christophe Sublet, United Kingdom Atomic Energy Authority (UKAEA), Oxfordshire, Great Britain
    Asst. Prof. Andrej Trkov
12. Working Group 6 - Conrad: Computational Dosimetry, Task on Standard Monte Carlo Modelling of a Medical Linac (Priority 2), Subtask: Uncertainty Assessment for Radiation Dosimetry (Priority 3)
    EURADOS
    G. Gualdrini, ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Montecuccolino Laboratories, Bologna, Italy
    Dr. Ivan Aleksander Kodeli
13. Evaluation and Validation of Promt Fission Neutron Spectra and the Corresponding Covariance Matrices
    15794/R0
    Teresa Ann Benson, IAEA - International Atomic Energy Agency, Vienna, Austria
    Dr. Ivan Aleksander Kodeli
14. Improvement of Evaluated Nuclear Data Files with Emphasis on Activation and Dosimetry Reactions
    14914/R0, R1
    Teresa Ann Benson, IAEA - International Atomic Energy Agency, Vienna, Austria
    Asst. Prof. Andrej Trkov
15. Investigation of Boundary Plasmas and Development of Diagnostic Methods with Emissive Probes Reactions
    BI-AT/09-10-013
    Dr. Cordina Ioniță-Schrittwieser, Institute for Ion Physics and Applied Physics, Leopold-Franzens-University of Innsbruck, Innsbruck, Austria
    Prof. Milan Čerček

R & D GRANTS AND CONTRACTS

1. Concrete Construction Properties and Water Seeping Through Concrete Structures
   Asst. Prof. Andrej Trkov, Dr. Igor Lengar
2. Development of Diagnostics for Certain Parameters of the Edge Plasma in Fusion Devices
   Asst. Prof. Andrej Trov, Prof. Milan Čerček
3. A Study of Plasma Parameters for Conditioning of the Inner Surfaces of a Fusion Reactor
   Asst. Prof. Andrej Trkov, Asst. Prof. Tomaž Gyergyek

RESEARCH PROGRAM

1. Reactor physics
   Asst. Prof. Andrej Trkov

NEW CONTRACTS

1. Reload operational core analysis, post refueling nuclear design check tests, PIS and KFSS cycle specific data for future fuel cycles, for Cycle 25
   Krško Nuclear Power Plant
   Dr. Marjan Kromar
2. Safety evaluation screening and safety evaluation in accordance with ESP 2.303; USAR change package in acordance with ESP2.302
   Institute of metals and technology
   Dr. Marjan Kromar

VISITORS FROM ABROAD

1. Dr. Jacques Maillard, CNRS – IDRIS, Orsay, France, 22. 2. – 24. 2. 2010
2. Dr. Sehila M. Gonzales de Vicente, programme leader for "Materials" at the European Fusion Development Agreement – EFDA, Garching, Germany, 9. 3. 2010
3. Dr. J. Blair Briggs, Idaho National Laboratory, Idaho, USA; Dr. Richard McKnight and Dr. Richard Lell, Argonne National Laboratory, Illinois, USA, 3. 5. - 7. 5. 2010
4. Prof. dr. Tsviatko Popov and Pavlina Ivanova, Faculty for Physics, University "St. Kliment Ohridski", Sofia, Bulgaria, 3. 5. – 14. 5. 2010 (T. Popov) and 3. 5. – 28. 5. 2010 (P. Ivanova)
5. Marian Dragos Nicolescu, University "Ovidius", Constanta, Romania, 1. 7. – 31. 7. 2010
6. Matej Peterka, Karlova University in Prague, Czech republic, 5. 7. – 18. 7. 2010
7. Jiri Adamek, Plasma Physics Institute, Czech Academy of Sciences, Association EURATOM/MPP CR, Prague, Czech republic, 11. 7. – 14. 7. 2010
8. Dr. Codrina Ionita Schrittwieser, Prof. Roman Schrittwieser and Hannes Gruenwald, Institute for Ion Physics, University of Innsbruck, Austria, 18. 7. – 31. 7. 2010
9. Dr. Roberto Capote Noy, International Atomic Energy Agency, Vienna, Austria, 16. 8. – 27. 8. 2010
10. Dr. Brian Syme, Head of the Neutron Diagnostics Group, JET – Joint European Thorus, Culham Centre for Fusion Energy, Culham, United Kingdom, 8. 9. – 11. 9. 2010

11. Dr. Enrico Sartori, NEA Data Bank, Issy-les-Moulineaux, France, 6. 9. – 9. 9. 2010
12. Hannes Gruenwald, Institute for Ion Physics, University of Innsbruck, Austria, 17. 10. – 30. 10. 2010
13. Dr. Christophe Destouche, Dr. Geslot Benoit, Dr. Barbot Loic and Dr. Gregoire Gilles, CEA, Cadarache, France, 8. 11. – 10. 11. 2010

STAFF

Researchers
1. Prof. Bruno Cvikl*
2. Prof. Milan Čerček
3. ***Prof. Bogdan Glumac, Head, retired 08.11.10***
4. Asst. Prof. Tomaž Gyergyek*
5. Asst. Prof. Robert Jeraj
6. Dr. Ivan Aleksander Kodeli
7. Dr. Marjan Kromar
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10. Asst. Prof. Tomaž Žagar*

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14. Urban Simončič, B. Sc.
15. Gašper Žerovnik, B. Sc.

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16. Alberto Milocco, M. Sc.

Technical and administrative staff
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18. Slavko Slavič, B. Sc.
19. Darinka Stich
20. Uršula Turšič, B. Sc.
21. Bojan Žefran

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

1. D. Barbee, Ryan T. Flynn, James E. Holden, Robert J. Nickles, Robert Jeraj, "A method for partial volume correction of PET-imaged tumor heterogeneity using expectation maximization with a spatially varying point spread function", *Phys. Med. Biol.*, vol. 55, issue 1, pp. 221-236, Jan. 2010.
2. Bruno Cvikl, "The drift-diffusion interpretation of the electron current within the organic semiconductor characterized by the bulk single energy trap level", *J. appl. phys.*, iss. 2, vol. 107, pp. 023710-1-023710-9, 2010.
3. Milan Čerček, Gregor Filipič, Tomaž Gyergyek, Jernej Kovačič, "Floating potentials in two-electron temperature plasma with two species of positive ions: kinetic model and PIC simulation", In: (Contributions to plasma physics, vol. 50, no. 9), 8th International Workshop on Electric Probes in Magnetized Plasmas, September 21-23 2009, Innsbruck, Austria, Karl-Heinz Spatschek, ed., Roman Schrittwieser, ed., M. Laux, ed., Berlin, Akademie-Verlag, 2010, pp. 909-914.
4. Tomaž Gyergyek, Jernej Kovačič, Milan Čerček, "A fluid model of the sheath formation in front of an electron emitting electrode with space charge limited emission immersed in a plasma that contains a one-dimensional mono-energetic electron beam", *Contrib. Plasma Phys. (1988)*, vol. 50, no. 2, pp. 121-134, 2010.
5. Tomaž Gyergyek, Jernej Kovačič, Milan Čerček, "Potential formation in front of an electron emitting electrode immersed in a plasma that contains a monoenergetic electron beam", *Phys. plasmas*, vol. 17, no. 8, pp. 1-16, 2010.
6. Radojko Jaćimović, Andrej Trkov, Gašper Žerovnik, Luka Snoj, P. Schillebeeckx, "Validation of calculated self-shielding factors fot Rh foils", In: *Proceedings*, (Nuclear instruments & methods in physics research. Section A, Accelerators, spectrometers, detectors and associated equipment, Vol. 622, issue 2), 5th International k[sub]0-Users Workshop, 13-17 September 2009, Belo Horizonte, Belo Horizonte, 2010, pp. 399-402.
7. Keisha C. McCall, D. Barbee, M.W. Kissick, Robert Jeraj, "PET imaging for the quantification of biologically heterogeneous tumours: measuring the effect of relative position on image-based quantification of dose-painting targets", *Phys. Med. Biol.*, vol. 55, pp. 2789-2806, 2010.
8. Luka Snoj, Andrej Kavčič, Gašper Žerovnik, Matjaž Ravnik, "Calculation of kinetic parameters for mixed TRIGA cores with Monte Carlo", *Ann. nucl. energy*, iss. 2, vol. 37, pp. 223-229, 2010.
9. Gašper Žerovnik, Janez Žerovnik, "Constructive heuristics for the canister filling problem", *Cent. Eur. j. oper. res.*, 19 pp., 2010.

Review Articles and Chapters in Books

1. Alberto Milocco, Andrej Trkov, Ivan Aleksander Kodeli, "The OKTAVIAN TOF experiments in SINBAD: Evaluation of the experimental uncertainties", *Ann. nucl. energy*, vol. 37, issue 4, pp. 443-449, 2010.

Published Conference Papers

Invited Paper

1. Radojko Jaćimović, Andrej Trkov, Peter Stegnar, "Temporal variation of the neutron flux in the carousel facility of the TRIGA Mark II reactor for diffrernt core set up", In: *Book of abstracts*, Fourth International Symposium on Nuclear Analytical Chemistry (NAC-IV), November 15-19, 2010, Mumbai, Mumbai, Department of Atomic Energy India, 2010, pp. 93-95.

Regular papers

1. P. Batistoni, M. Angelone, P. Carconi, U. Fischer, K. Fleischer, K. Kondo, A. Klix, Ivan Aleksander Kodeli, D. Leichtle, L. Petrizzi, M. Pillon, W. Pohorecki, M. Sommer, Andrej Trkov, R. Villari, "Neutronics experiments on HCPB and HCLL TBM mock-ups in preparation of nuclear measurements in ITER", In: *Proceedings of the ninth international symposium on fusion nuclear technology: Dalian, China, 11-16 October 2009*, (Fusion engineering and design, Vol. 85, Issues 7-9), M. A. Abdou, ed., Amsterdam, North-Holland, 2010, pp. 1675-1680.
2. Bruno Cvikl, Matjaž Koželj, "On the violation of the Frenkel enhanced space charge limited current effect for Alq[sub]3 organic semiconductor", In: *Proceedings*, Denis Đonlagić, ed., Iztok Šorli, ed., Polona Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2010, pp. 107-111, 2010.
3. Milan Čerček, Boris Fonda, Tomaž Gyergyek, Gregor Filipič, Jernej Kovačič, C. Ionita, Roman Schrittwieser, "Experimental study of the perturbation of a weakly magnetized plasma column by an emissive probe", In: *International Conference on Plasma Diagnostics, April 12-16, 2010, Pont-à-Mousson, France*, Nancy, Université, 2010, pp. 1-4.
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Research Monographs

1. John D. Bess, Nozomu Fujimoto, Barbara Dolphin, Luka Snoj, Atsushi Zukeran*, Evaluation of the start-up core physics tests at Japan's high temperature engineering test reactor (fully-loaded core)*, (INL/EXT, 08-14767), Idaho Falls, INL, 2010.
2. John D. Bess, Nozomu Fujimoto, James W. Sterbentz, Luka Snoj, Atsushi Zukeran*, Evaluation of the start-up core physics tests at Japan's high temperature engineering test reactor (annual core loadings)*, (INL/EXT, 09-15794), Idaho Falls, INL, 2010.
3. R. Capote, L. Leal, Ping Liu, Tingjin Liu, P. Schillebeeckx, M. Sin, I. Sirakov, Andrej Trkov, *Evaluated nuclear data for nuclides within the thorium-uranium fuel cycle*, Vienna, International Atomic Energy Agency, 2010.
4. Evgeny Ivanov, Ivan Aleksander Kodeli, Anatoli Tsiboulia, Barbara Dolphin, Virginia Dean*, SNEAK 7A and 7B PU-fueled fast critical assemblies in the Karlsruhe fast critical facility*, (IPNO-DR, 09-03), Paris, IPN, 2009.

DEPARTMENT OF EXPERIMENTAL PARTICLE PHYSICS F-9

Departmental research is devoted to experimental studies of elementary particles, to reveal the ultimate building blocks of matter and the nature of the interactions between them. Experiments are carried out within large collaborative programmes at international centres for particle physics at CERN, near Geneva, and at KEK, in Tsukuba. The department is also engaged in developing and applying technologically advanced particle detectors, which are demanded by such measurements. Astroparticle physics is an emerging field applying the experimental techniques of particle physics to solve astrophysical problems. Slovenian researchers are participating in measurements of ultra-high-energy cosmic rays with the Pierre Auger observatory spread over a surface of 3000 km² near Malargue in Argentina.

Head:
Prof. Marko Mikuž

In order to reveal the ultimate secrets of nature in the world of elementary particles, accelerators with higher and higher energies are needed. Their cost, both in terms of money and human resources, has grown to the level where they are affordable only as joint, international enterprises. Thus, future accelerators will be unique facilities of their kind, the first being the Large Hadron Collider (LHC), just completed at the European Organization for Nuclear Research (CERN) near Geneva. Researchers will exploit this facility to perform experiments in presently inaccessible regions of energy, which, though pushed higher and higher, still remain minute compared to that of the vast blast of the Big Bang that led to the creation of the Universe.

The Large Hadron Collider operated stably over the whole of 2010, enabling the ATLAS detector to produce relevant physics results from proton-proton and lead-lead collisions at unprecedented energies.

Together with colleagues from the Physics Department of the Faculty of Mathematics and Physics and the Faculty of Electrical Engineering of the University of Ljubljana, and from the Faculty of Chemistry and Chemical Technology of the University of Maribor, we are performing measurements at CERN and the Japanese centre KEK in Tsukuba. We are taking part in two experiments, each conducted as an international collaboration:

- ATLAS at the Large Hadron Collider (LHC) at CERN (3000 researchers, 174 institutions from 38 countries),
- Belle at the asymmetric electron-positron collider (KEK-B) at KEK (409 researchers, 62 institutions from 15 countries)

In the field of astroparticle physics we are part of the Pierre Auger collaboration (250 researchers, 94 institutions from 17 countries), which uses a giant scale (3000 km²) observatory near Malargue in Argentina for the detection of ultra-high-energy cosmic rays. This endeavour is carried out in collaboration with colleagues from the University of Nova Gorica.

A more detailed report on the 2010 activities follows, focused on the contributions of our researchers:

ATLAS experiment

For the ATLAS collaboration, 2010 constituted the first physics year, harvesting the record energy proton-proton collisions at 7 TeV centre of mass. The Large Hadron Collider started the collisions at the end of March and then continued at an ever-increasing rate until November. The instantaneous luminostity, a measure of the collision rate, was boosted by a factor of 100,000 and reached $2x10^{32}$ $cm^{-2}s^{-1}$. This surpasses the planned luminosity by a factor of two, but it is still a factor of 50 below the nominal LHC luminosity. The integrated luminostity in the ATLAS detector reached 45 pb^{-1} (Fig. 1), but remained somewhat under target, as peak performance and machine development were given priority over stable running for physics.

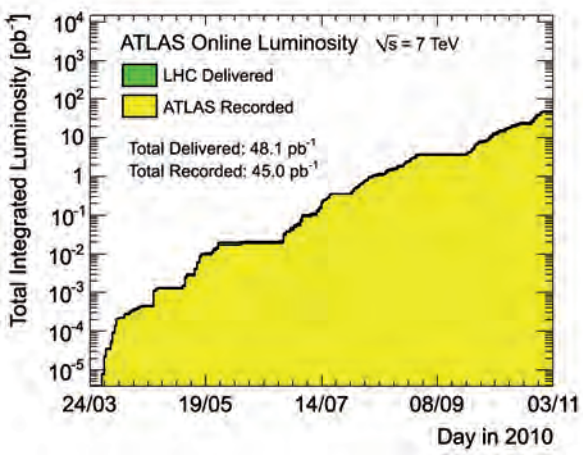

Figure 1: Development of integrated luminosity of 7 TeV proton-proton collisions in the Large Hadron Collider as delivered to the ATLAS detector.

Despite the smaller accumulated data sample the ATLAS collaboration was able to publish plenty of significant physics results. Production of all the known Standard Model particles in 7-TeV proton-proton collisions has been measured and the corresponding cross-sections were determined. The most relevant result is based on two jet analyses, where the invariant mass spectrum shows no influence stemming from a composite heavy quark. Due

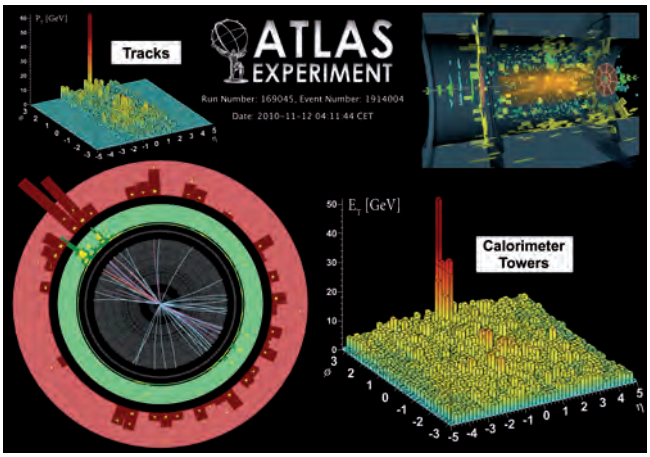

Figure 2: Computer visualization of a lead-lead collision event at 2.76 TeV per nucleon pair with two heavily imbalanced jets in the ATLAS detector. One of the parent quarks dissipated a sizable fraction of its initial energy when traversing the quark-gluon plasma.

to the high collision energy the lower limit on the mass of the composite quark could be pushed by a factor of two compared to the previous Tevatron result into the TeV range.

In November, lead-ion beams were replacing protons in the LHC. Although inferior by a factor of 2.5 (82/207) in terms of collision energy per nucleon pair, the superior total energy and the large collision volume make the quarks and gluons in the nucleons melt to form the quark-gluon plasma, a state of matter present in the early Universe. The main achievement of the ATLAS detector was the observation of jet quenching in central ion-ion collisions. A hard collision can result in a back-to-back quark pair, which normally appears as two transversely balanced jets in the detector. Yet due to the traversal of the colour-rich plasma medium, one of the quarks often loses a substantial amount of its energy, giving rise to strikingly imbalanced jets (Fig. 2).

During the running of the LHC, the efforts of our group were concentrated on the Beam Conditions Monitor (BCM), designed and built to warn of a possible beam loss and prevent damage to the detector. Diamond detectors record the passage of charged particles with a sub-ns time resolution, which enables a clear separation of events due to individual bunch-bunch collisions from the beam-induced background. We completed the logic circuit (FPGA), which indicates the danger of beam instability and records the luminosity of individual colliding bunches. The increased beam energy and luminosity rendered the BCM too sensitive, and it had to be removed from the beam abort logic. It remained, however, an important tool for beam-quality assessment. To retain adequate protection, an additional system the Beam Loss Monitor (BLM) was commissioned. It is based on an ionization current measurement in 12 diamond ionization chambers. The current is integrated over half an LHC orbit (40 μs), and upon exceeding a predefined threshold value a beam dump signal is issued.

After accurate measurements of the CP symmetry violation in the B meson system, the Belle Collaboration performed a series of measurements of extremely rare processes, which limit the set of models used to describe the so-called New Physics. These processes will be examined with a much greater accuracy with the Belle II detector, to start operating in 2014.

In 2010 the ATLAS experiment produced about 1.6 PBytes of raw data, corresponding to a quantity of data that can be written on 2.5 million CDs. The data will increase to 5 PBy in 2011, and by an additional factor of 30 during the experiment's life-cycle. It is thus impossible to store and process the data within a single computing centre. The network infrastructure is thereby an additional bottleneck. One cannot expect such a quantity of data to be sent over the Internet more than once: from CERN, where the experiment will take place, to one of the computing centres, where the data will actually be stored, and where particular data-processing procedures and physics analyses will take place according to the needs of the ATLAS collaboration. The use of Grid technology is the only solution facilitating a fast data transfer from the collider to remote centres where such quantities of data can be stored at a sufficient rate. Due to the quantity of data and the complexity of the processing it is mandatory to use Grid technologies also for data processing, since none of the research centres has enough storage and computing capacity.

Our computing cluster at Tier-2 level (SiGNET) is a member of the European Grid Infrastructure (EGI) and the Nordugrid collaboration. The cluster of 1150 cores and 600TB of storage, which are steadily upgraded, was participating in the production and reconstruction of data taken with the ATLAS detector at the LHC, making a significant (percent level) contribution to production among the 200 computing centres. We have successfully organized a workshop of the Nordugrid collaboration. In cooperation with ARNES, the Slovenian NGI was strengthened to actively participate in the European EGI initiative.

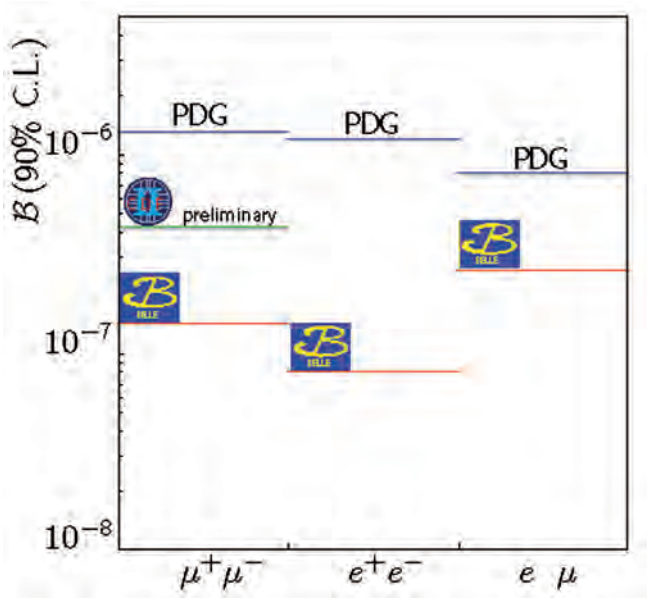

Figure 3: The measured upper limits for the rate of the decays $D^0 \to l^+ l^-$. The measurement of the Belle collaboration [1] is by far the most sensitive and enables us to constrain the parameters of the models that describe the New Physics

Belle detector at the asymmetric electron positron collider KEKB at KEK

One of the important unsolved questions of modern science is why we are living in a universe, in which matter (particles) totally dominates over antimatter (antiparticles). The necessary condition for this to happen

is a violation of the CP symmetry, which can be measured in the world of elementary particles as the difference between the decays of particles and their antiparticles. In more than a decade of measurements of violation of CP symmetry in the B meson system with the Belle detector at the KEKB collider, the predictions of the Kobayashi-Maskawa model, which theoretically describes the CP violation, were accurately confirmed, for which the Japanese theorists received the Nobel Prize for Physics in 2008. It also became clear that the observed asymmetry between the particles and antiparticles is too small to explain the dominance of matter over antimatter in the universe. Hence, there must exist as yet unknown particles and processes, which are popularly known as New Physics (NP). The purpose of the latest, extremely accurate, measurements using data recorded by the Belle detector, which stopped operation in July this year, and the planned measurements with the upgraded collider SuperKEKB and Belle II detector, which are expected to start taking data in 2014, is the search and the identification of the NP processes. In 2010, we published so far the most sensitive measurement of the D^0 meson decays into a pair of charged leptons (e^+e^- or $\mu^+\mu^-$) [1]. In the Standard Model of elementary forces between particles, these decays are extremely rare. The measured upper limits for the rates of these decays allow us to constrain several parameters of the models describing the NP processes. We searched for unknown sources of CP violation, for example by measuring the asymmetry between the rates of the decays $B^+ \rightarrow J/\Psi K^+$ and $B^- \rightarrow J/\Psi K^-$. The asymmetry was determined with an accuracy of 0.55% and also constrains some of the models of NP. While the mentioned measurements do not show deviations from the predictions of the Standard Model, the small signs of inconsistencies of the theory appear in the measurements of the B meson decays into a τ lepton and a neutrino. The measurement [2] is difficult, because the neutrinos are not detectable with the Belle detector. The rate of these decays, $(1.54 \pm 0.48)\cdot 10^{-4}$ (about 1 in 10000 B mesons decays in this way) is not entirely in agreement with the theoretical prediction $0.76\cdot 10^{-4}$. With the Belle II detector it will be possible to accurately check this and similar signs of inadequacy in the Standard Model.

Figure 4: Čerenkov detectors placed in the so-called Ground Array. More than 1600 such detectors measure high-energy particles through their interaction with water

Pierre Auger observatory

The Pierre Auger collaboration has constructed a huge high-energy cosmic ray observatory in Argentina covering a surface of more than 3000 km^2. The Pierre Auger Observatory is a "hybrid detector", employing two independent methods to detect high-energy cosmic rays. One technique detects high-energy particles through their interaction with water in more than 1600 Čerenkov detectors placed in the so-called Ground Array. The other technique tracks the development of air showers by detecting the ultraviolet light emitted high in the Earth's atmosphere. The observatory, originally sensitive to the cosmic rays with energies above 10^{19} eV, was recently upgraded with HEAT (High Elevation Auger Telescope), extending the sensitivity to lower energies.

Measurements of the Pierre Auger experiment are supporting the reduced correlation between the mass distribution in the Universe and the direction of cosmic rays

The energy spectrum has been recently published covering the energy range from 10^{18}eV to above 10^{20} eV. The position of the ankle and a flux suppression above it have been determined. The suppression is similar to what is expected from the GZK effect for protons or nuclei as heavy as iron, but could also be related to a change of the injection spectrum at the sources. Analyses of both the mean values and of the fluctuations of the shower maximum $\langle X_{max} \rangle$ reveal a change in the energy dependence of the composition around the ankle and a gradual increase in the average mass of cosmic rays with energy, provided that there are not significant changes in the properties of the hadronic interactions at ultra-high energies.

A detailed comparison of the muonic and electromagnetic content of the air showers far from the core shows an excess in the number of muons as compared to the protons' simulations. Showers initiated by photons and neutrinos have distinct signatures compared to showers initiated by protons or other nuclei, being possible to discriminate them and set bounds on their fluxes. The neutrino and photon bounds already exclude 'top-down' models for the production of ultra-high energy cosmic rays, favouring the acceleration in astrophysical scenarios.

Figure 5: Assembly of a silicon detector module for the PET probe.

It was shown that the arrival directions of cosmic rays with energy in excess of 55 EeV correlated with the positions of nearby AGN. As further data has been added, the degree of correlation has decreased. The region of the sky with the largest observed excess with respect to isotropy corresponds to Centauri A, which is the closest AGN. Nevertheless, at present there are multiple astrophysical models of anisotropy, which are fully consistent with the observed distribution of arrival directions. Our group is involved in data analysis, the LIDAR system operation, the development of the offline data-analysis package and the detectors' simulation and calibration.

Detector development

In collaboration with CERN, University of Valencia, University of Michigan, Ann Arbor and Ohio State University we constructed a silicon high-resolution PET probe. Such a probe as an add on to the usual PET scanner improves the resolution and diagnostic capabilities of the PET system.

Based on the successful measurement with a silicon photomultiplier detector module we created a new type of apparatus for positron tomography (PET) and measured its energy and time resolution. Such a counter is an extremely interesting candidate for dual-modality medical imaging, where a PET apparatus is embedded in an MRI imager, and the light sensors have to operate in magnetic fields exceeding 2 T. This research is a part of the FP7 research project aimed at the development of novel detection methods for particle physics and medical imaging. In preparation for the next generation of measurements of rare phenomena in B mesons decays with the Belle II spectrometer, we continued our study of sensors for two ring imaging Cherenkov detectors. In collaboration with leading producers in this area, Hamamatsu (Japan) and Photonis (France), we studied the characteristics of photomultiplier tubes with micro-channel plates and hybrid photon detectors with avalanche photodiodes as for photoelectron detectors.

We continued with the development of silicon detectors operating in high radiation fields. We irradiated the detectors at the Reactor Centre Podgorica to high neutron doses (10^{16} cm^{-2}), and measured the multiplication of free charge carriers near the electrodes. This phenomenon will allow the successful use of Si detectors in the upgrade of the ATLAS spectrometer.

Organization of conferences, congress and meetings

1. Workshop: 3rd MC-PAD Network Training Event on Radiation Hardness and Silicon processing and the Project Midterm Review, Institut Jožef Stefan, Ljubljana, Slovenia, 27. 9. 2010 – 29. 9. 2010

INTERNATIONAL PROJECTS

1. European Grid Initiative: Integrated Sustainable Pan-European Infrastructure for Researchers in Europe
   EGI-InSPIRE
   7. FP, 261323
   EC; The Stichting European Grid Initiative, Amsterdam, The Netherlands; Academic and Research Network of Slovenia - ARNES, Ljubljana, Slovenia
   prof. dr. Marko Mikuž
2. Improving Access to Text
   IMPACT
   7. FP, 215064
   EC; Lieke Ploeger, Koninklijke Biblioteek, Den Haag, The Netherlands
   Jan Jona Javoršek, B. Sc., Asst. Prof. Tomaž Erjavec
3. Conceptual Modelling of Networking of Centres for High-Quality Research in Slavic Lexicography and Their Digital Resources
   MONDILEX
   7. FP, 211938
   EC; Institute of Mathematics and Informatics of the Bulgarian Academy of Science, Sofia, Bulgaria
   Jan Jona Javoršek, B. Sc., Asst. Prof. Tomaž Erjavec
4. Marie Curie Training Network on Particle Detectors
   MC-PAD
   7. FP, 214560, PITN-GA-2008-214560
   EC; Seamus Hegarty, CERN, Geneva, Switzerland
   Prof. Peter Križan
5. Joint Research on Various Types of Radiation Dosimeters
   RADDOS
   7. FP, 207122
   EC; University College Cork, National University of Ireland, Tyndall National Institute, Cork, Ireland
   Dr. Gregor Kramberger
6. Enabling Grids for E-sciencE III
   EGEE-III
   EGEE-SA1, EGEE-NA2, EGEE-NA4
   7. FP, 222667
   EC; Dr. Bob Jones, Anna Cook, CERN IT-EGE, Geneva, Switzerland
   Prof. Marko Mikuž
7. Minimizing Activity and Dose with Enhanced Image Quality by Radiopharmaceutical Administrations
   MADEIRA
   7. FP – EURATOM, 212100
   EC; GSF - Forschungszentrum für Umwelt und Gesundheit GmbH, München Neuherberg, Germany
   Prof. Marko Mikuž
8. Collaboration DELPHI
   Dr. Jan Timmermans, CERN, Geneva, Switzerland
   Asst. Prof. Borut Paul Kerševan
9. Collaboration HERA-B
   Dr. Mike Medinnis, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany
   Prof. Peter Križan
10. Collaboration ATLAS
    Prof. Peter Jenni, Dr. Fabiola Gianotti CERN, Geneva, Switzerland
    Prof. Marko Mikuž
11. Collaboration CERN RD-39
    Dr. Jaako Haarkonen, HIP, Finland
    Dr. Zheng Li, BNL, USA
    Prof. Marko Mikuž

12. Collaboration CERN RD-42
    Prof. Peter Weilhammer, CERN, Geneva, Switzerland
    Prof. Marko Mikuž
13. Collaboration CERN RD-50
    Prof. Mara Bruzzi, University of Florence, Florence, Italy
    Dr. Michael Moll, CERN, Geneva, Switzerland
    Prof. Marko Mikuž
14. Collaborations Belle in Belle II
    Prof. Masanori Yamauchi, KEK, Tsukuba, Japan
    Prof. Peter Križan
15. Collaboration CIMA
    Cameras for Imaging in Medical Applications
    Prof. Peter Weilhammer, CERN, Geneva, Switzerland
    Prof. Marko Mikuž
16. Regional Training Course on Radiation Protection in PET/CT Imaging; Ljubljana, Slovenia,15.3.2010
    IAEA - International Atomic Energy Agency, Vienna, Austria
    Asst. Prof. Igor Mandič
17. Measurements of Mixing and CP Violation in DO System
    BI-JP/10-12/A-003
    Prof. Sokai Yoshihide, High Energy Accelerator Research Organization, KEK, Ibaraki, Japan
    Prof. Boštjan Golob
18. Development of New Detectors for PET Imaging
    BI-US/09-12-042
    Prof. Neal Clinthorne, University of Michigan, Dept. of Radiology, Ann Arbor, MI, USA
    Prof. Mikuž Marko

R &D GRANTS AND CONTRACTS

1. Particle detectors at future generation colliders
   Prof. Marko Mikuž
2. Gridification of Particle Physics Data Analysis: A Pilot Project of Slovenian National Grid Initiative
   Prof. Marko Mikuž
3. Optimization of a Direct Drive System for Electric Two-wheel Vehicles
   Andrej Detela
4. Measurements of Mixing and CP Symmetry Violation in D^0 Meson System
   Prof. Boštjan Golob, Prof. Marko Starič
5. Tracking system for particles in test beam setups
   Dr. Andrej Gorišek

RESEARCH PROGRAMS

1. Astroparticle Physics
   Asst. Prof. Marko Zavrtanik
2. Experimental Particle Physics
   Prof. Marko Mikuž

NEW CONTRACT

1. RD of DD motors for electric vehicles
   (Research and development of direct-drive motors for electric vehicles)
   Elaphe d.o.o.
   Andrej Detela

MENTORING

Ph. D. Theses

1. Matej Batič, *Positioning of radioactive source during brachytherapy tumor treatment using Anger camera* (mentor Igor Mandić; co-mentor Vladimir Cindro)
2. Liza Mijović, *Top quark mass measurement with the Atlas detector* (mentor Borut Paul Kerševan)

VISITORS FROM ABROAD

1. Joern Lange, degree in physics (PhD Student), University of Hamburg, Germany, 4. 1. 2010 - 16. 1. 2010
2. Dr. Shohei Nishida, KEK, Tsukuba, Japan, 20. 9. 2010 – 15. 11. 2010
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2. Danilo Zavrtanik, "Ultra high energy cosmic rays", *Contemp. Phys.*, vol. 51, no. 6, pp. 513-529, 2010.

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2. Marko Bračko, "News from Belle", In: *Proceedings of the Mini-Workshop Dressing Hadrons: Bled, Slovenia, July 4 - 11, 2010*, (Blejske delavnice iz fizike, let. 11, no. 1), Bojan Golli, ed., Mitja Rosina, ed., Simon Širca, ed., Ljubljana, DMFA - založništvo, 2010, pp. 49-55.
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1. Matej Batič, *Positioning of radioactive source during brachytherapy tumor treatment using Anger camera: doctoral dissertation*, Ljubljana, [M. Batič], 2010.

B. Sc. Theses

1. Jure Klučar, *Iskanje redkih razpadov* $D^+ \rightarrow \pi^+ I^+ I^-$ *z detektorjem BELLE: undergraduate thesis*, Ljubljana, [J. Klučar], 2010.
2. Eva Ribežl, *Meritev razpadov* $B^\pm \rightarrow J/\psi\pi^\pm$ *z detektorjem BELLE: undergraduate thesis*, Ljubljana, [E. Ribežl], 2010.

DEPARTMENT OF INORGANIC CHEMISTRY AND TECHNOLOGY K-1

The Department of Inorganic Chemistry and Technology is one of the leading groups in the world in the field of the synthesis of new inorganic compounds containing fluorine. The main research fields are: the synthesis of new coordination compounds with different ligands, the chemistry of noble gases, the chemistry of elements of the main groups and the synthesis of new inorganic materials with special properties. A great deal of the activity of the group has been devoted to technological, ecological and safety problems in Slovenia. The group has already been cooperating closely with Slovenian industry for more than thirty years. It is also active in the field of education and in the field of the promotion of natural sciences among students of colleges and elementary schools.

Head:
Asst. Prof. Tomaž Skapin

In the field of the research of new inorganic compounds containing fluorine, new coordination compounds of the type $[M^{x+}(L)_n](AF_6^-)_x$ have been synthesized (M = metal; A = P, As, Sb, Nb, or Ru; L= ligand, e.g. XeF_2, HF and x is the oxidation number of the central atom). In connection with this the synthesis and characterization of the compound $[Ba(XeF_2)_5](VF_6)_2$, which is isostructural with the compounds [Ba(XeF2)5](AF6)2, (A = As, Sb, Nb, Ru), should be mentioned. This system is interesting because only the anion changes, which allows us to study the Lewis basicity of the corresponding AF_6^- anions.

In the field of coordination compounds with at least two perfluorinated anions the coordination compounds of the type $Ba(BF_4)(AF_6)$, where A = V, Ru, Sb, Nb, Ta, B, were isolated last year. All these compounds crystallize in the orthorombic space group and have a structure similar to the structure of the compound $Ba(BF_4)(AsF_6)$. This year our investigations were extended to the reactions with strontium as the central atom. The compounds of the type $Sr(BF_4)(AF_6)$, where A could be P, As, Sb, Bi, Ru, V, Nb and Ta were isolated. These compounds are analogous to the previously isolated barium compounds. The same was revealed in the case of lead as the central atom. The compound $Pb(BF_4)(AsF_6)$ is isostructural with analogous barium and strontium compounds. In the case of the compound $Cd(BF_4)(TaF_6)$ it was shown that the cadmium compounds are different from the barium, strontium and lead compounds. The compound $Cd(BF_4)(TaF_6)$ crystallizes in the monoclinic space group ($P2_1/c$). The coordination around the Cd atom is eight in the form of a distorted Arhimedian antiprism. In each molecule there are four BF_4^- and four TaF_6^- moieties. Each is connected to four cadmium atoms. In the case of the BF_4^- anion the distances B–F are 137–139 pm and in the case of TaF_6^- the distances Ta–F are around 185 pm for the terminal F atom and between 192–194 pm for the bridging F atom.

The compounds $[Ba(XeF_2)](VOF_4)_2$ and $[Ba(HF)](VOF_4)_2$ represent the first compounds with oxyfluoro anions and XeF_2 or HF as ligands.

We are especially proud because we succeeded in the preparation of the first coordination compounds with XeF_2 and HF as ligands in coordination compounds in which the anion is not weakly coordinating the perfluoro anion but the oxyfuoro anion. These are the compounds $[Ba(XeF_2)](VOF_4)_2$ and $[Ba(HF)](VOF_4)_2$. The anion oxytetrafluorovanadat(V) forms the dimer $V_2O_2F_8^{2-}$ which was only recently described in the literature. Our compounds represent the second case of the compounds with this anion.

Reactions between strong Lewis acids (AsF_5, SbF_5) and the group 13 metal trifluorides (MF_3, M = Al, Ga, In, Tl) in anhydrous hydrogen fluoride at ambient temperature were also investigated. Reactions only proceed in three cases, yielding $InF_3{\cdot}3SbF_5$, $TlF_3{\cdot}3SbF_5$ and $TlF_3{\cdot}AsF_5{\cdot}2HF$. The latter is an intermediate product which releases HF during the isolation yielding $TlF_3{\cdot}AsF_5$. The experimental results confirmed the expectations expressed in the literature that the preparation of cationic species by fluoride ion abstraction from MF_3 (M = Al, Ga, In, Tl) is highly unlikely. The non-reactivity of AlF_3 and GaF_3 is a consequence of their higher lattice energies in comparison to InF_3 and TlF_3. The isolated solids could be better formulated as fluorine-bridged polymeric adducts, i.e., $MF_3{\cdot}3SbF_5$ (M = In, Tl) and $TlF_3{\cdot}AsF_5$, than the ionic $M(SbF_6)_3$ and $TlF_2(AsF_6)$ compounds. Extremely elongated Sb–F(–In) bonds observed in the crystal structure of $InF_3{\cdot}3SbF_5$, indicate the very high Lewis acidity of In^{3+}, meanwhile the acidity of Tl^{3+} is lower. In the case of the weaker Lewis acid, the AsF_5, reaction only proceeded with TlF_3.

In cooperation with Polish partners (University of Warsaw) we have investigated the structural and magnetic properties of Ag(II) ternary fluorides. It has been discovered that in the case of M_2AgF_4 (M = K) two crystal

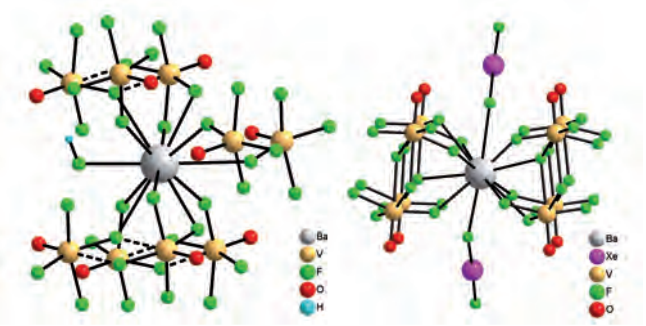

Figure 1: The crystal structures of the compounds $[Ba(XeF_2)](VOF_4)_2$ and $[Ba(HF)](VOF_4)_2$

Silylenes show the regio-selective activation of the C–F bonds of fluoroarenes without any additional catalyst.

structure modifications exist, where the first one is layered, meanwhile the second one consists of infinite chains. We showed that the latter one is thermodynamically favoured over the former one. The relative stability of both phases was rationalized in terms of the size of the M^+ cation. Together with foreign researchers we studied the surface chlorination of $Li_{4/3}Ti_{5/3}O_4$ (Aichi Institute of Technology, Nagoya, Japan). In cooperation with Colorado State University, the selective fluorination of fullerenes and the preparation of the metal salts of super weakly coordinated anion $B_{12}F_{12}^{2-}$ were investigated.

In cooperation with the Department of Solid State Physics (F-5) the research of ferroelectric and ferromagnetic ternary metal fluorides was continued. This year, besides the systems CuF_2-FeF_3-KF, CrF_3-FeF_2-KF and FeF_2-FeF_3-KF, the compound $Pb_5Cr_3F_{19}$ was also studied. The contribution of our department was in the preparation and structural characterization of these new compounds.

In cooperation with the University of Göttingen we have studied some of the silicon compounds with silicon in a formal low oxidation state, stabilized by large electron donor groups. Four different compounds were used: RSi (R = CH(C=CH_2)(CMe)(2,6-*i*$Pr_2C_6H_3N)_2$), $RSiCl_2$ (R = 1,3-bis(2,6-diisopropylphenyl)imidazol-2-ylidene), RSiCl (R = PhCN(*t*$Bu)_2$) and RSi–SiR (R = PhCN(*t*$Bu)_2$). Silylene RSi (R = CH(C=CH_2)(CMe)(2,6-*i*$Pr_2C_6H_3N)_2$) showed the regio-selective activation of the C–F bonds of fluoroarenes and the chemo-selective activation of a C–H bond of partially fluorinated arenes, while RSiCl (R = PhCN(*t*$Bu)_2$) showed regio- and chemo-selective activation of the C–F over the C–H bonds without any additional catalyst. To the best of our knowledge this is the first stoichiometric main group system described that is able to activate the C–F bond of perfluoroarenes and simultaneously activates the C–H bond over the C–F bond of polyfluoroarenes. This demonstrates that the low valent silicon, congener of carbon, mimics transition-metal complexes. The reactions of $RSiCl_2$ (R = 1,3-bis(2,6-diisopropylphenyl)imidazol-2-ylidene) and RSiCl (R = PhCN(*t*$Bu)_2$) with nickel tetracarbonyl yielded compounds with a silicon-nickel bond. RSi–SiR (R = PhCN(*t*$Bu)_2$) reacts with benzil through cycloaddition forming two dioxasilole rings. The reactivity of the RSi–SiR compound was also shown in the reaction with N_2O, where the Si–Si bond is split and two Si_2O_2 four-member rings stabilized by organic ligands were formed.

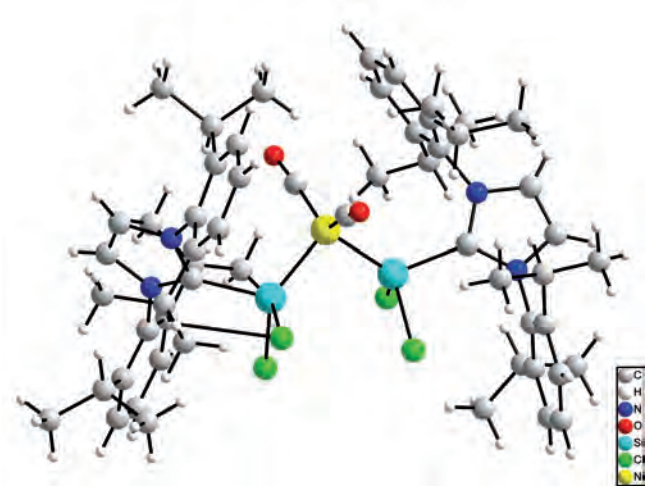

Figure 2: Adduct between Si(II) and nickel tetracarbonyl

Using electrochemical synthesis some copper(I) complexes have been obtained and structurally investigated: Cu[2-all-bta]HSO_4 (I), Cu[2-all-bta]ClO_4 and Cu[2-all-bta]BF_4·H_2O (bta - benzotriazole). Compound I represents the first known copper(I) hydrosulphate π-complex. The direct interaction between $Cu(ClO_4)_2$·$6H_2O$ and the mixture of 1- and 2-allylbenzotriazole resulted in Cu[(1-all-bta)(2-all-bta)]ClO_4. Under different synthetic conditions Cu[2-all-bta]HSO_4·H_2O and Cu[(1-all-bta)(2-all-bta)]BF_4 which were non-isostructural to the ClO_4^- derivative, were prepared. Cu[(1-all-bta)]BF_4 and unprecedented $Cu_4Cl_3ClO_4$(1-all-bta)$_2$(C_2H_5OH) were also obtained and structurally investigated.

In the past year the contents of fluorine in different types of tea were determined and their contribution to the daily intake of fluorine estimated. Investigations aimed at finding some additional plants that could serve as possible indicators of fluorine pollution were also started. In the field of titrimetric analysis a generalized equivalent mass was considered from the viewpoint of the generalized approach to electrolytic systems.

Our department was the organiser of the 16th European Symposium on Fluorine Chemistry (16th ESFC), held in Ljubljana on July 18–23. Traditionally, this event brings together the whole international fluorine community. All the aspects of fluorine chemistry were presented in a single event covering all the various fields, from basic research through to applications. Participants (333) from 21 countries came from universities, institutes and industry. It is important to note that more than one third of the participants were students. One of the highlights of the symposium, interesting also to a broader public, was the opening ceremony with the contribution of Prof. Dr. Herbert W. Roesky, from Georg-August Universitaet, Goettingen. He presented some attractive chemical experiments.

Research in the field of polymerization in a low-temperature plasma resulted in the synthesis of new polymeric materials on the basis of aromatic hydrocarbons, which have appropriate properties for utilization in gas sensors. In the framework of a cooperation with the Centre of Excellence PoliMaT new hydrophilic aliphatic hydrocarbon plasma polymers with incorporated amino functional groups were prepared and characterized. The antimicrobial activity of these kinds of polymers suggests possible applications as coatings in medicine.

The European Symposium on Fluorine Chemistry, one of the most important international meetings on fluorine chemistry, was – after 15 years – once again organised by the Department of Inorganic Chemistry and Technology.

Transition-metal sulphides and oxides, synthesized in the Departments K-1, F-7 and F-5 in the form of nanomaterials, were tested for catalytic activity in reactions of carbon dioxide and carbon monoxide with hydrogen. At

temperatures up to 400 °C transition-metal sulphides showed very low or slight activity, whereas the activity of the tested oxide nanomaterials scored high and approached the activity of the best conventional catalytic materials. The catalytic research was conducted in cooperation with the Centre of Excellence NANOCENTER.

We continued the research on the transformation of contaminated biomass to clean fuels and on the optimisation of the final solution of PCB-contaminated landfill. We also proceeded with the work in the project Access to Technology and Know-how in Cleaner Production in Central Europe - Act Clean.

We further investigated the chemistry of the catalytic oxidation of elemental mercury dissolved in a solution of wet FGD by oxygen (air). This process offers the basis for the optimisation of the desulphurisation technology in respect to controlling and minimising the re-emission of dissolved and captured Hg^{2+} or even for the removal of Hg^0 from flue gases. We reported on this work at the expert workshop M(ercury) E(missions) from C(oal), held in Glasgow and at the 8th International Conference on Hot Gas Cleaning (8IGCHT) held in Taiyuan, China.

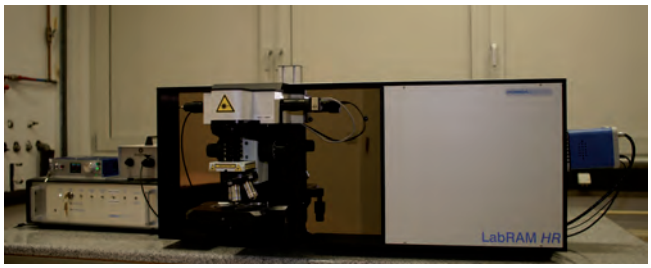

Figure 3: A high-resolution Horiba Raman spectrometer Labram HR was purchased in 2010 with the participation of the Slovenian Research Agency. This Raman spectrometer is equipped with a microscope and the automatic switching of laser exciting lines at 633 and 532 nm.

The catalytic oxidation of Hg^0 in a solution of wet FGD with air oxygen represents an alternative to the two emerging technologies: the first of them increases the emission of bromides and the second one (adsorption on activated charcoal) is extremely expensive.

In the field of environmental and social impact assessments two co-workers of the department joined the EU FP7 project CiViTAS ELAN in the roll of evaluators of five (of a total of sixteen) measures under implementation in Ljubljana and in the partner cities of Ghent, Porto, Brno and Zagreb. The aim of these measures is to improve the quality and safety of the public and private users' mobility. A special emphasis is given to the cost–benefit analysis of the measures, which is carried out thoroughly on three of the five measures.

In the EU FP7 project Integ-Risk we continued our work on the key performance indicators on the quality for mutual consideration of the process safety risk assessment and spatial planning process.

In the fields of process safety (industrial risks) and the reliability of processes/equipment we have been engaged in consultations with local industry and the competent national authorities. With Istrabenz plini d. o. o. we continued with consultation services related to the implementation and performance of a safety management system (in the context of EU directive 96/82/EC, or Seveso II). With Nafta Petrochem d. o. o., Plinarna Maribor d. o. o., Istrabenz plini d. o. o., Agency for commodities reserves of RS (ZRSBR), and TE-TO Ljubljana we carried out updates of their safety management systems and updates for a number of safety reports and similar documents for the purpose of the licensing procedures. In addition, we were engaged by the Ministry for the Environment and Spatial Planning of the Republic of Slovenia in a further update of an expert review of the process safety aspects for the project documentation for two planned LNG terminals in the Gulf of Trieste, Italy.

Five co-workers were actively engaged in the work of the Jožef Stefan International Postgraduate School as lecturers and as mentors to five M.Sc. and six Ph.D. students. In addition, the School of Experimental Chemistry maintained its very important relations with elementary and secondary schools through experimental courses performed in a specialised laboratory or through direct demonstrations at the schools. A part of these activities is included in the European project KidsINNscience.

Figure 4: The 16th European Symposium on Fluorine Chemistry: "Chemical Curiosities" presented by prof. dr. Herbert W. Roesky as a part of the opening ceremony (top), reception at Ljubljana Castle (bottom).

Some outstanding publications in the past year

1. Gerbec M., A reliability analysis of a natural-gas pressure-regulating installation, Reliab. Eng. Syst. Saf., 95 (2010), 1154-1163
2. Stergaršek A., Horvat M., Frkal P., Stergaršek J., Removal of Hg^0 from flue gases in wet FGD by catalytic oxidation with air : an experimental study, Fuel, 89 (2010), 3167-317
3. Mazej Z., Goreshnik E. A., Fluoride ion donor properties of group 13 trifluorides (MF_3, M = Al, Ga, In, Tl) and crystal structures of $InF_3 \cdot 3SbF_5$, $TlF_3 \cdot 3SbF_5$ and $TlF_3 \cdot AsF_5 \cdot 2HF$, New J. Chem., 34 (2010), 2806-2812

4. Tavčar G., Sen S. S., Azhakar R., Thorn A., Roesky H. W., Facile syntheses of silylene nickel carbonyl complexes from Lewis base stabilized chlorosilylenes, Inorg. Chem., 49 (2010), 10199-10202
5. Utsunomiya H., Nakajima T., Ohzawa Y., Mazej Z., Žemva B., Endo M., Influence of conductive additives and surface fluorination on the charge/discharge behavior of lithium titanate ($Li_{4/3}Ti_{5/3}O_4$), J. Power Sources, 195 (2010), 6805-6810
6. Anukul J., Prinson S. P., Tavčar G., Roesky H. W., Schulzke C., Selective aromatic C-F and C-H bond activation with silylenes of different coordinate silicon, J. Am. Chem. Soc., 132 (2010), 10164-10170

Organization of conferences, congress and meetings

1. Organization of the 16th European Symposium on Fluorine Chemistry, Ljubljana, Slovenia, 18.–23. 7. 2010

INTERNATIONAL PROJECTS

1. Innovation in Science Education - Turning Kids on to Science
   KidsINNscience
   7. FP, 244265
   EC; Nadia Prauhart, Markus Meissner, Austrian Institute of Ecology, Österreichisches Ökologie-Institut, Vienna, Austria
   Tomaž Ogrin, M. Sc., Dr. Špela Stres
2. Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related Risks
   iNTeg-Risk
   7. FP, 213345, NMP2-LA-2008-213345
   EC; European Virtual Institute for Integrated Risk Management, Stuttgart, Germany
   Asst. Prof. Marko Gerbec, Prof. Branko Kontić
3. Mobilising Citizens for Vital Cities Ljubljana-Gent-Zagreb-Brno-Porto
   CIVITAS-ELAN
   7. FP, 218954, TREN/FP7TR/218954
   EC; Zdenka Šimonovič, Mestna občina Ljubljana, Ljubljana, Slovenia
   Asst. Prof. Marko Gerbec, Dr. Davor Kontić, Prof. Branko Kontić
4. Access to Technology and Know-how in Cleaner Production in Central Europe
   ACT CLEAN
   Central Europe Programme
   EC; Jakob Gross, Horst Pohle, Federal Environment Agency, Dessau-Roßlau, Germany
   Dr. Andrej Stergaršek, Andrej Gyergyek, B. Sc., Asst, Prof. Sonja Lojen
5. Novel Flurides of Divalent Silver and Palladium: Various Pathways Towards Superconductivity
   BI-PL/10-11-003
   Dr. Grochala Wojceich, The University of Warsaw, Warsaw, Poland
   Dr. Zoran Mazej
6. Copper(I) π-Complexes as Potentional Compounds with Three-Dimensional Frameworks
   BI-UA/09-10-015
   Dr. Marian Mys´kiv, Chemical Department, Ivan Franko National University, L´viv, Ukraine
   Dr. Zoran Mazej
7. Advanced Nanocaged Fluorocarbon Materials and Their Chemical Modifications
   BI-US/08-10-018
   Prof. Steven Strauss, Department of Chemistry, Colorado State University, Fort Collins, CO, USA
   Dr. Zoran Mazej

R & D GRANTS AND CONTRACTS

1. Fate and Speciation of Pollutants in the Transformation of Contaminated Biomass into Synthetic Fuel and Pure Hydrogen
   Dr. Andrej Stergaršek

RESEARCH PROGRAM

1. Inorganic Chemistry and Technology
   Prof. Boris Žemva

NEW CONTRACTS

1. Conditioning of radioactive waste of small producers
   ARAO
   Asst. Prof. Gašper Tavčar
2. Consultation services for novelation/updates of the safety report
   Zavod Republike Slovenije za blagovne rezerve
   Asst. Prof. Marko Gerbec

VISITORS FROM ABROAD

1. Prof. Dr. Herbert W. Roesky, University of Goettingen, Germany, 16.–23. 7. 2010
2. Prof. Dr. Steven Strauss and Dr. Olga Boltalina, Colorado State University, USA., 16.–25. 7. 2010
3. Clara Sousa Silva, Universtiy of Edinburgh, Scotland, 1. 10.–17. 12. 2010
4. Tomasz Michałowski , University of Warsaw, Poland, 21.–28. 11. 2010

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3. Dr. Adolf Jesih
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19. Tine Oblak, M. Sc.
20. Tomaž Ogrin, M. Sc.

Technical and administrative staff
21. Pero Kolobarić
22. Robert Moravec
23. Mira Zupančič

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Original Articles

1. Jana Anukul, Samuel P. Prinson, Gašper Tavčar, Herbert W. Roesky, Carola Schulzke, "Selective aromatic C-F and C-H bond activation with silylenes of different coordinate silicon", *J. Am. Chem. Soc.*, vol. 132, no. 29, pp. 10164-10170, 2010.
2. Jana Anukul, Gašper Tavčar, Herbert W. Roesky, John Michael, "Germanium(II) hydride mediated reduction of carbon dioxide to formic acid and methanol with ammonia borane as the hydrogen source", *Dalton trans. (2003. Print)*, vol. 39, no. 40, pp. 9487-9489.
3. Jana Anukul, Gašper Tavčar, Herbert W. Roesky, Carola Schulzke, "Facile synthesis of dichlorosilane by metathesis reaction and dehydrogenation of dihydrogermane by a frustrated Lewis pair", *Dalton trans. (2003. Print)*, vol. 39, pp. 6217-6220, 2010.
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5. Marko Gerbec, "A reliability analysis of anatural-gas pressure-regulating installation", *Reliab. eng. syst. saf.*, vol. 95, no. 11, pp. 1154-1163, 2010.
6. Evgeny A. Goreshnik, Zoran Mazej, Marian G. Mys'kiv, "Synthesis, crystal structure and Raman spectra of $AgBF_4 \cdot C_3O_3(NC_3H_5)_3H_2O$ a silver(I) π-complex with 1,3,5-triallyl-1,3,5-triazine-2,4,6-trione", *J. organomet. chem.*, vol. 695, no. 19/20, pp. 2201-2204, 2010.
7. Evgeny A. Goreshnik, Marian G. Mys'kiv, "Copper(I) hexafluorosilicate π-complex with N-allylmorpholinium cation: a rare case of (C=C + 3O) Copper(I) coordination in the structure of $[Cu(C_4H_8ONH(C_3H_5))(H_2O)_2]SiF_6\dot{H}_2O$", *J. chem. crystallogr.*, vol. 40, no. 4, pp. 381-383, 2010.
8. Xiaohong Kang, Hidetoshi Utsunomiya, Takashi Achiha, Yoshimi Ohzawa, Tsuyoshi Nakajima, Zoran Mazej, Boris Žemva, Morinobu Endo, "Effect of conductive additives and surface fluorination on the electrochemical properties of lithium titanate ($Li_{4/3}Ti_{5/3}O_4$)", *J. Electrochem. Soc.*, vol. 157, no. 4, pp. A437-A442, 2010.
9. Dominik Kurzydłowski, Mariana Derzsi, Armand Budzianowski, Zvonko Jagličić, Wiktor Koźmiński, Zoran Mazej, Wojciech Grochala, "Polymorphism of fluoroargentates(II): Facile collapse of a layered network of $\alpha - K_2AgF_4$ due to the insufficient size of the potassium cation", *European Journal of Inorganic Chemistry*, vol. 2010, no. 19, pp. 2919-2925, 2010.
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12. Zoran Mazej, Evgeny A. Goreshnik, "Fluoride ion donor properties of group 13 trifluorides (MF_3, M = Al, Ga, In, Tl) and crystal structures of $InF_3 \times 3SbF_5$, $TlF_3 \times 3SbF_5$ and $TlF_3 \times AsF_5 \times 2HF$", *New j. chem. (1987)*, vol. 34, no. 12, pp. 2806-2812, 2010.
13. Zoran Mazej, Evgeny A. Goreshnik, Iztok Arčon, Nataša Zabukovec Logar, Venčeslav Kaučič, "Apparently regular octahedral coordination of Ag(II) in $IF_6[Ag(SbF_6)_3]$", *Z. anorg. allg. Chem. (1950)*, vol. 636, no. 1, pp. 224-229, 2010.
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15. Marian G. Mys'kiv, Evgeny A. Goreshnik, "Bis[bis(3, 5-diamino-1H-1,2,4-triazol-4-ium)copper(I)] tris(hexafluoridosilicate)", *Acta crystallographica. E, Structure Reports*, vol. 66, no. 11, pp. m1453-m1454, 2010.
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18. Sakya S. Sen, Gašper Tavčar, Herbert W. Roesky, Daniel Kratzert, Jakob Hey, Dietmar Stalke, "Synthesis of a stable four-membered Si_2O_2 ring and a dimer with two four-membered Si_2O_2 rings bridged by two oxygen atoms, with five-coordinate silicon atoms in both ring systems", *Organometallics*, vol. 29, no. 10, pp. 2343-2347, 2010.
19. Natalia B. Shustova, Zoran Mazej, You-Sheng Chen, Alexey A. Popov, "Saturnene revealed: X-ray crystal structure of $D_{5d} - C_{60}F_{20}$ formed in reactions of C_{60} with $AxMF_y$ fluorinating agents (A=Alkali Metal; M=3d Metal)", *Angew. Chem. (Int. ed., Print)*, vol. 49, no. 4, pp. 812-815, 2010.
20. Andrej Stergaršek, Milena Horvat, Peter Frkal, Jošt Stergaršek, "Removal of Hg^0 from flue gases in wet FGD by catalytic oxidation with air", *Fuel (Guildf.)*, vol. 89, no. 11, pp. 3167-3177, 2010.
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23. Hidetoshi Utsunomiya, Tsuyoshi Nakajima, Yoshimi Ohzawa, Zoran Mazej, Boris Žemva, Morinobu Endo, "Influence of conductive additives and surface fluorination on the charge/discharge behavior of lithium titanate ($Li_{4/3}Ti_{5/3}O_4$)", *J. power sources*, vol. 195, no. 19, pp. 6805-6810, 2010.

Review Articles and Chapters in Books

1. Davor Kontić, Marko Gerbec, "Bridging the gap between risk assessment and land-use planning", In: *Risk management*, (Safety and risk in society), Benigno Jordão, ed., Emilio Sousa, ed., New York, Nova Science Publishers, cop. 2010, pp. 89-124.
2. Maja Ponikvar-Svet, Loryn R. Keating, Bryan J. Dobson, Joel F. Liebman, "Interplay of thermochemistry and Structural Chemistry, the journal (volume 16, 2005) and the discipline", *Struct. chem.*, vol. 21, no. 3, pp. 527-540, 2010.
3. Maja Ponikvar-Svet, Joel F. Liebman, "Interplay of thermochemistry and Structural Chemistry, the journal (volume 20, 2009) and the discipline", *Struct. chem.*, vol. 21, no. 5, pp. 1131-1149, 2010.

Published Conference Papers

Regular papers

1. Marko Gerbec, "Case study: reliability analysis of natural-gas pressure-regulating istalation", In: *Reliability, risk and safety: back to the future: proceedings and Monographs in Engineering, Water and Earth Sciences, ESREL 2010, September 15, 2010, Rhodes, Greece*, Ben J. M. Ale, ed., Ioannis A. Papazoglou, ed., Enrico Zio, ed., London, Taylor & Francis, 2010, pp. 1121-1128.
2. Marko Gerbec, "Prognosis of the natural-gas pressure-regulating installation reliability", In: *38th ESReDA Seminar Advanced maintenance modelling, 4-5th May, 2010, Pecs, Hungary*, [S. l., s. n.], 2010, 12 pp.
3. Andrej Stergaršek, Milena Horvat, Sergio Ribeiro Guevara, Peter Frkal, Jošt Stergaršek, "Catalytic oxidation of Hg23 in wet FGD by air-contributions to the development of the chemical model of the process", In: *Final program and abstracts*, GCHT-8, 8th International Symposium on Gas Cleaning at High Temperatures, August 23-25, 2010, Taiyuan, Shanxi, China, [S. l., s. n.], 2010, 14 pp.
4. Gašper Tavčar, Sakya S. Sen, Jakob Hey, Herbert W. Roesky, "Reaktivnost nekaterih silicijevih spojin v nizkih oksidacijskih stanjih", In: *Slovenski kemijski dnevi 2010, Maribor, 23. in 24. september 2010*, [Maribor], FKKT, [2010], 6 pp.

Theses

B. Sc. Thesis

1. Kristian Radan, *Spojine nekaterih dvovalentnih kovin z dvojnimi perfluoro anioni: diplomsko delo*, Ljubljana, [K. Radan], 2010.

DEPARTMENT OF PHYSICAL AND ORGANIC CHEMISTRY K-3

The basic research of the department is focused on the experimental and theoretical study of various physico-chemical processes at surfaces and in atmospheric chemistry. The main attention in the field of organic chemistry is directed to halogenated, in particular fluorinated, organic molecules.

Head:
Prof. Ingrid Milošev

Experimental research in the field of electrochemistry continues for the materials that are important in biomedical and technological applications. In the field of corrosion we are interested in various modes of protecting metals and alloys from corrosion – from corrosion inhibitors to surface layers and functional modifications of the surface. The effectiveness of 3-amino-1,2,4-triazole (ATA), benzotriazole (BTAH), and 1-hydroxybenzotriazole (BTAOH) inhibitors against the corrosion of copper in a 3% NaCl solution were determined by means of electrochemical and topography measurements. We established that BTAH is the most effective corrosion inhibitor for copper in near-neutral chloride solutions. ATA has similar corrosion-inhibition characteristics, although it shows a somewhat lower inhibition effect for pitting corrosion. On the other hand, BTAOH performs much worse against both pitting and the general type of corrosion. To disentangle the factors involved in the inhibition of corrosion with the aid of extensive computer simulations based on density functional theory, an approximate scheme to treat the adsorption at an electrified surface was introduced. A careful analysis of the obtained results allowed us to pinpoint the superior inhibiting action of BTAH and ATA as a result of their ability to form strong N-Cu chemical bonds in the deprotonated form. While these bonds are not as strong as the Cl-Cu bonds, the presence of a solvent favours the adsorption of inhibitor molecules onto the surface due to the stronger solvation of the Cl^- anions. Moreover, benzotriazole displays the largest affinity among the three inhibitors to form intermolecular aggregates, such as the $[BTA\text{-}Cu]_n$ polymeric complex. This is another factor contributing to the stability of the protective inhibitor film on the surface, thus making benzotriazole an outstanding corrosion inhibitor for copper.

Using quantum mechanical computer simulations we were able to explain, on the atomic level, the elementary factors that are involved in the corrosion-inhibiting action of a few azole-based inhibitors for copper in near neutral media.

The formation of various coatings on the surface of metals and alloys is another form of corrosion protection for technologically important materials like aluminium and its alloys. In the past, these materials were protected using conversion chromate coatings. However, because of the cancerogenicity and toxicity of the chemicals used in their production, the use of chromate coatings has been banned. In the past decade numerous studies have been devoted to the investigations of alternative ways of protection for aluminium alloys. One of the possibilities is silane coatings which represent a non-toxic, environmentally friendly replacement for coatings with hexavalent chromium. Alkoxy silanes are hybrid organic-anorganic compounds that have a hydrolysable group X – ethoxy, methoxy and organo-functional group Y – vinyl, mercapto, amino in their structure $X_3Si(CH_2)_nY$. In collaboration with a group from the Faculty of Technology and Metallurgy from Belgrade we studied vinyltriethoxysilane coatings on aluminium. Using the X-ray photoelectron spectroscopy we identified Si–O–Si and Si–O–Al bonds and thus contributed to the clarification of the formation mechanism of the silane coatings on aluminium and the mechanism of their corrosion protection.

One of the promising methods for the functional modifications of the surface in terms of corrosion protection are the self-assembled layers. We have studied the formation of self-assembled layers on the surface of copper and bronze during immersion in tetradecanoic acid, $CH_3(CH_2)_{12}COOH$. The uniform, self-assembled, thin layers thus formed on the copper consist of nano-grains and nano-plates, whereas lamellate patterns were observed on bronze. The modified surface is hydrophobic, with contact angles up to 140°. The corrosion testing of modified surfaces in a 0.014 M Na_2SO_4 + 0.024 M $NaHCO_3$ solution shows that these layers act like corrosion inhibitors, with an effectiveness up to 97% on copper, and up to 68% on bronze. The formation of nanostructured, hydrophobic layers represents therefore a promising and simple treatment of corrosion protection. This technical application is actually inspired by transferring the fascinating lotus effect to artificial surfaces. The microscopic structure and surface chemistry of the lotus leaves result in a hydrophobicity with a contact angle > 90° and a sliding angle < 10°, preventing them from being wetted by liquids and enabling self-cleaning properties; droplets of water roll off the surface, taking mud and undesirable particulate contaminants with them.

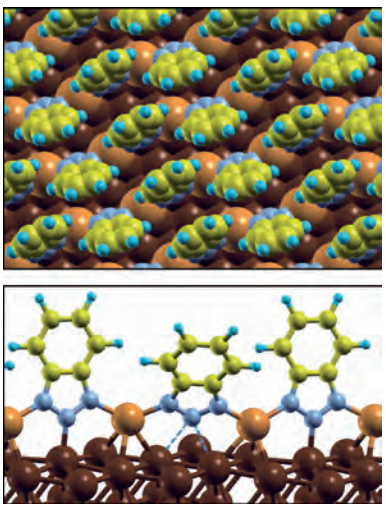

Figure 1: Atomic structure of organometallic molecular necklace formed between benzotriazole molecules and copper ions on the surface of copper. This structure forms a very stable protective film on the surface, thus making benzotriazole an outstanding corrosion inhibitor for copper.

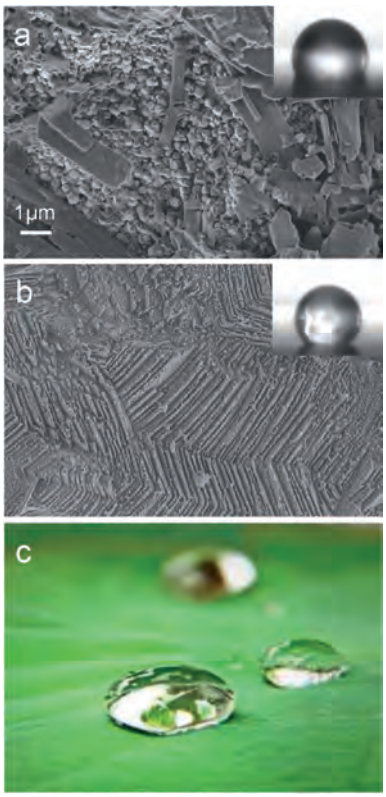

Figure 2: Microscopic images of the surface after 10-days immersion in an ethanol solution of tetradecanoic acid show (a) the formation of nano-grains and nano-plates on copper, and (b) the formation of nano-lamellate patterns on bronze. Photographs of a water droplet during measurements of contact angles are given in insets. (c) Water droplet floats on lotus leaf and enables the self-cleaning process.

Our studies on biomedically important materials which last for more than ten years continue in different fields. Our collaboration with the group from Institute of Physical Chemistry "Illie Murgulescu" from Bucharest and the University of Primorska is devoted to a new alloy containing titanium, niobium and zirconium. The alloy is based on the nano-architecture bioalloy/nanometre oxide layer/nanometre functional layer. We are interested in the electrochemical behaviour of this material under simulated physiological conditions and its cytotoxicity. Our long-term collaboration with the Valdoltra Orthopaedic Hospital continues the investigations devoted to the effects of various physiological conditions on the corrosion stability of the three most important groups of orthopaedic materials. In collaboration with the Faculty of Chemical Engineering and Technology from Zagreb we investigate the possibilities to modify the surface of Nitinola by anodic and self-assembled layers.

Our theoretical investigations of atmospherically relevant radical reactions were based on quantum chemical methods and were focused on the examination of the mechanism of the reaction of the sulphur-containing HOSO radical and NO2. The results suggest that the initial association of the radicals leads to two possible intermediates in a barrierless exothermic process. The $HOS(O)NO_2$ intermediate easily decomposes into HONO + SO_2 through the low-energy product complex HONO...SO_2, while the HOS(O) ONO dissociates to $HOSO_2$ + NO products. From the thermodynamic aspect, the main products in the title reaction are HONO+ SO_2, whereas $HOSO_2$ + NO are expected as minor products.

In the framework of the Laboratory for Organic and Bioorganic Chemistry we continued the investigation of the application of principles of green chemistry to the transformations of organic compounds, stressing the selective introduction of halogen atoms into organic compounds. Selective and efficient fluorination of organic 1,3-dicarbonyl compounds was achieved using the electrophilic fluorinating reagents Selectfluor™ F-TEDA-BF_4 (1-chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane bis tetrafluoroborate) in an aqueous medium or Accufluor™ NFSi (N-fluorobenzensulfonimide) under solvent-free reaction conditions (SFRC). Under both reaction conditions the cyclic 1,3-dicarbonyl compounds were transformed into 2-fluoro-substituted derivatives and acyclic analogues into 2,2-difluoro-substituted compounds, while the reactions of 1-trifluoromethyl-substituted 1,3-dicarbonyls in water resulted in the formation of 2,2-difluoro-3,3-dihydroxy-1-one derivatives. The reactivity of the starting material in water was found to be dependent on its enolizability, hydrophobic interactions and aggregate state at the reaction temperature. Reactions under SFRC proceeded in the molten eutectic phase of the reactants. The technique of competitive reactivity was used in order to evaluate and better understand the effects of the reaction conditions on the course of these reactions. We originally showed that direct fluorination of ketones could also be performed under SFRC. We published these discoveries in Advanced Synthesis&Catalysis the leading journal for applied chemistry. We discovered and developed the new method for aerobic oxidative transformation of the organic compounds using the reaction system air/HNO_3(cat)/TEMPO (cat) and applied the method for the oxidation of alcohols to aldehydes or ketones and the oxidative iodination of organic compounds using elemental iodine. Oxidative chlorination with HCl/H_2O_2 in 1,1,1-trifluoroethanol was used to transform aryl iodides into aryliodine(III) dihalides. In this instance 1,1,1-trifluoroethanol is not only the reaction medium, but is also an activator of hydrogen peroxide for the oxidation of hydrochloric acid to molecular chlorine. Aryliodine(III) dichlorides were formed in 72–91% isolated yields in the reaction of aryl iodides with 30% aqueous hydrogen peroxide and hydrochloric acid at ambient temperature. A study of the effect that substituents on the aromatic ring have on the formation and stability of aryliodine(III) dichlorides shows that the transformation is easier to achieve in the presence of the electron-donating groups (i.e., methoxy), but in this case the products rapidly decompose under the reported reaction conditions to form chlorinated arenes. On the basis of invitation we prepared a contribution for the Encyclopedia of Reagents for Organic Synthesis. In collaboration with the company Ecot we developed new products for autocosmetics; with the company Krka we developed independent protocols for the preparation of pharmaceuticals; with Institute for Agriculture and Semenarna we developed new agrochemicals; and in the framework of the Centre of Excellence CIPKeBiP we developed the fluorinated synthons for a biosynthesis of macrolide pharmaceuticals.

An interesting feature of the HOSO + NO_2 reaction from a fundamental perspective is that it represents the first known energetically favourable process for the exchange of sulphur and nitrogen centres, i.e., the exchange of sulphur in HOSO by nitrogen resulting in HONO.

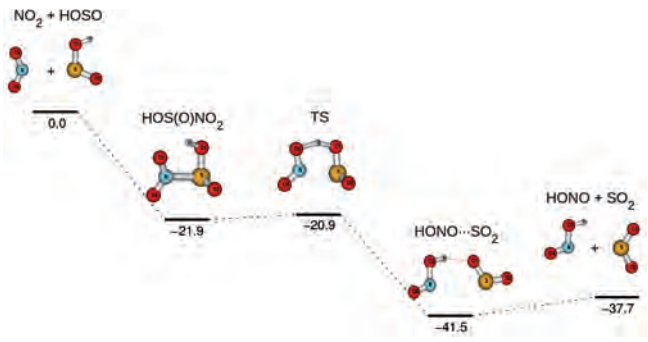

Figure 3: CBS-QB3 minimum energy path (relative energy in J/mol) for the HOSO + NO_2 reaction.

Some outstanding publications in the past year

1. M. Finšgar, I. Milošev, Inhibition of copper corrosion by 1,2,3-benzotriazole: A review, Corrosion Science, 52 (2010), 2737-2749.
2. A. Kokalj, S. Peljhan, M. Finšgar, I. Milošev, What Determines the Inhibition Effectiveness of ATA, BTAH, and BTAOH Corrosion Inhibitors on Copper?, J. Am. Chem. Soc., 132 (2010), 16657-16668
3. A. Lesar and A. M. Kosmas, Theoretical study on the mechanism of the reaction of CF_3S with NO_2 , J. Chem. Phys. A,114 (2010) ,1147-1152
4. G. Stavber, S. Stavber, Towards greener fluorine organic chemistry: direct electrophilic fluorination of carbonyl compounds in water and under solvent-free reaction conditions. Advanced Synthesis & Catalysis, 352 (2010), 2838-3846

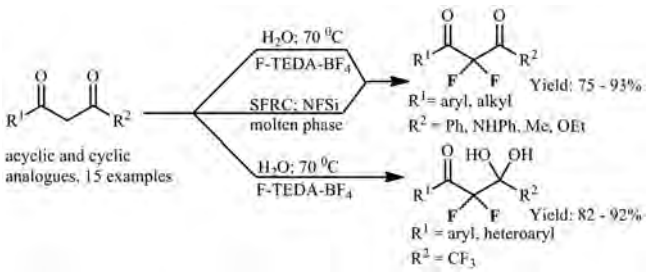

Figure 4: The invention and development of the method for direct fluorination of 1,3-dicarbonyl compounds in aqueous media and under solvent-free reaction conditions was achieved and originally, under the latter conditions, performed also the direct fluorination of ketones.

INTERNATIONAL PROJECTS

1. Controlled Surface Structuring and Surface Functionalisation of Advanced Biomedical Titanium Alloys for Ortopaedic Implants
   SURFUNCTI
   MNT ERA NET II
   Institute of Physical Chemistry »Illie Murgulescu«, Bucharest, Romania
   Prof. Ingrid Milošev
2. Improvement of Resurfacing Hip Implants with DLC, TiO_2 and DLC-p-h Nanocomposite Coatings
   RHSI-DLC-NanoComp
   MAT ERA NET
   ORTON Research Institute, Helsinki, Finland
   Prof. Ingrid Milošev
3. Bioengineering Advanced Metallic Materials and Functional Coatings for Medical Application
   BI-HR/10-11-015
   Prof. Zoran Grubač, University of split, Faculty of Chemistry and Tehnology, Split, Croatia
   Prof. Ingrid Milošev
4. Analytical Package of MSA, HCl and HCOOH; Acid Corrosiveness Characterization of AISI 316 and API N-80 Steel Grades
   Contract dtd. 12. 7. 2010
   Dr. Stefan Fassbender, BASF SE, Ludwigshafen/Rhein, Germany
   Prof. Ingrid Milošev
5. Electrochemical non-Metalic Coatings on Modified Metal Surfaces
   BI-SR/10-11-008
   Prof. Vesna Mišković-Stanković, Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia
   Prof. Ingrid Milošev

R & D GRANTS AND CONTRACTS

1. Survivorship of Total Hip Replacements as a Function of Type of Bearing Surfaces
   Prof. Ingrid Milošev
2. Role of Molecular Structure of Inhibitors and their Selfassembling in Corrosion Protection of Metal Surfaces
   Dr. Anton Kokalj
3. The Effect of Bio-environment on the Stability of Biomedical Metallic Materials
   Prof. Ingrid Milošev

RESEARCH PROGRAMS

1. Bioanorganic and Bioorganic Chemistry
   Prof. Stojan Stavber
2. Multiphase Nanoarchitectures: Development, Physical and Chemical Characterization and Simulation of Processes
   Prof. Ingrid Milošev

MENTORING

Ph. D. Theses

1. Małgorzata Figurska, *Mechanical, histological and biological analysis of artificial joint loosening* (mentor Romuald Będziński; co-mentor Ingrid Milošev)
2. Matjaž Finšgar, *Benzotriazole and polyethyleneimine corrosion inhibitor for copper and steel in chloride solutions* (mentor Ingrid Milošev; co-mentor Boris Pihlar)

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1. Jozefina Katić, B.Sc., University of Zagreb, Faculty of Chemical Engineering and Technology, Zagreb, Croatia, 5 - 9 July 2010
2. Dr. Željka Petrović, University of Zagreb, Faculty of Chemical Engineering and Technology, Croatia, 5 - 9 July 2010
3. Prof. Vesna Mišković-Stanković, University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia, 8 - 10 November 2010
4. Prof. Jelena Bajat, University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia, 21 - 23 November 2010
5. Sanja Eraković, B.Sc., University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia, 21 - 26 November 2010
6. Željka Jovanović, B.Sc., University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia, 21 - 26 November 2010

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Ph. D. Thesis

1. Matjaž Finšgar, *Benzotriazole and polyethyleneimine corrosion inhibitor for copper and steel in chloride solutions: doctoral dissertation*, Ljubljana, [M. Finšgar], 2010.

B. Sc. Theses

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ELECTRONIC CERAMICS DEPARTMENT

K-5

The Electronic Ceramics Department is active in the research of the synthesis, properties and applications of materials for electronics and energetics, mainly complex multifunctional materials and structures. The materials of interest include ceramic piezoelectrics, ferroelectrics, relaxors, conductive oxides and materials for solid-oxide fuel cells (SOFCs). The emphasis is on the creation of the properties by the synthesis and structure at the nano-, micro- and macro-levels. The group also works on the principles of basic technologies for ceramic pressure sensors, ceramic MEMS and flexible electronics.

Head:
Prof. Marija Kosec

Within the research of environment-friendly **lead-free piezoelectric ceramics** the focus has been on alkali niobates and tantalates. The prototype incipient ferroelectric potassium tantalate and the antiferroelectric sodium niobate were studied. They are both end-members of the best piezoelectric compositions, they crystallize in the perovskite syngony, and they share the problems related to processing, mainly the synthesis and sintering of single-phase materials to high density, which are related to the hygroscopic nature of alkali reagents and the high vapor pressure of alkali oxides at sintering temperatures.

Single-phase $NaNbO_3$ was synthesized by solid-state synthesis from Nb_2O_5 and mechanochemically activated Na_2CO_3. The **phase transitions of sodium niobate** powder were examined in order to contribute to the clarification of its structural behavior below 400 °C by differential scanning calorimetry and high-temperature X-Ray diffraction. The results showed the existence of the Q polymorph at room temperature, not previously reported for the powder, which underwent a transition to the R polymorph upon heating through a temperature region between 265 °C and 326.5 °C. This transition was mainly related to the displacement of Na into a more symmetrical position and a minor change of the tilting system.

The $NaNbO_3$ powder was further compacted and sintered in air. The evolution of the microstructure and the grain growth mechanism were examined by a systematic study of the different stages of sintering. A narrow sintering temperature interval, typical for alkaline niobates, was observed. The relative densities of the samples sintered in air at 1350 °C for 2 hours were around 95 %. An extremely high velocity of the grain boundaries was observed, resulting in grains as large as 100 μm even after short sintering times (≤ 15 min). Based on the study of pore-shape evolution with time, the pore-boundary separation conditions were identified.

The **$KTaO_3$** powder was prepared by heating the mechanochemically activated K_2CO_3-Ta_2O_5 powder mixture at 800 °C. Phase-pure $KTaO_3$ ceramics, as determined by the X-ray diffraction, were obtained by hot-pressing the calcined powder compacts at 1250°C and reached relative densities exceeding 95 %. A combination of two analytical spectroscopic methods of transmission electron microscopy was employed for the nanoscale compositional analysis: energy-dispersive X-ray (EDXS) and electron energy-loss spectroscopy (EELS). Compositional inhomogeneities, which were identified in the as-calcined powder sample, were found to affect the subsequently produced ceramic, which showed compositional deviations of up to 5%. These findings led to an improvement of the $KTaO_3$ processing procedure, namely, another heating of the powder at 800 °C was performed. The double-calcination of the powder resulted in high-quality ceramics with an almost doubled value of the dielectric permittivity, i.e. 4080 (1 kHz, 5 K), as compared to the ceramics from the powders, prepared by a one-step calcination. The value is comparable to the literature reports on single crystals.

Within the activities on **lead-based piezoceramics** the synthesis and characterization of composites composed of the lead zirconate titanate solid solution (PZT) and tetragonal stabilized zirconia need to be mentioned. Within the EU 7FP project HIPERact we have studied ceramics with a reduced sensitivity to stress or extreme humidity conditions. Preliminary studies, performed in collaboration with Technical University Darmstadt, show that the addition of zirconia influences the phase composition, microstructure, electrical properties and fracture toughness of the composites. The improvement in fracture toughness was observed in the composite with 5vol% of ZrO_2.

We further studied the ferroelectric and piezoelectric properties of **multiferroic $BiFeO_3$**. We found that the switching of domains by an electric field is strongly inhibited due to clamping of domain walls by defects. The

- **Prof. Dr. Marija Kosec received the Ferroelectrics Recognition Award 2010. IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society awarded her for significant contributions to the processing science and technology of ferroelectric powders, bulk ceramics, thin and thick films.**
- **Prof. Dr. Barbara Malič received the Zois award for important achievements in the field of ferroelectric ceramics and thin films.**

By controlling the nano-scale homogeneity of the powders, we have prepared high-quality incipient ferroelectric $KTaO_3$ ceramics with dielectric properties comparable to those of single crystals. Sebastjan Glinšek presented the results of the research at the 18th Conference on Materials and Technologies in Portorož, and was awarded for the best presentation among young researchers in the field of inorganic materials.

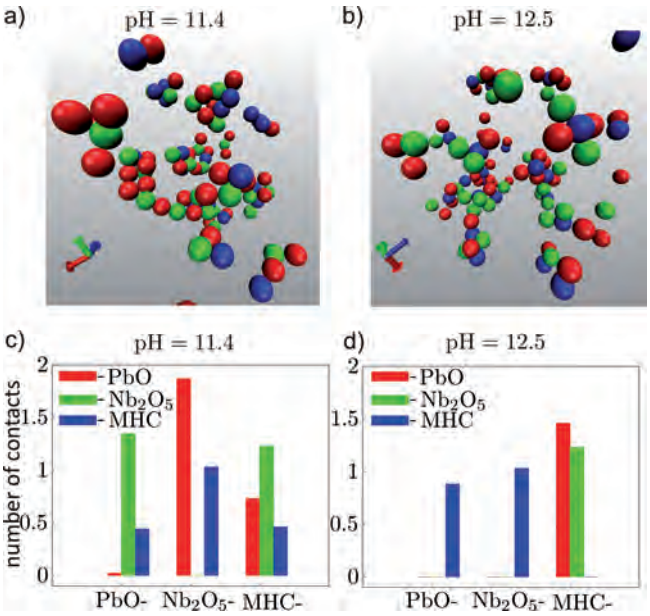

Figure1: Modelling of the formation of colloidal aggregates in suspensions for $Pb(Mg_{1/3}Nb_{2/3})O_3$ synthesis. Equilibrated spatial distribution of the particles in the suspension with a) pH=11.4 and b) pH=12.5, PbO are coloured red, Nb_2O_5 green, and $(MgCO_3)_4{\cdot}Mg(OH)_2{\cdot}4H_2O$ (MHC) blue. The number of contacts of one type of particles with other particles, normalized on the number of particles for a) pH 11.4 and b) pH 12.5 case. For example one MHC particle is in contact with 1.5 PbO particles and 1.3 Nb_2O_5 particles in average. PbO–MHC and Nb_2O_5–MHC contacts are desired for the synthesis, whereas PbO–PbO, Nb_2O_5–Nb_2O_5, MHC–MHC and PbO–Nb_2O_5 are not desired.

Calorimetric measurements revealed a giant electrocaloric effect in $(Pb_{0.88}La_{0.08})(Zr_{0.65}Ti_{0.35})O_3$ thin films on platinized silicon substrates, with the temperature change exceeding 40 K at a field amplitude around 1.1 MV/cm, measured at 318 K.

domain-wall mobility can be increased by freezing the disordered defect state, which can be achieved by rapidly cooling the ferrite from above the Curie temperature (Tc). The crucial factor is the cooling rate; namely, slow cooling (1°C/min) from above Tc causes the diffusion of defects back into their ordered (equilibrium) state that pin domain walls and decrease the remanent polarization. We also studied in detail the dependence of the piezoelectric d_{33} coefficient on the frequency and amplitude of AC pressure. A considerable increase in d_{33} of 25 %, namely, from 27 pC/N to 34 pC/N upon application of 3 MPa of AC pressure, was obtained.

A detailed study of the synthesis of the $(K,Na,Li)(Nb,Ta)O_3$ (KNLNT) solid solution revealed that the formation of the amorphous carbonato complex during the **mechanochemical activation** step is essential in order to obtain KNLNT ceramics with a high homogeneity and an improved piezoelectric response. Driven by this discovery, our next step was to focus on the identification of such intermediate phases and on the understanding of their formation. A combination of nuclear magnetic resonance (NMR) and Raman spectroscopy confirmed the formation of the carbonato complex in the A_2CO_3–Nb_2O_5 (A = K, Na) systems. The NMR investigation showed that the chemical environment of Na changes during milling; the intermediate state cannot be described by a simple linear superposition of the spectra of Na_2CO_3 and $NaNbO_3$. On the other hand, Raman spectroscopy also showed the formation of new Nb-O bonds during milling, which are not typical for perovskite phases or Nb_2O_5.

We have demonstrated **a new approach to the solid-state synthesis of $Pb(Mg_{1/3}Nb_{2/3})O_3$ (PMN)** based materials. It is not easy to prepare pyrochlore-free PMN by a one-step solid-state synthesis. With the appropriate manipulation of charges on the reagent particles, we were able to prepare water-based suspension mixtures with the distribution of particles favorable for the perovskite phase formation. The surface charge was tuned by the pH of the suspension. We have modeled the formation of the contacts between the particles in the suspension with the use of Monte Carlo simulations. At pH values higher than 11.8 the contacts between the particles are formed, which slow down the formation of secondary phases. After drying, the mixture was heated and single-phase PMN was synthesized. The ceramics, sintered at only 950 °C, exhibited properties comparable to those of the ceramics sintered at 200 °C higher temperatures. The same principle was further applied for the synthesis of 0.65 $Pb(Mg_{1/3}Nb_{2/3})O_3$–0.35 $PbTiO_3$. Here, the single-phase perovskite material was prepared at as low as 850 °C. (**Figure 1**).

We have prepared **$KTaO_3$ thin films by Chemical Solution Deposition** (CSD) on different substrates from acetate-alkoxide based sols. The perovskite phase crystallized after heating at 900 °C in a rapid thermal annealing furnace. About 200-nm-thick films exhibit a frequency independent permittivity with a room-temperature value of 200 in the 1 kHz – 15 GHz range. Further dielectric measurements in broad frequency and temperature ranges are in progress in collaboration with the Condensed Matter Physics Department and the Institute of Physics from Prague.

Potassium sodium niobate **$(K_{0.5}Na_{0.5})NbO_3$ (KNN) thin films** on $Pt(111)/TiO_2/SiO_2/Si$ substrates have been prepared from the acetate-alkoxide-based precursor solutions with the stoichiometric composition and with 5 mol % and 10 mol % excess of sodium or potassium acetate. Upon rapid thermal annealing at 750 °C the films crystallized in pure perovskite monoclinic phase with a {100} preferential orientation. The amount of alkali excess in the precursor solutions, 5 or 10 mol %, influenced the nucleation and growth processes, resulting in the films with granular equiaxed microstructures or columnar microstructures, respectively. The energy-dispersive X-ray spectroscopy in a field-emission scanning electron microscope revealed that the volatilization of potassium oxide was more pronounced than the volatilization of sodium oxide. The films prepared from the solution with 5 mole % potassium excess had the composition which was the closest to the nominal KNN composition among all samples. The dielectric permittivity and losses of the latter films were around 450 and 3 % at 100 kHz and 300 K.

The **$(Pb_{0.88}La_{0.08})(Zr_{0.65}Ti_{0.35})O_3$ (PLZT)** thin films were prepared by CSD from lead acetate, lanthanum nitrate and transition metal propoxides in

2-methoxyethanol on platinized silicon substrates with the nucleation layer of $PbO/PbTiO_3$ and rapid thermal annealing at 650 °C. The films crystallized in a perovskite phase with preferred (100) orientation. The microstructure of about 450-nm-thick films consisted of columnar grains. The calorimetric measurements near room temperature, performed by colleagues from the Condensed Matter Physics Department, confirmed a giant electrocaloric effect in PLZT thin films. (**Figure 2**)

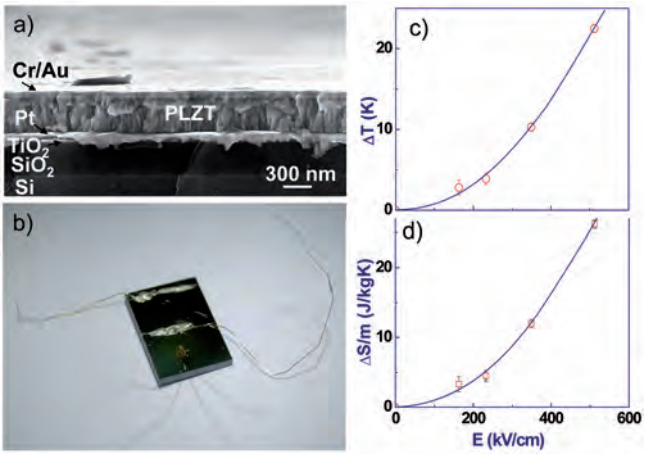

Figure 2: Microstructure of the $(Pb_{0.88}La_{0.08})(Zr_{0.65}Ti_{0.35})O_3$ (PLZT) thin film on platinized silicon substrate (a), photo of the thin-film sample with contacts (b), temperature change (c) and entropy change (d) depending on the applied electric field as determined by the direct calorimetric measurement.

We studied the low-temperature CSD of **ZnO thin films**. Microstructural and chemical analyses performed in collaboration with colleagues from the Condensed Matter Physics Department and Surface Engineering and Optoelectronics Department showed that the Zn-acetate derived thin films heated at 150°C in air were amorphous and contained no organic residues. The films deposited on SiO_x/Si and heated at 450°C were crystalline and consisted of randomly oriented grains with a diameter of about 20 nm. The physical characterization of the films was performed in collaboration with CEMOP Uninova, Portugal in the frame of a EU 6FP project MULTIFLEXIOXIDE. All the thin films were transparent, exhibiting a transmission of over 80 % in the visible range. The resistivity of the 120-nm-thick ZnO films processed at 150 °C was 57 MΩcm and upon heating at 450 °C it decreased to 1.9 kΩcm.

The development of transparent materials and their integration with the organic substrate have enabled manufacturing of **transparent, flexible electronics**. We have continued research on the development of materials and procedures for the fabrication of thin-film transistors (TFT) on polymer substrates. We studied the phase equilibria in $ZnO\text{-}In_2O_3\text{-}Ga_2O_3\text{-}ZrO_2$ and $Ta_2O_5\text{-}HfO_2\text{-}SiO_2\text{-}Al_2O_3$ systems. The reactivity of these systems was significantly improved by mechanochemical activation of the reagent mixtures. Sintering between 1350 °C and 1500 °C resulted in ceramics with an equilibrium chemical composition and a dense, homogeneous microstructure. Using this approach ceramic targets with a diameter of 50 mm were fabricated and further used for the sputtering of amorphous thin-film semiconductors and dielectrics in TFTs with outstanding properties. The work was performed in collaboration with CEMOP Uninova, Portugal, and the University of Barcelona, Spain, and a patent application has been filed.

The article Alkaline-earth doping in (K,Na) NbO_3 based piezoceramics, authors: B. Malič, J. Bernard, J. Holc, D. Jenko, and M. Kosec, Journal of the European Ceramic Society, 25 [12] 2005, 2707-2711, has been among the top 10 cited articles published in this journal in the past five years.

In_2O_3-ZnO 2D-structures were processed by **ink-jet printing** and heating at 150 °C and 450 °C with the aim for implementation in transparent electronics. The In-Zn-solution precursor, based on In-alkoxide and Zn-acetate in 2-methoxyethanol, was originally designed for the deposition of thin films. To adapt it for piezoelectric ink-jet printing, the viscosity and surface tension were adjusted by the addition of a more viscous 1,3-propanediol. The printing parameters: the temperatures of the cartridge and the substrate, and the drop spacing were adjusted to allow patterning with a 40 μm resolution on SiO_x/Si and glass substrates. The ink-jet printed 2D-structures heated at 150 °C were amorphous and, according to infrared spectroscopy, organics-free. Upon heating at 450 °C they crystallized without any preferential orientation, similar to the spin-coated thin films.

We also studied the ink-jet printing of ceramic suspensions. The ink should have suitable properties for jetting, high stability, particle size < 200 nm, surface tension ~28-30 mN/m and viscosity ~10-12 mPas. The TiO_2 powder which was electrostatically stabilized in water by adjusting the pH was used as the model system. We have prepared stable TiO_2 and PZT suspensions under controlled milling conditions, namely, at the optimal solids load, the amount of surfactants and additives for lowering the surface tension. The suspensions were used for patterning thick-film structures by ink-jet printing. (**Figure 3**)

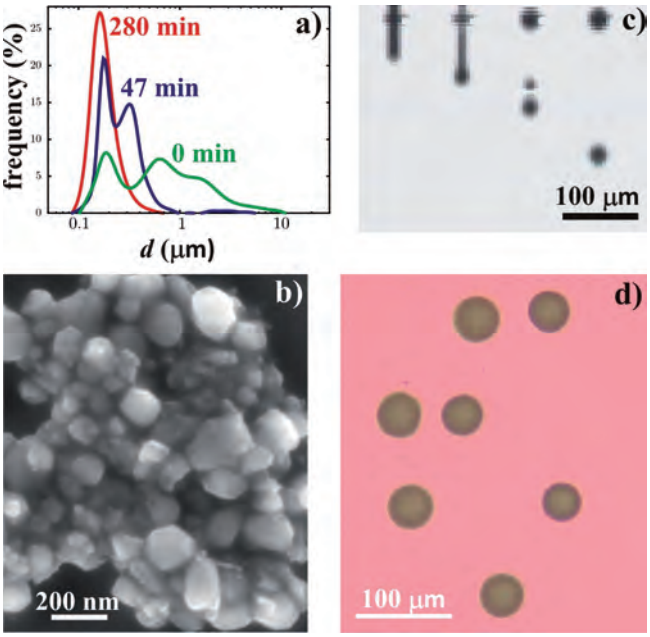

Figure 3: Aqueous TiO_2 suspensions for patterning structures by ink-jet printer. a) Evolution of the particle size distributions of TiO_2 particles during milling. b) TiO_2 powder after milling. c) Ejection of the drops from the ink-jet printer head. d) Pattern of TiO_2 printed on SiO_x/Si substrate.

We have continued research on the processing of **thick-film structures by electrophoretic deposition (EPD)**. The work on lead-zirconate-titanate (PZT) thick-film structures for high-frequency ultrasound transducers (> 40 MHz) was performed in collaboration with François-Rabelais University, Tours, France. At optimized characteristics of the suspension (zeta potential,

The innovation: "Electrocalorics: Materials for application in cooling and heating devices of new generation" by Alja Kupec, Brigita Rožič (Department of Condensed Matter Physics), prof. dr. Z. Kutnjak (Department of Condensed Matter Physics), prof. dr. M. Kosec and prof. dr. B. Malič was selected as one of the best eight innovations in 2010 in the competition for the rectors award from the University of Ljubljana.

viscosity, electrical conductivity, concentration), deposition parameters (voltage, deposition time) and sintering conditions we prepared the PZT structures with a thickness of 30 μm and about 80 % of theoretical density. The thickness-coupling coefficient of 48 %, obtained in the films, confirmed that the EPD process was suitable for the fabrication of efficient high-frequency transducers for high-resolution medical imaging.

We investigated the processing of **(K,Na)NbO_3 (KNN) thick films by screen printing** with the aim to find the conditions for low-temperature sintering and to prepare films with an enhanced functional response. The sintering temperature of the thick films and ceramics was 950 °C, which is 200 °C lower in comparison to the sintering temperature of KNN ceramics prepared by the conventional solid-state method. The low sintering temperature and the single-phase KNN were achieved by mechanochemical activation of the starting powder mixture. The thick films exhibited orientation primarily in the (100) direction and in the (10-1) direction. We attribute the orientation development to the compressive thermal stress in the KNN films during cooling. The comparison between the films sintered with or without the packing powder of the same composition, confirmed that its presence enhanced densification, orientation and prevented the sublimation of alkali oxides from the films. The dielectric and piezoelectric properties of the films sintered in the presence of the packing powder were higher, the d_{33} was ~70 pC/N as compared to 100-120pC/N for KNN bulk ceramics.

Within the EU 7FP project MICROFLEX a **thick-film temperature sensor on textile**, based on a polymer-carbon composite, was fabricated. The temperature sensors exhibited a positive temperature coefficient of 700 ppm / K in the range of 10 to 70 °C. In addition we succeeded to produce a stable suspension of submicron PZT particles in a UV-curing acrylic polymer for ink-jet printing. The suspension is suitable for the manufacture of piezoelectric sensors and actuators on flexible substrates.

In cooperation with our colleagues from the University of Warsaw, the study of **lead-free materials for thick-film resistors** was continued. Thick-film resistors with a sheet resistivity between 50Ω and 50 kΩ were printed and fired on different LTCC (Low Temperature Co-fired Ceramics) substrates. Interactions between thick-film resistors and glassy LTCC materials influenced the electrical characteristics. The sheet resistivity, current noise indices and temperature coefficients of resistivity increased as compared to the values obtained on alumina. The characteristics are acceptable for use in electronic circuits; the low gauge factors of around 3 imply that the performance of the resistors would be stable.

Investigations of the **phase equilibria** in the RuO_2–CaO–V_2O_5 system are related to the lead-free thick-film resistors, as the perovskite $CaRuO_3$ is used as the conductive phase in some lead-free, thick-film resistors. V_2O_5 is added to lead-free glasses in thick-film resistors to prevent crystallization during firing. The calcium ruthenate decomposes to RuO_2 and CaO in the presence of V_2O_5 in the glass phase during annealing.

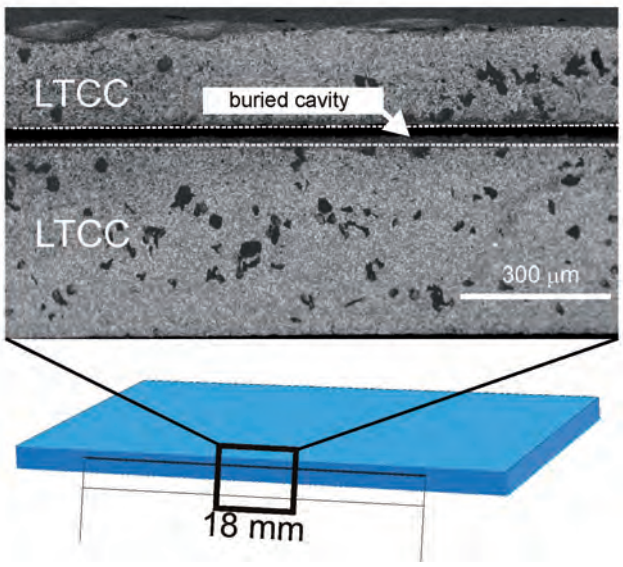

Figure 4: The microstructure of the buried cavity in the LTCC structure (top) and a schematic cross-section (bottom). The technology for well-defined buried cavities with a very high width-to-depth ratio (18 mm / 35 μm) and with a thin ceramic membrane on the top presents an extraordinary technological achievement making possible the fabrication of complex ceramic micro-systems.

The investigations of different **LTCC materials** used in multilayer circuits and 3D structures with buried cavities (MEMS – Micro Electro Mechanical Systems) were continued. These materials are composed of low-temperature crystallizing glass and Al_2O_3. The LTCC materials were fired at different temperatures and the evolution of the phase composition, the microstructure and mechanical characteristics was studied. During annealing the Al_2O_3 dissolved into the glass phase and the anorthite crystallized. When using the optimized firing conditions a quite high flexural strength of 350 MPa could be obtained.

In cooperation with colleagues from the Department of Systems and Control, from the Laboratory of Catalysis and Chemical Reaction Engineering, National Institute of Chemistry and from HIPOT-RR the 3D **LTCC structures for ceramic micro-reactors** were designed. A ceramic micro-reactor fuel processor was developed for the steam-reforming of liquid fuel and water into hydrogen, designed for low-temperature fuel cells. The system consists of the evaporator, the mixing chambers, the burner compartment with exhausts and the reactor for catalyzed reactions between reactants. The micro-reactor includes a thick-film-based temperature sensor and pressure sensors.

In cooperation with the research partner HIPOT-RR and the industrial partner HYB d.o.o., technological processes for the production of the LTCC-based **ceramic pressure sensors** were developed. Carbon- and carbonate-based fugitive materials have been investigated for the realization of the

buried cavities. These materials enable the realization of well-defined buried cavities with a very high width-to-depth ratio and with a thin ceramic membrane on top. Selected characteristics of the pressure sensor were optimized, for example, a better sensitivity, a larger signal/noise ratio and lower power consumption. **(Figure 4)**

In cooperation with the Slovenian company ETI d.d. Izlake we investigated the possibility of recycling the porcelain scrap in the **production of alumina porcelain**. We found that the addition of porcelain scrap improved the mechanical strength of the porcelain. The improved manufacturing process of the alumina porcelain with the addition porcelain scrap led to a patent application.

Some outstanding publications in the past year

1. Jenny Tellier, Danjela Kuščer, Barbara Malič, Jena Cilenšek, Miha Škarabot, Janez Kovač, Gonçalo Gonçalves, Igor Muševič, Marija Kosec, Transparent, amorphous and organics-free ZnO thin films produced by chemical solution deposition at 150 °C, Thin solid films, 2010, 518 (18), 5134-5139.
2. Tadej Rojac, Marija Kosec, Bojan Budič, Nava Setter, Dragan Damjanovič, Strong ferroelectric domain-wall pinning in $BiFeO_3$ ceramics, Journal of Applied Physics, 2010, 108 (7), 0741071-8.
3. Marina Santo-Zarnik, Darko Belavič, Srečo Maček, The warm-up and offset stability of a low-pressure piezoresistive ceramic pressure sensor, Sensors and Actuators A: Physical, 2010, 158 (2), 198-206.
4. Hana Uršič, Andreja Benčan, Miha Škarabot, Matjaž Godec, Marija Kosec, Dielectric, ferroelectric, piezoelectric, and electrostrictive properties of $K_{0.5}Na_{0.5}NbO_3$ single crystals, Journal of Applied Physics, 2010, 107 (3), 0337051-5.
5. Hana Uršič, Marko Hrovat, Janez Holc, Jenny Tellier, Silvo Drnovšek, Nicolas Guiblin, Brahim Dkhil, Marija Kosec, Influence of the substrate on the phase composition and electrical properties of 0.65PMN-0.35PT thick films, Journal of the European Ceramic Society, 2010, 30 (10), 2081-2092.

Patent granted

1. Procedure for the preparation of ceramics based on alkaline niobates tantalates using mechanochemical activation
   Tadej Rojac, Marija Kosec, Janez Holc
   Patent No. SI 22838 (A)
2. Alumina porcelain with improved thermal properties and its production
   Martina Oberžan, Janez Holc, Marjan Buh, Ivan Lavrač, Marija Kosec
   Patent No. SI 23000 (A)

Awards and appointments

1. Glinšek Sebastjan: Award for the best presentation among young researchers in the field of inorganic materials, Portorož, Slovenia,18th Conference on Materials and Technologies
2. Kosec Marija: 2010 Ferroelectrics Recognition Award, Edinburgh, Great Britain, IEEE Ultrasonics, Ferroelectrics and Frequency Control Society
3. Malič Barbara: Zois Award for extraordinary achievements on the field of ferroelectric ceramics and thin films, Ljubljana, Ministry for Higher Education, Science and Technology

Organization of conferences, congress and meetings

1. Workshop on structural characterization, Ljubljana, Slovenia, January 28, 2010
2. 4th Day of Young Researchers, Ljubljana, Slovenia, February 11, 2010
3. Training course on processing and structural characterization of lead-based and lead-free piezoelectric ceramics, Tronhdeim, Norway, June 13, 2010
4. Conference ELECTROCERAMICS XII, Trondheim, Norway, June 12-17, 2010
5. Conference on Sensors and Actuators 2010, Ljubljana, Slovenia, October 20-21, 2010

INTERNATIONAL PROJECTS

1. Oxide Materials Towards a Matured Post-silicon Electronics Era
   ORAMA
   7. FP, NMP3-LA-2010-246334
   EC; Dr. Bernd Szyszka, Head of Department Large Area Coating, Fraunhofer Institute for Surface Engineering and Thin Films (IST), Braunschweig, Germany; Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung E.V., Muenchen, Germany
   Prof. Marija Kosec, Prof. Barbara Malič
2. Micro Fabrication Production Technology for MEMS on New Emerging Smart Textiles/Flexibles
   MICROFLEX
   7. FP, NMP2-LA-2008-211335
   EC; Dr. Steve Beeby, University of Southampton, School of Electronics and Computer Science, Hampshire, Southampton, Great Britain
   Prof. Marija Kosec, Dr. Janez Holc, Prof. Tomaž Kosmač
3. Novel Technology for High-PERformance Piezoelectric Actuators
   HIPER-Act, CP-IP 212394, FP7-NMP-2007-LARGE-1, 7. FP
   EC; Anders Bjerrum, Claus Bo Andersen, Noliac A/S, Kvistgaard, Denmark
   Prof. Marija Kosec, Asst. Prof. Andreja Benčan Golob
4. Monolithic above IC Ultra High Value Capacitors for Mobile and Wireless Communication Systems
   CAMELIA
   6. FP; NMP3-CT-2006-033103
   EC; Dr. Richard Winfield, Tyndall National Institute, Lee Maltings, Cork; University College Cork, National University of Ireland, Cork, Ireland
   Prof. Barbara Malič
5. Multifunctional Ceramic Layers with High Electromagnetoelastic Coupling in Complex Geometries
   MULTICERAL
   6. FP, NMP3-CT-2006-032616
   EC; Prof. Andrei Kholkin, University of Aveiro, Dept. of Ceramics & Glass Engineering, Aveiro, Portugal
   Prof. Marija Kosec, Dr. Janez Holc, Prof. Robert Blinc, Prof. Raša Pirc
6. Multicomponent Oxides for Flexible and Transparent Electronics
   MULTIFLEXIOXIDES
   6. FP, NMP3-CT-2006-032231
   EC; Prof. Rodrigo Ferrao de Paiva Martins, UNINOVA - Instituto de Desenvolivimento de Novas Technologias, Monte de Caparica, Portugal
   Asst. Prof. Danjela Kuščer Hrovatin
7. Multifunctional & Integrated Piezoelectric Devices
   MIND
   6. FP, NMP3-CT-2005-515757
   EC; Wanda Wolny, Ferroperm Piezoceramics A/S, Kvistgård, Denmark
   Prof. Marija Kosec, Prof. Barbara Malič
8. New Generation of 3D Integrated Passive Components and Microsystems in LTCC Technology
   IPCTECH
   EUREKA
   Asst. Prof. Marko Hrovat
9. Study Visits - Hosting Groups from Slovenia in the Countries of Norway, Iceland and Liechetnstein
   NFM-NFM-109/09, SI-549/2010
   EC; CMEPIUS, Ljubljana, Slovenia
   Prof. Marija Kosec
10. Training in the frame of the Leonardo da Vinci mobility at the Instituto de Ciencia de Materiales de Madrid
    UIT
    LDV-MOB-87/10
    EC; CMEPIUS, Ljubljana, Slovenia
    Dr. Hana Uršič Nemevšek
11. Lead-free Piezoelectric Ceramics based on Alkaline Niobates/Tantalates: Study of Synthesis, Structure and Phase Transition
    BI-FR/10-11-PROTEUS-003
    Dr. Brahim Dkhil, Ecole Centrale Paris, Chatenay-Malabry Cedex, France
    Prof. Barbara Malič
12. Studies on Structure-Properties Relationship of Novel Electronic Ceramics
    BI-CN/09-11-001
    Prof. Hong Wang, Xi'an Jiaotong University, Xi'an, China
    Prof. Marija Kosec
13. Investigation of Advanced Deposition Technologies for Interconnections in Organic and Flexible Electronics
    BI-PL/10-11-013
    Prof. Janusz Sitek, Tele and Radio Research Institute, Warsaw, Poland
    Asst. Prof. Danjela Kuščer Hrovatin
14. Study of Novel Synthesis Routes of Environment-friendly Complex Oxides
    BI-RO/10-11-005
    Prof. dr. Maria Magdalena Zaharescu, Ilie Murgulescu Institute of Physical Chemistry, Bucharest, Romania
    Prof. Barbara Malič

R & D GRANTS AND CONTRACTS

1. Energy-saving Ceramic Pressure Sensors with Digital Output
   Asst. Prof. Marko Hrovat
2. Mechanochemical Synthesis of Complex Ceramic Oxides
   Dr. Tadej Rojac
3. Miniaturised Ceramic Low Pressure Sensors
   Asst. Prof. Marko Hrovat
4. Functional Properties of Thin Films Based on Environment Friendly Complex Perovskite Materials: Dependence on Microstructure and Chemical Homogeneity
   Prof. Barbara Malič
5. Processing of Ceramic Microelectromechanical Systems (MEMS) by Novel Technologies
   Dr. Janez Holc
6. Ceramic Materials for 3D Structures and Study of Functional Properties
   Dr. Janez Holc
7. Textured Ceramic Films for Sensors and Actuators
   Prof. Marija Kosec

RESEARCH PROGRAM

1. Electronic Ceramics, Nano-, 2D and 3D Structures
   Prof. Marija Kosec

NEW CONTRACTS

1. Collaboration at the project NODISEA PI2 "Fuses for the new applications"
   ETI d.d.
   Dr. Janez Holc
2. Recycling of porcelain scrap C-120 in order to improve thermal shoch resistance and mechanical strength in accordance with PI4 "Fuses for the new applications", project NODISEA
   Jožef Stefan International Postgraduate School
   Prof. Marija Kosec

MENTORING

Ph. D. Thesis

1. Hana Uršič Nemevšek, *Structural and electrical properties of 0.65PMN-0.35PT thick films on different substrates* (mentor Marija Kosec; co-mentor Marko Hrovat)

VISITORS FROM ABROAD

1. Dr. Ewa Markiewicz, Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland, January 20-29, 2010
2. Prof. Dr. Maria Zaharescu, Ilie Murgulescu Institute of Physical Chemistry, Bucharest, Romania, April 15-20, 2010
3. Prof. Dr. Manfred Rühle, MPI für Metallforschung, Stuttgart, Germany, May 19-21, 2010
4. Prof. Dr. Ahmad Safari, The Glenn Howatt Electroceramic Laboratory, The University of New Jersey, New Jersey, USA, June 3-6, 2010
5. Prof. Dr. Franck Levassort, François-Rabelais University of Tours, Tours, France, June 7-9, 2010
6. Alann Renault, François-Rabelais University of Tours, Tours, France, June 7-9, 2010
7. Prof. Dr. Hisao Suzuki, Department of Materials Science, Shizuoka University, Shizuoka, Japan, June 17-19, 2010
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9. Ridvan Demiryurek, Sabanci University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey, July 5 – September 12, 2010
10. Bilal Demir, Sabanci University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey, July 5 – September 12, 2010
11. Dr. Oana Catalina Mocioiu, Institute of Physical Chemistry Ilie Murgulescu, Bucharest, Romania, August 15 – September 4, 2010
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18. Aneta Arazna, Tele and Radio Research Institute, Warsaw, Poland, September 28 - October 2, 2010
19. Prof. Dr. Ralf Moos, Universität Bayreuth, Bayreuth, Germany, October 19-20, 2010
20. Prof. Dr. Dragan Damjanovic, Ceramics Laboratory, Swiss Federal Institute of Technology-EPFL, Lausanne, Switzerland, October 26-30, 2010
21. Prof. Dr. Maya Glinchuk, Institute of Problems of Materials Science, NAS of Ukraine, Kiev, Ukraine, November 7-20 2010
22. Prof. dr. Angus Kingon, Brown University, Rhode Island, USA December 13-17 2010

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29. Tina Ručigaj, B. Sc.

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BIBLIOGRAPHY

Original Articles

1. Pedro Barquinha, Danjela Kuščer, Marija Kosec, (10 authors), "Low-temperature sputtered mixtures of high-K and high bandgap dielectrics for GIZO TFTs", *J. Soc. Inf. Disp.*, vol. 18, no. 10, pp. 762-772, 2010.
2. Marko Hrovat, Janez Holc, Małgorzata Jakubowska, Konrad Kiełbasiński, Kostja Makarovič, Darko Belavič, "Subsolidus phase equilibria in the CaO-poor part of the $RuO_2 - CaO - SiO_2$ system", *Mater. res. bull.*, vol. 45, no. 12, pp. 2040-2043, 2010.
3. Elena-Daniela Ion, Barbara Malič, Iztok Arčon, Jana Padežnik Gomilšek, Alojz Kodre, Marija Kosec, "Characterization of lanthanum zirconate prepared by a nitrate-modified alkoxide synthesis route: from sol to crystalline powder", In: *COST 539: electroceramics from nanopowders produced by innovative methods (ELENA), 1 to 3 September 2008, Manchester, UK*, (Journal of the European Ceramic Society, vol. 30, iss. 2), Robert Freer, ed., Colin Leach, ed., Barking, Elsevier, 2010, pp. 569-575.
4. Konrad Kiełbasiński, Małgorzata Jakubowska, Anna Młożniak, Marko Hrovat, Janez Holc, Darko Belavič, "Investigation on electrical and microstructural properties of Thick Film Lead-Free resistor series under various firing conditions", *J. mater. sci., Mater. electron.*, vol. 21, no. 10, pp. 1099-1105, 2010.
5. Jurij Koruza, Jenny Tellier, Barbara Malič, Vid Bobnar, Marija Kosec, "Phase transitions of sodium niobate powder and ceramics, prepared by solid state synthesis", *J. appl. phys.*, vol. 108, no. 11, pp. 113509-1-113509-9, 2010.
6. Marija Kosec, Hana Uršič, Janez Holc, Marko Hrovat, Danjela Kuščer, Barbara Malič, "High-performance PMN-PT thick films", *IEEE trans. ultrason. ferroelectr. freq. control*, vol. 57, no. 10, pp. 2205-2212, 2010.
7. Danjela Kuščer, Marija Kosec, "$0.65Pb(Mg_{1/3}Nb_{2/3})O_3 - 0.35PbTiO_3$ thick films repared by electrophoretic deposition from an ethanol-based suspension", *J. Eur. Ceram. Soc.*, vol. 30, no. 6, pp. 1437-1444, 2010.
8. Adrijan Levstik, Cene Filipič, Vid Bobnar, Silvo Drnovšek, Janez Holc, Marija Kosec, "Polaron conductivity mechanism in $0.5Pb(Zr_{0.575}Ti_{0.425})O_3 - 0.5Pb(Fe_{2/3}W_{1/3})O_3$", *Phys., B Condens. matter*, vol. 405, no. 20, pp. 4271-4273, 2010.
9. Adrijan Levstik, Cene Filipič, Vid Bobnar, Silvo Drnovšek, Janez Holc, Zvonko Trontelj, Zvonko Jagličić, "Ordering of polarons in $Pr_{0.5}Ca_{0.5}MnO_3$", *Solid state commun.*, vol. 150, no. 27-28, pp. 1249-1252, 2010.
10. Sheng-Guo Lu, Brigita Rožič, Q. M. Zhang, Zdravko Kutnjak, Xinyu Li, E. Furman, Lee J. Gorny, Minren Lin, Barbara Malič, Marija Kosec, Robert Blinc, Raša Pirc, "Organic and inorganic relaxor ferroelectrics with giant electrocaloric effect", *Appl. phys. lett.*, vol. 97, no. 16, pp. 162904-1-162904-3, 2010.
11. Barbara Malič, M. L. Calzada, Jena Cilenšek, Lorena Pardo, Marija Kosec, "Thermal analysis study of diol based precursors for chemical solution deposition of $0.7Pb(Mg_{1/3}Nb_{2/3})O_3 - 0.3PbTiO_3$ thin films", *Advances in applied ceramics*, issue 3, vol.109, pp. 147-151, 2010.
12. Roman Pačnik, Darko Belavič, Marko Hrovat, Marija Kosec, "The benchmarking of force sensors for the weighing of small masses in cost-sensitive applications", *Inf. MIDEM*, vol. 40, no., pp. 45-52, 2010.
13. Tadej Rojac, Andreja Benčan, Marija Kosec, "Mechanism and role of mechanochemical activation in the synthesis of $(K, Na, Li)(Nb, Ta)O_3$ ceramics", *J. Am. Ceram. Soc.*, issue 6, vol. 93, pp. 1619-1625, 2010.
14. Tadej Rojac, Marija Kosec, Bojan Budič, Nava Setter, Dragan Damjanović, "Strong ferroelectric domain-wall pinning in $BiFeO_3$ ceramics", *J. appl. phys.*, vol. 108, no. 7, pp. 074107-1-074107-8, 2010.
15. Brigita Rožič, Barbara Malič, Hana Uršič, Janez Holc, Marija Kosec, Bret Neese, Q. M. Zhang, Zdravko Kutnjak, "Direct measurements of the giant electrocaloric effect in soft and solid ferroelectric materials", In: *Proceedings of the 4th Asian meeting on Ferroelectrics (AMF-4), December 12th-15th, 2003, Materials Research Centre, Bangalore, India*, (Ferroelectrics, vol. 405, no. 1), S. B. Krupanidh, ed., New York, Gordon and Brench, 2010, pp. 26-31.
16. M. Sagmeister, U. Brossmann, Emil J. W. List, R. Ochs, D. V. Szabo, R. Saf, Werner Grogger, Elena Tchernychova, R. Würschum, "Synthesis and optical properties of organic semiconductor: zirconia nanocomposites", *J. nanopart. res.*, vol. 12, no. 7, pp. 2541-2551, 2010.
17. Marina Santo-Zarnik, Darko Belavič, Srečo Maček, "The warm-up and offset stability of a low-pressure piezoresistive ceramic pressure sensor", *Sens. actuators, A, Phys.*, vol. 158, no. 2, pp. 198-206, 2010.
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19. Gaj Stavber, "The road to greener applied organic synthesis: performing organic reactions in micelle-based and host-guest aqueous nanoreactors", *Aust. J. Chem.*, vol. 63, no. 5, pp. 849-849, 2010.
20. Gaj Stavber, Stojan Stavber, "Towards greener fluorine organic

water and under solvent-free reaction conditions", *Advanced Synthesis & Catalysis*, vol. 352, no. 16, pp. 2838-3846, 2010.
21. Izabela Szafraniak-Wiza, Bożena Hilczer, Biljana Stojanović, Ewa Talik, Adam Pietraszko, Barbara Malič, "Ferroelectric perovskite nanopowders obtained by mechanochemical synthesis", *Processing and application of ceramics*, vol. 4, no. 3, pp. 99-106, 2010.
22. Jenny Tellier, Danjela Kuščer, Barbara Malič, Jena Cilenšek, Miha Škarabot, Janez Kovač, Gonçalo Gonçalves, Igor Muševič, Marija Kosec, "Transparent, amorphous and organics-free ZnO thin films produced by chemical solution deposition at 150 23C", *Thin solid films*, vol. 518, no. 18, pp. 5134-5139, 2010.
23. Hana Uršič, Andreja Benčan, Miha Škarabot, Matjaž Godec, Marija Kosec, "Dielectric, ferroelectric, piezoelectric, and electrostrictive properties of $K_{0.5}Na_{0.5}NbO_3$ single crystals", *J. appl. phys.*, vol. 107, no. 3, pp. 033705-1-033705-5, 2010.
24. Hana Uršič, Marko Hrovat, Janez Holc, Jenny Tellier, Silvo Drnovšek, N. Guiblin, Brahim Dkhil, Marija Kosec, "Influence of the substrate on the phase composition and electrical properties of 0.65PMN-0.35PT thick films", *J. Eur. Ceram. Soc.*, vol. 30, no. 10, pp. 2081-2092, 2010.
25. Mirjana M. Vijatović, Jelena D. Bobić, Biljana Stojanović, Barbara Malič, "Barium titanate thick films prepared by screen printing technique", *Processing and application of ceramics*, vol. 4, no. 2, pp. 53-58, 2010.
26. Benpeng Zhu, Jiangxue Han, Jing Shi, K. Kirk Shung, Qing Wei, Yuhong Huang, Marija Kosec, Qifa Zhou, "Lift-off PMN-PT thick film for high-frequency ultrasonic biomicroscopy", *J. Am. Ceram. Soc.*, vol. 93, no. 10, pp. 2929-2931, 2010.

Review Articles and Chapters in Books

1. Marija Kosec, Barbara Malič, Andreja Benčan, Tadej Rojac, Jenny Tellier, "Alkaline niobate-based piezoceramics: crystal structure, synthesis, sintering and microstructure", *Functional materials letters*, vol. 3, no. 1, pp. 15-18, 2010.
2. Tadej Rojac, Marija Kosec, "Mechanochemical synthesis of complex ceramic oxides", In: *High-energy ball milling: mechanochemical processing of nanopowders*, Małgorzata Sopicka-Lizer, ed., Boca Raton, CRC, Oxford, Cambridge, New Delhi, Woodhead, 2010, pp. 113-148.

Published Conference Papers

Regular papers

1. Darko Belavič, Marko Hrovat, Marina Santo-Zarnik, Janez Holc, Mitja Jerlah, Kostja Makarovič, Marija Kosec, "Tehnologija LTCC in njena uporaba za izdelavo keramičnih mikrosistemov", In: *Vir znanja in izkušenj za stroko: zbornik foruma*, Industrijski forum IRT, Portorož, 7.-8. junij 2010, Tomaž Perme, ed., Darko Švetak, ed., Jože Balič, ed., Škofljica, Profidtp, 2010, pp. 175-180.
2. Darko Belavič, Marina Santo-Zarnik, Kostja Makarovič, Marko Hrovat, "An investigation of the temperature and humidity dependence of the initial capacitance of the LTCC-based capacitive pressure sensor", In: *Proceedings*, Denis Đonlagić, ed., Iztok Šorli, ed., Polona Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2010, pp. 297-301.
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1. Danjela Kuščer, *Inkjet printing of ceramic suspensions: lecture slides*, Ljubljana, Institut Jožef Stefan, 2010.
2. Barbara Malič, Marija Kosec, *Ceramic processing of targets for Physical Vapor Deposition: lecture slides*, Ljubljana, Institut Jožef Stefan, 2010.
3. Barbara Malič, Jenny Tellier, Marija Kosec, *Solutions for thin film deposition and ink-jet printing of functional-oxide materials: lecture slides*, Ljubljana, Institut Jožef Stefan, 2010.

Theses

Ph. D. Thesis

1. Hana Uršič, *Structural and electrical properties of 0.65PMN-0.35PT thick films on different substrates: doctoral dissertation*, Ljubljana, [H. Uršič Nemevšek], 2010.

B. Sc. Thesis

1. Jernej Pavlič, *Preparation and characterization of $(K, Na)NbO_3$ based thick films: undergraduate thesis*, Ljubljana, [J. Pavlič], 2010.

Patents

1. Martina Oberžan, Janez Holc, Marjan Buh, Ivan Lavrač, Marija Kosec, *Alumina porcelain with improved thermal properties and its production: SI23000 (A)*, Ljubljana, Urad RS za intelektualno lastnino, 30. okt. 2010.
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2. Rodrigo Ferrão De Paiva Martins, Elvira Maria Correia Fortunato, Pedro Miguel Candido Barquinha, Nunes Pereira, Gonçalo Gonçalves, Danjela Kuščer, Marija Kosec, Maria Silvina Vieira Pereira Ferreira, *Amorphous multicomponent dielectric based on the mixture of high band gap and high K materials, respective devices and manufacture: PPI42360-10*, Lisboa, National Institute of Industrial Properties, 5. avg. 2010.
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ENGINEERING CERAMICS DEPARTMENT

K-6

The Engineering Ceramics Department is the leading group in the field of structural ceramics and ceramic technologies in Slovenia. The research programme comprises phenomena relevant to materials synthesis and component fabrication as well as mechanisms leading to the degradation of engineering ceramic structures under operating conditions. The applied research work is focused on new applications of engineering ceramics, the development of novel, high-strength, wear-, corrosion- and/or heat-resistant materials and the development of alternative, cost-effective and environmentally friendly ceramic technologies.

Head:
Prof. Tomaž Kosmač

In 2010 we continued our research on the hydrolysis of aluminium nitride (AlN) powder in diluted aqueous slurries. The work was done in the scope of a dissertation of a young researcher that was successfully defended at Jožef Stefan International Postgraduate School. The hydrolysis process can be divided into three temperature-dependent stages. The first stage includes the induction period, when the degradation of the AlN powder in water is slow. During the induction period a dense, amorphous water soluble aluminium hydroxide layer is formed on the surface of the AlN particles. The second, faster stage represents the formation of poorly crystalline aluminium monohydroxide (boehmite; γ-AlOOH) on the surface of the AlN particles. The third stage is accompanied by the formation of aluminium trihydroxide (bayerite; γ-$Al(OH)_3$), until the AlN completely decomposes. The presence of the aluminium mononuclear species, $Al(OH)^{4-}$, which is the main precursor governing the aluminium hydroxides' precipitation was also confirmed. Besides that, we discovered that the hydrolysis of AlN powder can be retarded or even prevented by dispersing the powder in water constantly cooled to 5 °C. By using the appropriate solid loadings of the powder the hydrolysis could be kept in the induction period. Our extensive knowledge of AlN powder hydrolysis enabled its use for the preparation of porous Al_2O_3 ceramics, by the HAS ("Hydrolysis assisted solidification") process, exhibiting higher flexural-strength values compared to those prepared by conventional methods. α-Al_2O_3 crystallites, which nucleate within θ-Al_2O_3 lamellas during sintering, greatly enlarge the surface area of the necks formed between the main particles of the specimen and are the strength-determining factor in porous ceramics prepared in this way. The hydrolysis was later on also exploited for the synthesis of nanostructured boehmite coatings with a high specific surface area. After subsequent heat treatment the boehmite coating transformed into one of the transitional aluminas depending on the temperature of the heat treatment. In cooperation with dentists from the Medical Faculty it was shown that the synthesis of nanostructured δ-Al_2O_3 coatings is an effective, non-invasive preparation method for oxide ceramic dental restorations, such as ZrO_2, Al_2O_3 and InCeram™, prior to cementation with dental cements. This nanostructured δ-Al_2O_3 coating significantly improves the adhesion between the ceramic surface and the dental cement. The strength of the joint was confirmed by a shear-bond strength test. In co-operation with the research group of Prof. Matthias Kern from the University of Kiel in Germany it has been demonstrated, that the adhesive alumina costing is acid-resistant; besides, the bond strength was not diminished even after long-term thermo-cycling in an aqueous environment, indicating that the adhesive coatings can be used in the dental technician's lab. The process was also patented.

Researchers from the department and the research programme group received the Paffenbarger award for the presented original research paper "Resin Bond Strength to Nanostructured Alumina Coated Dental Oxide Ceramics" at the Annual Meeting of the Academy of Dental Materials.

The rheological properties of paraffin-wax suspensions with high solid loadings were also investigated in 2010. The possibilities for the use of sterically stabilized paraffin-wax suspensions for the shaping of green parts by low-pressure injection moulding (LPIM) were investigated. It was determined that such sterically stabilized suspensions exhibit low viscosity, but, in contrast to weakly flocculated suspensions, they do not show a Binhgham type of shear flow and do not have a yield stress, even at very

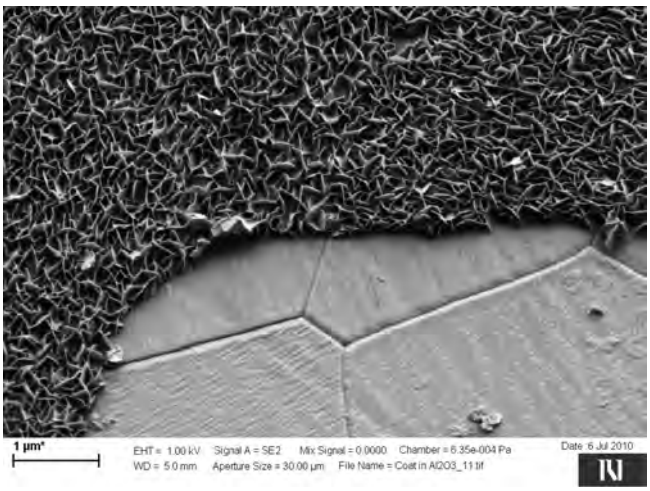

Figure 1: Nanostructured δ-Al_2O_3 coating on alumina ceramic substrate.

- **A new, one-step manufacturing process for a composite ceramic heater was developed and patented.**
- **Biscuit-sintered material exhibits a low elastic modulus and a two-times-higher bi-axial flexural strength, compared to the samples prepared only from micron-sized core material.**

high solids loadings. Due to the low viscosity these suspensions are very appropriate for shaping using LPIM; however, there are problems with the binder removal. Since they do not exhibit a yield stress, the shaped parts deform during thermal treatment above the melting point of the binder, which cannot be successfully overcome even when using the powder bed.

The research on electrically conductive composites based on silicon nitride (Si_3N_4) with dispersed titanium nitride (TiN) particles was continued in 2010. Such composites that can, due to their electrical conductivity, be machined by electrical discharge (EDM), can be used for the production of various heating elements. The composite was prepared by the formation of conductive TiN particles on the Si_3N_4 powder surface by the gel-precipitation of hydroxides and subsequent thermal treatment. After calcination at 600 °C in air metallic hydroxides were transformed into crystalline TiO_2. At 900 °C in a NH_3 gas flow they react with NH_3 to form TiN. To fabricate electrically conductive Si_3N_4/TiN composites the Si_3N_4 powders coated with various amounts of nano-sized TiN particles were sintered together with yttria and alumina additives at 1850 °C for 2 h in a nitrogen atmosphere. The results of the electrical conductivity and flexural strength measurements demonstrated that the sintered composites containing various TiN contents make these ceramics suitable for the production of heating elements at 23 vol. % of TiN. These composites with 23 vol. % of TiN exhibited a high electrical conductivity, i.e., $3.6 \times 10^3\ \Omega^{-1}m^{-1}$, and a suitable flexural strength of 360 MPa. The amount of TiN required to fabricate the Si_3N_4/TiN composite with appropriate properties can be reduced by approximately 10 vol. %, compared with the ceramics obtained from a mechanical mixture of the Si_3N_4 and TiN powders.

The research and development of dental ceramics based on tetragonal zirconia (Y-TZP) ZrO_2 was mainly focused on the following two issues: we continued the investigation of phase instability of conventionally sintered dental 3Y-TZP ceramics in simulated clinical conditions. Sintered samples in the shape of discs were exposed to accelerated ageing in an artificial saliva solution at 134 °C. The influence of the material and processing variables on the transformation rate was investigated and the effect of a mechanical surface treatment and accelerated ageing on the survival rate during cyclic mechanical loading (fatigue testing) was evaluated. In order to estimate the expected lifetime of dental restorations from Y-TZP ceramics, the in-vivo experiments of the ageing of materials were designed in cooperation with dentists from the Medical Faculty: two pairs of sintered ceramic discs were mounted into the lingual part of the removable denture and the relative amount of transformed monoclinic zirconia is determined every six months and compared with the results of in-vitro tests of accelerated ageing in artificial saliva. In 2010, six patients were included in this study and the results after twelve months is that the kinetics of ageing of dental Y-TZP ceramics in the mouth cavity is substantially different to the kinetics of accelerated ageing under isothermal conditions. The development of porous yttria-stabilized tetragonal zirconia (Y-TZP) ceramics for dental applications was continued, aimed at reducing the elastic modulus while preserving a useful strength. The preparation of so-called "core-shell" composites is based on the aggregation of particles of various sizes of same material in the suspension, which results in a homogeneous distribution of nano-sized particles attached to the surface of submicron-sized particles. The samples were shaped by slip casting and when completely dried, sintered in air to reach a determined relative density. The prepared "core-shell" composites exhibit approximately two times higher bi-axial flexural strength at 70 % of theoretical density, compared to the samples prepared only from micron-sized core material. The promising results achieved last year were confirmed in 2010 and explained using dilatometric analysis, TEM analysis and analysis of sintering kinetics. The results of the analyses indicate that nanoparticles begin to sinter first in the bimodal particle mixture and these sintered clusters of nanoparticles fill the contact areas between the micron-sized particles, therefore reducing the driving force for the sintering of micron-sized material and the densification rate. At the same time, a larger contact area, on behalf of larger necks between the micron-sized particles results in higher flexural-strength values in a moderately porous regime.

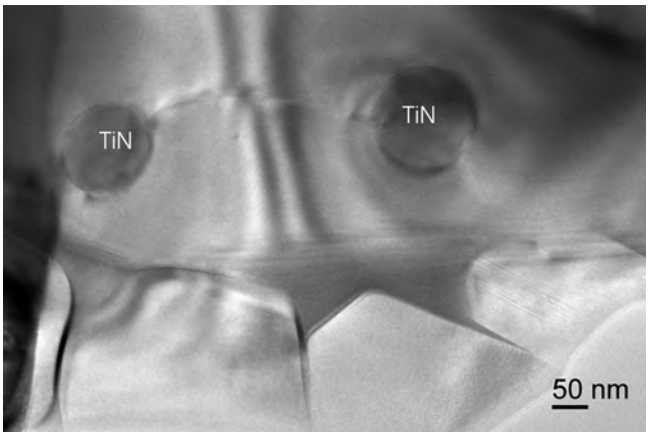

Figure 2: TEM analysis of Si_3N_4/TiN nano-composite sintered at 1850 °C for 2 h in N_2

In 2010 the investigations in the field of the synthesis of bioactive calcium phosphate coatings on zirconia Y-TZP substrates were continued. This Y-TZP ceramic is, due to its aesthetic and mechanical properties, frequently used in medicine as a material for dental implants. The fixation of an implant can be improved when its surface is covered by a bioactive calcium phosphate coating that forms a strong bond with the bone tissue. The coatings were prepared using a biomimetic method in which the ceramic substrate is immersed in a solution with same physiological temperature and a similar composition to the human blood plasma. The crystallization of calcium phosphates from aqueous solutions is a complex process, since

the smallest change in the synthesis conditions can influence the properties of the formed crystals, such as composition, crystal structure, morphology, etc. For this reason the influence of various parameters (temperature, pH, solution composition, time of synthesis) on the synthesis of coatings were researched. The obtained results enable us to control the synthesis of the coatings, by changing the conditions, the coatings with the desired properties can be synthesized.

Using a new model, describing the thermal debinding of green parts produced by low-pressure injection moulding, the binder removal step was shortened by 80 %.

In 2010 we cooperated with many other research institutions and industrial partners.

The Engineering Ceramics Department cooperates with the Interdent company from Celje in the applicative research project "Ageing of dental zirconia (Y-TZP) ceramics under simulated clinical conditions". In the investigation two commercially available granulates of zirconia powder with same chemical composition, differing in average size of primary crystallites and specific surface are, were used. The processing variables were the pressure of the uniaxial dry pressing, the time and the temperature of the pre-sintering, which influenced the strength and workability of the semi-manufactured product and the shrinkage during sintering to final density.

Within our bilateral cooperation with Chubu University near Nagoya in Japan the research on wear resistance of titanium alloys was continued. In spite the fact that these alloys are widely used as a bone implants there is still a problem of bad wear resistance of these materials. After direct nitration in ammonia at elevated temperatures, on the surface of the alloy a layer composed of titanium nitride is formed that results in significantly increased surface hardness. The wear of the titanium alloy can be increased by a factor of 300 using this method. But, more importantly, the adhesion between the titanium nitride and the alloy was improved in comparison to the TiN coating prepared by the commonly used PVD method.

In the frame of European project from 7. FP AppliCMA – "Development of wear resistant coatings based on complex metallic alloys for functional applications", in which JSI is one of the partners, our department is in charge of the synthesis of super-hard $AlMgB_{14}$ compound, sintering of the powders and microscopic analysis of the products. The above-mentioned compound was synthesized and solid sample used for thin films synthesis was prepared.

During our research work in the area shaping of ceramic products using low-pressure injection moulding (LPIM) the cooperation with Hidria AET company also continued in 2009. This company uses the LPIM process for shaping of the alumina ceramic products. We focused mainly on the investigation of thermal debinding of green parts in highly porous powder bed. It was discovered that in this process the removal of the binder follows two main mechanisms. At the temperatures from the binder melting point (60 °C) to 180 °C the binder is removed by thermal expansion and capillary suction of binder into highly-porous powder bed. At the temperatures above 180°C the main mechanism of binder removal is oxidation and binder degradation into gaseous products. On the basis of this research a new theoretical model of binder removal up to 180 °C developed in 2009 was extended with the model of binder removal above 180 °C, that is taking into account the oxidation and degradation of the binder. Both models were thoroughly experimentally verified and good agreement with the experimental data was confirmed.

Some outstanding publications in the past three years

1. Irena Pribošič, Sabina Beranič, Tomaž Kosmač. Biomimetic preparation and characterization of bioactive coatings on alumina and zirconia ceramics. J. Am. Ceram. Soc., 2010, vol. 93, no. 1, p. 288-294.
2. Sebastjan Perko, Aleš Dakskobler, Tomaž Kosmač. High-performance porous nanostructured ceramics. J. Am. Ceram. Soc., 2010, vol. 93, issue 9, p. 2499-2502,
3. Peter Jevnikar, Kristoffer Krnel, Andraž Kocjan, Nenad Funduk, Tomaž Kosmač. The effect of nano-structured alumina coating on resin-bond strength to zirconia ceramics. Dent. Mater., 2010, vol. 26, no. 7, p. 688-696,
4. Kristoffer Krnel, Andraž Kocjan, Tomaž Kosmač. A simple method for the preparation of nanostructured aluminate coatings. J. Am. Ceram. Soc., 2009, vol. 92, no. 10, p. 2451-2454.
5. Aleš Dakskobler, Tomaž Kosmač. Rheological properties of re-melted paraffin-wax suspensions used for LPIM. J. Eur. Ceram. Soc., 2009, vol. 29, no. 10, p. 1831-1836.
6. Kristoffer Krnel, Aljoša Maglica, Tomaž Kosmač. b-SiAlON/TiN nanocomposites prepared from TiO_2-coated Si_3N_4 powder. J. Eur. Ceram. Soc., 2008, vol. 28, no. 5, p. 953-957.

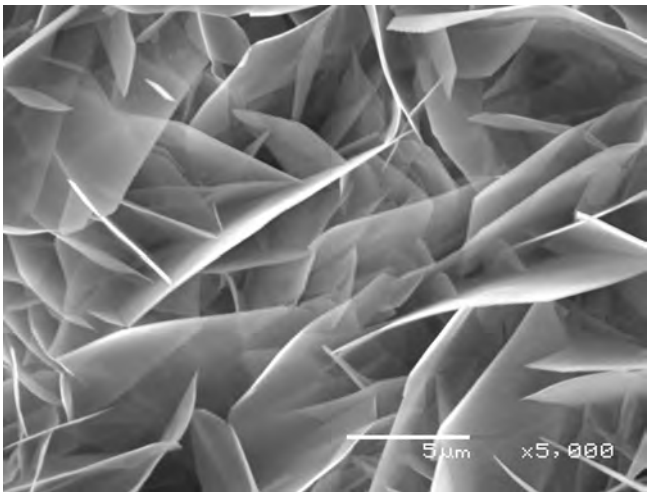

Figure 3. Crystals of octacalcium phosphate prepared using bio-mimetic method.

7. Andraž Kocjan, Kristoffer Krnel, Tomaž Kosmač. The influence of temperature and time on the AlN powder hydrolysis reaction products. J. Eur. Ceram. Soc., 2008, vol. 28, no. 5, p. 1003-1008.
8. Tomaž Kosmač, Aleš Dakskobler, Čedomir Oblak, Peter Jevnikar. The strength and hydrothermal stability of Y-TZP ceramics for dental applications. International journal of applied ceramic technology, 2007, vol. 4, no. 2, p. 164-174.

Awards and appointments

1. Golobič Matjaž, Kocjan Andraž, Kosmač Tomaž, Jevnikar Peter: The Paffenbarger Award (1st place) was given for the outstanding student presentation at the annual meeting of the Academy of Dental Materials, Trieste, October 7-9, 2010 (international award) "Resin bond strength to alumina coated dental oxide ceramic", Poster 111, Dent Mater, 2010, vol. 26, S1, p. e52-53

INTERNATIONAL PROJECTS

1. Micro Fabrication Production Technology for MEMS on New Emerging Smart Textiles/ Flexibles
   MICROFLEX
   7. FP, NMP2-LA-2008-211335
   EC; Dr. Steve Beeby, University of Southampton, School of Electronics and Computer Science, Hampshire, Southampton, Great Britain
   Prof. Tomaž Kosmač, Prof. Marija Kosec, Dr. Janez Holc
2. Development of Wear Resistant Coatings based on Complex Metallic Alloys for Functional Applications
   appliCMA
   7. FP, 214407
   EC; Susanne Fuchs, Austrian Research Centers GmbH - ARC, Functional Materials, Seibersdorf, Austria; Aerospace & Advanced Composites GmbH, Langesgericht Wiener Neustadt Austria, Wiener Neustadt, Austria
   Dr. Kristoffer Krnel, Dr. Miha Čekada, Prof. Janez Dolinšek, Dr. Srečo D. Škapin
3. Formation of Modified Oxide Layers to Improve the Wear Resistance of Titanium-based Alloys for Artificial Joint Prostheses
   BI-JP/08-10-003
   Prof. Tadashi Kokubo, Chubu University, Department of Biomedical Sciences, College of Life and Health Sciences, Matsumoto-chi, Kasugai, Aichi, Japan
   Prof. Tomaž Kosmač

R & D GRANTS AND CONTRACTS

1. Phase-boundary Investigations between Biomimetically Prepared Calcium Phosphate and Al_2O_3 oz ZrO_2 Ceramics
   Dr. Irena Pribošič
2. Ageing of Dental Zirconia (Y-TZP) Ceramics under Simulated Clinical Conditions
   Prof. Tomaž Kosmač
3. Patterns, Structural Self-assembling and Magnetoelectrics in Mixtures of Nanoparticles and Liquid Crystals
   Dr. Aleš Dakskobler, Prof. Samo Kralj
4. Ceramic Materials for 3D Structures and Study of Functional Properties
   Prof. Tomaž Kosmač, Dr. Janez Holc

RESEARCH PROGRAM

1. Engineering and bio-ceramics
   Prof. Tomaž Kosmač

MENTORING

Ph. D. Thesis

1. Andraž Kocjan, *The hydrolysis of AlN powder and its use for the synthesis of nanostructured alumina coatings* (mentor Tomaž Kosmač; co-mentor Kristoffer Krnel)

VISITOR FROM ABROAD

1. Prof. Dr. Ken Anusavitze, University of Florida, Gainesville, USA, October 9-10, 2010
2. Frank Lehmann, Britta Schlüter, Universitätsklinikum Schleswig-Holstein - Campus Kiel, Klinik für Zahnärztliche Prothetik, Propädeutik und Werkstoffkunde, Arnold-Heller-Str. 3 - Haus 26, D-24105 Kiell, Germany, November 27 - December 1, 2010

STAFF

Researchers
1. Prof. Tomaž Kosmač, Head
2. Asst. Prof. Kristoffer Krnel
Postdoctorial associates
3. Dr. Aleš Dakskobler
4. Dr. Andraž Kocjann
5. Dr. Irena Pribošič
6. Dr. Krunoslav Vidović*
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7. Lovro Gorjan, B. Sc.**
8. Aljoša Maglica, B. Sc.
9. Sebastjan Perko, B. Sc.
10. Martin Štefanič, B. Sc.
Technical officer
11. Natalija Petkovič Habe, B. Sc.
Technical and administrative staff
12. Darko Eterović
13. Mojca Hren
14. Tomislav Pustotnik

Note:
* part-time JSI member
** researcher financed by industry

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Original Articles

1. Lovro Gorjan, Aleš Dakskobler, Tomaž Kosmač, "Partial wick-debinding of low-pressure powder injection-moulded ceramic parts", *J. Eur. Ceram. Soc.*, vol. 30, no. 15, pp. 3013-3021, 2010.
2. Peter Jevnikar, Kristoffer Krnel, Andraž Kocjan, Nenad Funduk, Tomaž Kosmač, "The effect of nano-structured alumina coating on resin-bond strength to zirconia ceramics", *Dent Mater*, vol. 26, no. 7, pp. 688-696, 2010.
3. Aljoša Maglica, Kristoffer Krnel, Tomaž Kosmač, "Preparation of Si_3N_4 − TiN ceramic composites", *Mater. tehnol.*, vol. 44, no. 1, pp. 31-35, 2010.
4. Aljoša Maglica, Kristoffer Krnel, Tomaž Kosmač, "Preparation of Si3N4-TiN ceramic composites", *Mater. tehnol.*, vol. 44, no. 1, pp. 31-35, 2010.
5. Sebastjan Perko, Aleš Dakskobler, Tomaž Kosmač, "High-performance porous nanostructured ceramics", *J. Am. Ceram. Soc.*, vol. 93, issue 9, pp. 2499-2502, 2010.
6. Irena Pribošič, Sabina Beranič, Tomaž Kosmač, "Biomimetic preparation and characterization of bioactive coatings on alumina and zirconia ceramics", *J. Am. Ceram. Soc.*, vol. 93, no. 1, pp. 288-294, 2010.
7. Sam Zhang, Andraž Kocjan, F. Lehmann, Tomaž Kosmač, Matthias Kern, "Influence of contamination on resin bond strength to nano-structured alumina-coated zirconia ceramic", *Eur J Oral Sci*, vol. 118, no. 4, pp. 396-403, 2010.

Published Conference Papers

Regular papers

1. Kostja Makarovič, Janez Holc, Marko Hrovat, Darko Belavič, Aleš Dakskobler, Andreja Benčan, Marija Kosec, "Mechanical properties of an LTCC materials under various firing conditions", In: *Proceedings*, Denis Đonlagić, ed., Iztok Šorli, ed., Polona Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2010, pp. 131-134.
2. Krunoslav Vidović, Milan Ambrožič, Kristoffer Krnel, Tomaž Kosmač, Stephen Akers, "The fracture strength of fibre-cement corrugated sheets: a statistical approach using weibull analysis", In: *Proceedings*, IIBCC 2010, 12th International Inorganic-Bonded Fiber Composites Conference, 21-24 September 2010, Aalborg, Denmark, Eigil V. Sorensen, ed., Henning M. Thygesen, ed., Aalborg, Aalborg University, 2010, pp. 116-129.

Textbooks and Lecture Notes

1. Aleš Dakskobler, Tomaž Kosmač*, Particle dispersion and forming of powder compacts: literature for the course "Processing of nanopowders"*, (Nanosciences and nanotechnologies), Ljubljana, Jožef Stefan International Postgraduate School, 2010.
2. Kristoffer Krnel, Tomaž Kosmač*, Mehanske lastnosti materialov: študijsko gradivo: predmet: Biokeramični materiali*, (Nanoznanosti in nanotehnologije), Ljubljana, Jožef Stefan International Postgraduate School, 2010.
3. Kristoffer Krnel, Tomaž Kosmač*, Statistika pri vrednotenju mehanskih lastnosti inženirske in bio-keramike: študijsko gradivo: predmet: Biokeramični materiali*, (Nanoznanosti in nanotehnologije), Ljubljana, Jožef Stefan International Postgraduate School, 2010.

Theses

Ph. D. Thesis

1. Andraž Kocjan*, The hydrolysis of AIN powder and its use for the synthesis of nanostructured alumina coatings: doctoral dissertation*, [Ljubljana, A. Kocjan], 2010.

Patent Applications

1. Aleš Dakskobler, Andraž Kocjan, Manca Logar*, Postopek priprave nosilnega koloidnega prahu z visoko specifično površino: P-201000330*, Ljubljana, Urad RS za intelektualno lastnino, 20. okt. 2010.
2. Aleš Dakskobler, Andraž Kocjan, Manca Logar*, Postopek priprave nosilnega koloidnega prahu z visoko specifično površino (dopolnilna prijava k prijavi P-201000330): P-201000433*, Ljubljana, Urad RS za intelektualno lastnino, 9. dec. 2010.

DEPARTMENT FOR NANOSTRUCTURED MATERIALS K-7

The basic and applied research in the Department for Nanostructured Materials includes ceramic materials, metals, intermetallic alloys and minerals. Our research encompasses conventional processing as well as the development of new technologies and methods for preparing new materials with novel properties. It includes experimental and theoretical investigations of structures, analyses of chemical compositions at the atomic level, and measurements and calculations of physical properties, all of which help us to improve the properties of micro- and nanostructured materials.

Head:
Prof. Spomenka Kobe

One-dimensional and two-dimensional **Fe-Pd-based nanostructures** were prepared on conductive substrates and via **template-assisted electro-deposition** into high-aspect-ratio track-etched polycarbonate and alumina membranes. Successful co-deposition of both metals was achieved after complexing them with citrate and ammonia. The formation of complexes was confirmed by UV-VIS spectroscopy. Based on that knowledge an efficient recipe for the preparation of a stable electrolyte was proposed. $Fe_{50}Pd_{50}$ tubes were then successfully electrodeposited. The as-deposited nanotubes had an fcc crystal structure, which results in low coercivity ($H_c \approx 10$ kA/m). Angular-dependence measurements of the coercivity, where the hysteresis loops were measured as a function of the angle (θ) of the applied demagnetizing field, revealed a combination of magnetization-reversal mechanisms, consisting of the curling mechanism, which dominates at low angles, with a transition to coherent rotation at angles >70°. A maximum in the coercivity of 135 kA/m was achieved upon annealing at 550 °C due to the formation of the tetragonal phase. Another composition of $Fe_{70}Pd_{30}$ was also investigated due to its magnetic shape memory effect. It was shown that the $Fe_{70}Pd_{30}$ nanotubes are ferromagnetic and stable over a wide range of pHs, both of which are important characteristics for their use in intelligent drug-delivery systems.

$Fe_{70}Pd_{30}$ nanotubes were successfully functionalized with a model drug, i.e., paracetamol. The proposed type of release, with an initial burst and a slower release of the remaining drug, could be suitable for applications where a fast action is required, which then has to be maintained for a certain time period.

With a proper FEGSEM set-up and taking into account the specifics related to the X-ray spectroscopy of exited spectral lines in the low-energy range (< 5 keV) we have accurately determined the elemental composition of the Fe-Pd nanostructures (rods, tubes, films).

Using EDS and WDS methods, which were optimized for nanometer-scale compositional analyses, we studied the composition of the reaction phase, which was formed by diffusion of terbium (Tb) into the **$Nd_2Fe_{14}B$ hard-magnetic materials for improved coercivity**. Analyses were carried out at a sub-micrometer analytical resolution (0.1–0.4 μm). Accurate quantitative analyses, performed using different combinations of Tb-L,M, Nd-L,M and Fe-K,L spectral lines, gave consistent results, which confirmed that the composition of the reaction phase corresponds to $(NdTb)_2Fe_{14}B$, with a ratio Nd:Tb = 1:1.

In the field of **magnetocaloric materials** we investigated a wide range of Fe substitutions of the $Gd_5Si_2Ge_2$ basic alloy with the aim to quantitatively clarify the effect of iron with respect to the reduction in entropy and hysteresis losses. Our activity was focused on substituting both elements (Si and Ge) with Fe ($Gd_5Si_{2-Z/2}Ge_{2-Z/2}Fe_Z$). We were looking for a possible explanation for the interesting magnetic properties of the newly formed $Gd_5(Si,Ge)_3$ phase. All three systems X for the Si, Y for the Ge and Z for the Si/Ge substitutions were compared in a systematic approach. The final results showed that the refrigeration capacity (RC) was optimized with 0.125 % of Fe addition and the simultaneous substitution of both Ge and Si. The GS alloy can be used at room temperature. **The hysteresis losses were drastically decreased with a small decrease in the net refrigeration capacity** (NRC).

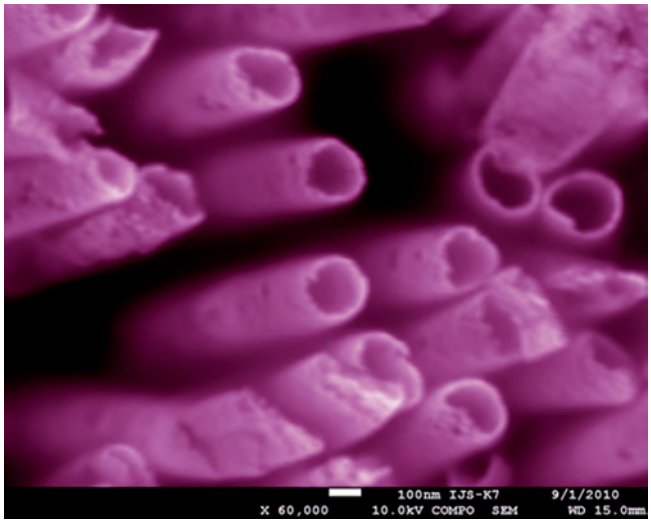

Figure 1: Ferromagnetic Fe-Pd-based electrodeposited nanotubes

We also continued our search for magnetocaloric materials with second-order magnetic transitions to be implemented into a cooling device for computers, which work at elevated temperatures. These iron-based alloys have to be both rare-earth free and cost effective.

In the continuation of the research in **quasicrystals-forming alloys** we prepared a series of **Ti-Zr-Ni** samples by melt-spinning and subsequent thermal treatment at 700°C for 2 hours in a dynamic 10^{-5} mbar vacuum in order

An important achievement was the interpretation of the magnetic and magneto-elastic measurements on the multiferroic Sr_2CrReO_6. On the basis of ab-initio calculations a model, which relates the two properties, was proposed.

to obtain a mixture of hexagonal C14 Laves and α,β-(Ti, Zr) phases. These samples were exposed to hydrogen gas at 300°C and 50 bar for 16 hours. The mass% of H was determined gravimetrically and volumetrically. When approximately 1 % of air was present in absorption chamber we found relatively narrow area in the Ti-Zr-Ni phase diagram, the so-called zero-zone, where the amounts of hydrogen in the crystalline samples varied between 0 and 0.8 mass%. Surprisingly, icosahedral quasicrystalline (i-QC) samples showed no selective hydrogenation and absorbed more than 1.5 mass% H in the interval of compositions where the i-phase is formed. XPS analysis revealed that the oxide layer thickness is similar after melt-spinning and thermal treatment for both types of samples, i.e., from inside and outside of the zero-zone. However, after hydrogenation the zero-zone samples had a 5-times thicker surface oxide layer. In order to find, whether this is correlated with a different electronic structure, the DOS near the E_F was compared by ^1H NMR. In addition, the thermal desorption of hydrogen revealed that H-bonding sites are not correlated with selective hydrogenation.

A detailed transmission electron microscopy study confirmed the formation of solid spheres filled with nitrogen gas in their central regions, thus forming gas nano-containers.

In the frame of the EU's MNT ERA-Net project Hydrogen-impermeable nanomaterial coatings for steels (Hy-nano-IM) we entered the final year of the project to develop hydrogen-impermeable coatings for the long-term storage and transport of gaseous and liquid hydrogen. Just recently we published a paper entitled Hydrogen permeation through TiAlN-coated Eurofer '97 steel in the journal Surface Coatings and Technology (10.1016/j.surfcoat.2010.08.133) where we report on a **permeation reduction factor for hydrogen of up to 20,000 using TiAlN coatings**.

We investigated technologically interesting properties of materials within the framework of the density-functional theory. We were focused on the modelling of mechanical and tribological properties of a diamond-like carbon (DLC). We were also involved in the calculation of the transport properties of the approximants of quasicrystals. Part of theoretical research was focused on the interpretation of the magnetic and magneto-elastic measurements of the multiferroic Sr_2CrReO_6. Experimental results demonstrate large magneto-elastic properties and the dependence of the magnetic anisotropy on the substrate crystalline phase.

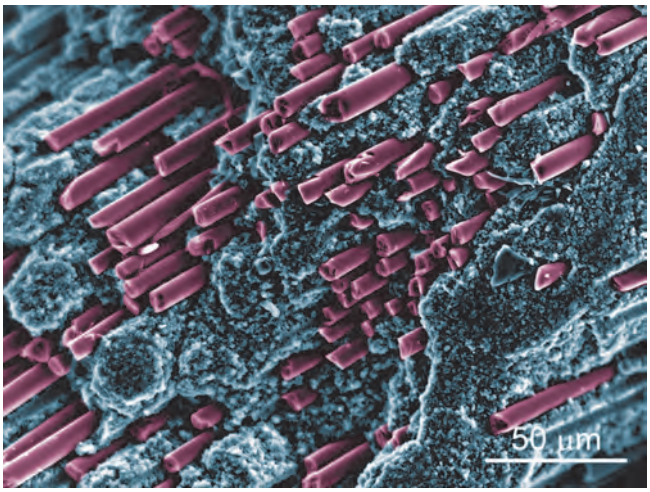

Figure 3: Fracture surface of the SiC/SiC composite prepared by SITE-P process.

Hollow nanospheres as gas containers. One can imagine a cup of fine dust that can supply astronauts with their daily oxygen needs while in space or to picture a bag of dust rich with hydrogen gas, safe and easy to transport, that can provide enough hydrogen for fuel-cell-powered vehicles that can drive you from one city to another. All this is one step closer with a novel approach to the formation of metallic nanospheres filled with gas, based on a melt-solidification mechanism, which could be in principle applied to most metallic systems. For the first time, this phenomenon was observed during the formation of Sm-Fe-Ta nano-spheres by pulsed-laser deposition in nitrogen gas.

The formation of hollow spheres filled with gas is believed to be related to the general affinity of liquid metals for gas intake. During the rapid solidification the dissolved gas in the molten sphere is trapped due to the formation of a solid rim, preventing the outward diffusion of the gas. If the melt contains more than an equilibrium amount of nitrogen it is possible that the gas recombines to form N_2 molecules, filling the void inside the nanosphere.

A noticeable advance has also been achieved in the **development of fusion-relevant material** (FP7, EURATOM). A new process "SITE" for the

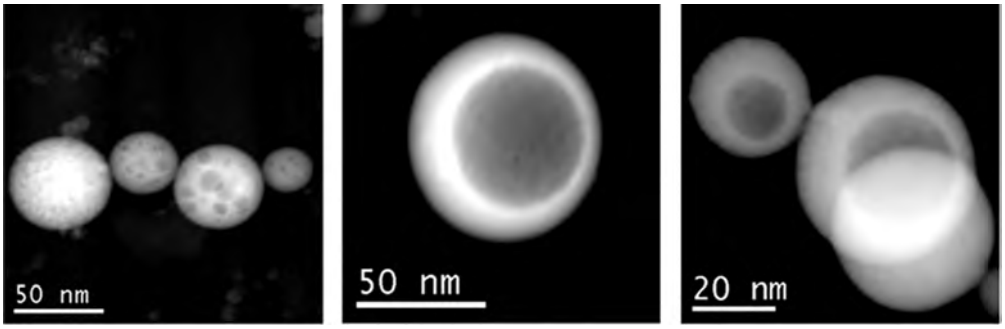

Figure 2: Hollow nanospheres filled with nitrogen gas

fabrication of ceramic matrix composites has been introduced and has been well recognised internationally. The process paralleled with the Japanese process "NITE" is based on electrophoretic infiltration of the ceramic fabric with ceramic powder, followed by infiltration with sintering aids or a pre-ceramic polymer precursor. In this way the material's properties have closely matched the requirements given by the European Fusion Development Agreement, EFDA. The results have been partially published in J. of Nuclear Materials.

Within the FP7 IP project Meddelcoat **we achieved the target properties of the coatings for Ti-based bone implants**. The second sort of coating developed within the project has been designed for improvement of implants' osteointegration. It is composed of a porous titanium layer (Alhenia, Switzerland) coated with sol-gel-synthesised bioactive glass. Both coatings have been patented.

The research of biomaterials also involved the development of **silicon carbide ceramics as a metal-free alternative to some metallic implants**. Sintering without undesired metals represents quite a challenging task and was found to be possible only if the green density is sufficiently high. The most favourable result was recently achieved by using Mg-compounds as a sintering aid and sintering in the presence of oxygen.

Perovskite $BaTiO_3$ nanorods and $SrTiO_3$ nanotubes were synthesized by sol-gel electrophoretic deposition into anodic aluminum oxide (AAO) membranes. Measurements of electrical conductivity on individual $BaTiO_3$ nanorods showed the linearity and high reversibility of the electrical conductivity as a function of humidity. This is why single **$BaTiO_3$ nanorods are potentially used for micro-nano humidity sensors**. On the other hand, the $SrTiO_3$ single nanotubes exhibited a photo-effect under UV radiation.

Homogeneous nucleation inside the pores of a template produces a critical number of crystallites leading to their self-organization when the nanocrystals reach the sizes that are equal to the mean free distance between the nuclei. Due to steric constraints the crystals start to organize in order to most efficiently fill the available surface of the pore walls. This process leads to the formation of domains containing a large number of idiomorphic $SrTiO_3$ nano-cubes that are self-aligned into an almost perfect cube-on-cube and cube-to-wall registry, which makes up the walls of the tubules. The described mechanism shows the ability of nanocrystals with well-defined morphologies to adapt spatial constraints and self-organize into desired architectures. By optimizing the processing parameters to control the rates of nucleation and growth as well as the morphology dictated by the crystallography of the nanocrystals units one should be able to design layers of any desired material in a chosen crystallographic orientation in virtually any geometrical setting.

In the research field of materials for biomedical applications we confirmed the bioactivity and photocatalytic activity of the hydrothermally synthesised TiO_2-coating as well as the sufficient adhesion strength, which makes it applicable for implants to prevent inflammation.

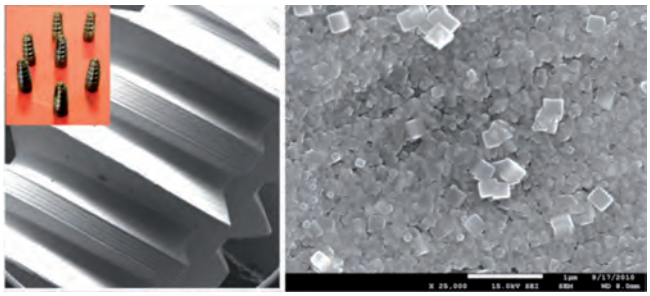

Figure 4: Bioactive and photocatalytic TiO_2-based coating on dental implant

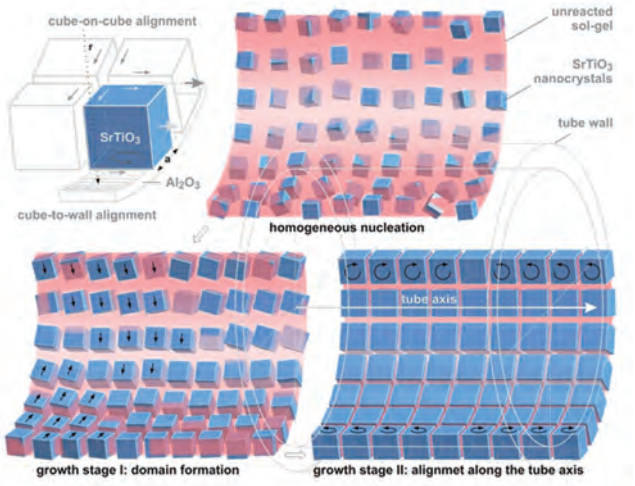

Figure 5: Self-assembly of $SrTiO_3$ nanocrystals in tubular geometry. The process of self-assembly of $SrTiO_3$ nanocrystals in AAO templates comprises three basic mechanisms: (i) homogeneous nucleation of $SrTiO_3$ crystals in thin film of precursor sol-gel, (ii) domain formation due to cube-on-cube alignment of $SrTiO_3$ nanocrystals and (iii) final cube-to-wall alignment.

For the synthesis of **nano-sized TiO_2 powders in either rutile or anatase** crystal form we have successfully tailored the sol-gel and gel-sol processes so that we are able to produce TiO_2 nano-powders with the desired nanocrystal sizes, size distribution, morphology, and crystal structure. Synthesized particles were thoroughly investigated using electron microscopy and microanalytical methods and the nucleation and growth of specific bi-pyramid morphologies were explained. Nanosized anatase was used and tested in DSSC (dye-sensitized solar cells) solar cells.

The self-assembly of **Ge quantum dots in an amorphous silica matrix** after irradiation with high-energy ions was investigated using electron microscopy and microanalysis. Together with colleagues from Croatia, Italy and Czech Republic we published an explanation for the self-assembly and the influence of various parameters on the final ordered structure. In collaboration with scientists from Portugal the influence of size and morphology of CeO_2 and TiO_2 substrates and catalytic Au and Pt particles on the final catalytic properties of the material was studied and four papers were published in different international journals.

In the frame of a national project "Research and **conservation of natural heritage** in the field of mineralogy in Slovenia" we published a book "Minerals of the lead and zinc ore deposit Mežica", which is the first

We reported an unusual crystallization phenomenon that results in the self-assembly of sub-micron tubules of crystalline $SrTiO_3$. The deposition of the tubular structures was done in the pores of anodized aluminum oxide templates by the electrophoretic deposition of $SrTiO_3$ sols and subsequent annealing. A mechanism for this phenomenon was proposed.

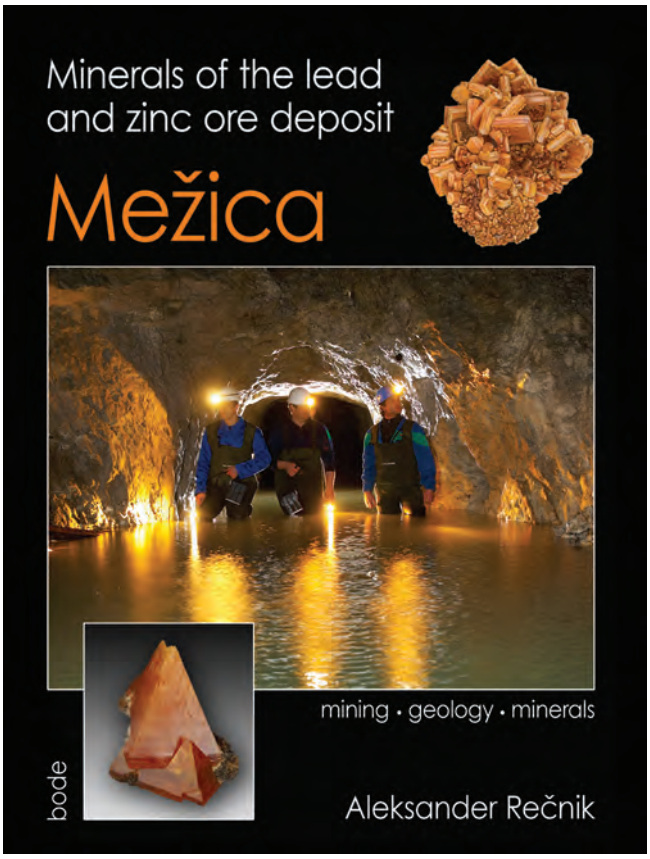

Figure 6: Cover page of the monograph: Minerals of the lead and zinc ore deposit Mežica

detailed description of Slovenia's largest ore deposit. The book is a first comprehensive overview of mining history, geology and mineralogy of the Mežica mine (Carinthia, Slovenia), where over 1000 km of tunnels were excavated together with several hundred kilometers of stopes and mine workings on the existing ore bodies. The most abundant mineral of the deep oxidation zone is wulfenite, which has been mined as a molybdenum ore. The Mežica mine became famous for the **unusual pyramidal and bi-pyramidal wulfenite crystals**. On these material two types of wulfenite twins were identified and named after their localities as the **Igrčevo- and the Doroteja-Law of twinning**. Today, Mežica is known as one of the world's richest wulfenite deposits and one can barely find any major mineralogical collections or museums that do not have a specimen from this classic Slovenian locality. This richly illustrated monograph has over 240 high-quality photographs of superb older and also new specimens collected during 2005-2010 in the frame of a research project guided by the author. The book was published in Slovene, English and German editions.

Slovenian meteorite. We started with systematic studies of a stony meteorite that fell in 2009 on Slovenian territory, more specifically on the Mežaklja plateau. This finding is of utmost importance for Slovenia as well as for the wider European area. This is due to the fact that the number of intact, well-preserved **extraterrestrial relicts**, where the weathering processes did not destroy their original structure, is very limited. As such, they can give important information about the formation of the early solar system as well as the origin and evolution of the Earth and other planets.

After successful synthesis of nano-powders of ZnO with rod-like and plate-like grains, our focus was on the preparation of **spherical ZnO nano-powders**. Via an appropriate gelatin process of Zn-acetate solution in alcohol media using Li-hydroxide we prepared ZnO nano-powder of highly uniform spherical grains with a size of about 5 nm. Transparent and conductive ZnO thin films are in great demand for **applications in optoelectronics**. We studied the synthesis of ZnO thin films on the glass substrates from water solutions of Zn-nitrate at 90 °C, which is much below the typical temperature of the hydrothermal synthesis at 150 °C. The ZnO films with the thickness of about 5 μm and about 75% translucency were successfully prepared. We also continued with a study of the nucleation and crystallization of ZnO bipods where we explained the origin of inversion-domain boundary in a series of papers.

We performed a quantitative evaluation of ZnO grain growth with Bi_2O_3 and SnO_2 additions by a classic grain-growth kinetic analysis. We found that a low grain-growth exponent (N) of 2 is characteristic for the initial growth stage, when ZnO grains grow exaggeratedly under the influence of inversion boundaries (IBs). At a lower sintering temperature of 950°C this stage is predominant up to 240 minutes of sintering, whereas at higher temperatures (1100-1300°C) it ends already after 15 minutes. In this IB-induced growth stage, the N-values are even lower with higher sintering temperatures and reach values as low as 1.4. In this stage, the apparent grain-growth energy for the growth of ZnO grains is ~148 kJ/mol. After the impingement of the plate-like ZnO grains with IBs, further growth follows the Ostwald-ripening mechanism, which is an incomparably slower growth process. In this growth stage, the N-value increases to ~3.5 and the apparent grain-growth energy is increased to ~353 kJ/mol. After long sintering times, the samples reach an equilibrium microstructure and the grain growth is virtually stopped, which is reflected in very high N-values of 20 and more.

We started research in the field of oxide **thermoelectric (TE) materials** on the n-type compounds from the system Zn-In-O and the p-type compounds from the Ca-Co-O system. The influence of the starting composition and the preparation process on the formation of the TE compounds, their structure, phase composition and microstructure of the samples was studied. The assembling of the measuring system for the TE characterization of materials up to the temperature of 1000K is the final stage.

We continued the development of the **low-doped varistor ceramics** with only about 3 wt% of dopants added to the ZnO. The compositions which enable the preparation of either coarse- or fine-grained ceramics with breakdown voltages in the range from 60 to 350V/mm were optimized for the amount of added oxides of Co, Mn and Ni in order to enhance the energy characteristics of the varistor ceramics at high currents.

Within the project on the development of surge protections for solar panels and wind-turbine generators the influence of the thermal treatment and the nature of the secondary intergranular phases on the dc stability of the ZnO-based varistor ceramics was studied for its enhancement. The processing of the tubes by the slip-casting of

the stable varistor powder mixture water suspension into the gypsum moulds was developed. Varistor tubes with lengths in the range from 25 to 60 mm, diameter 12 to 14 mm and wall thickness from 1.5 to 4 mm, were successfully prepared within the project for the industrial partners.

We have performed the characterization of various materials on the micro- and nanoscales using a high-resolution scanning electron microscope FEGSEM combined with analytical methods of energy-dispersive and wavelength-dispersive X-ray spectroscopy, EDS and WDS. Numerous analyses and expertise relating to microstructural characterization of materials were performed for domestic industrial partners in order to solve technological problems in current production and/or in the research and development of new products. The main collaborations were realized with the companies LE Tehnika, SwatyComet, Hidria AET, Iskra-Zaščite, Termoelektrarna Toplarna Ljubljana, BiaSeparations, Cinkarna Celje, and ITW Metalflex.

One of important research areas of the group is the implementation and development of various electron microscopy analytical techniques within the existing EU project ESTEEM, such as electron energy-loss spectroscopy (EELS), high-resolution scanning transmission electron microscopy (STEM, HAADF-STEM) electron holography and mechanical preparation of the TEM samples. In atomically-resolved HAADF-STEM we were among the first to show on model ceramic materials that realistic values of the Debye-Waller factor for atoms comprising the investigated structure (interface, planar fault, etc.) are needed for an exact quantitative interpretation of experimental HAADF-STEM intensities. The research group is additionally strongly involved in managing the **Center for Electron Microscopy** within the frame of the national infrastructure Center for microstructural and surface analysis. Implementation of various electron microscopy analytical techniques and the possibility for researchers to access research infrastructure for electron microscopy is of utmost importance for numerous research institutions, industrial partners, as well as for graduate and post-graduate education.

Some outstanding publications in the past year

1. Kristina Žagar, Aleksander Rečnik, Pulickel M. Ajayan, Miran Čeh. Oriented cube-on-cube nanocrystal assembly of $SrTiO_3$ tubules. Nanotechnology (Bristol), 2010, vol. 21, no. 37, p. 375605-1-375605-7.
2. Sašo Šturm, Kristina Žužek Rožman, Boštjan Markoli, Evangelia Sarantopoulou, Zoe Kollia, Alciviadis-Constantinos Cefalas, Spomenka Kobe. Formation of core-shell and hollow nanospheres through the nanoscale melt-solidification effect in the Sm-Fe(Ta)-N system. Nanotechnology (Bristol), 2010, vol. 21, no. 48, p. 485603-1-485603-8.
3. Saša Novak, Goran Dražić, Katja König, Aljaž Iveković. Preparation of SiC_f/SiC composites by the slip infiltration and transient eutectoid (SITE) process. J. nucl. mater.. [Print ed.], 2010, vol. 399, no. 2/3, p. 167-174, doi: 10.1016/j.jnucmat.2010.01.014.
4. Darja Pečko, Kristina Žužek Rožman, Paul J. McGuiness, Boris Pihlar, Spomenka Kobe. Temperature-driven microstructural, compositional, and magnetic changes in electrodeposited Fe-Pd thin films. J. appl. phys., 2010, vol. 107, no. 9, p. 09A712-1-97A712-3.
5. Matej Komelj. Magnetoelasticity driven magnetic anisotropy changes in strained Sr_2CrReO_6. Phys. rev., B, Condens. matter mater. phys., 2010, vol. 82, no. 1, p. 012410-1-012410-3.
6. Andraž Kocjan, Paul J. McGuiness, Spomenka Kobe. Desorption of hydrogen from Ti-Zr-Ni hydrides using a mass spectrometer. Int. j. hydrogen energy. [Print ed.], 2010, vol. 35, no. 1, p. 259-265, doi: 10.1016/j.ijhydene.2009.10.081.

Awards and appointments

1. Saša Novak Krmpotič, Aljaž Ivekovič, Goran Dražič: "Densification of SiC by electrophoretic deposition and polymer infiltration and pyrolysis process". Aljaž Ivekovič "The Best Poster Award in the Category Microstructure & Properties", 11th ICCPS International Conference on Ceramic Processing Science, Zürich, Switzerland, 29 August – 1 September 2010
2. Tea Toplišek: "Microstructure and mechanical properties of SiC fibers for potential use in a future fusion reactor". Best Poster Award in the appreciation of outstanding work and attractive visual presentation, Nuclear Energy for New Europe 2010, Portorož, Slovenia, 6–9 September 2010.

Organization of conferences, congress and meetings

1. 21st International Workshop on Rare-Earth Permanent Magnets and their Applications-REPM'10, Bled, Slovenia, 29 August – 2 September 2010
2. Fusion EXPO, Barcelona, Spain, 17–21 March 2010 (co-organisers)

3. Fusió. Energia per al futur, Fusion EXPO, the Science Museum of Terrassa, Terassa, Spain, 4 March–2 May 2010 (co-organisers)
4. Fusion EXPO, ESOF - Euro Science Open Forum 2010, Torino, Italy, 2–7 July 2010 (co-organisers)
5. Fusion Roadshow, Llowlab, Biddinghuizen, The Netherlands, 20–22 August 2010 (co-organisers)
6. Fusion – Energy of the future, Maxi Fusion EXPO, Palace of the Academies, Brussels, Belgium, 24 September 2010 and 25 October–15 November 2010 (co-organisers)
7. MACAN Partner Meeting, Bohinj, 25–28 July 2010
8. Slovenia-China Workshop, Jožef Stefan Institute, Ljubljana, Slovenia, 4 June 2010
9. 18th Conference on Materials and Technologies, 15–17 November 2010 (co-organisers)
10. European School in Materials Science: Properties of Complex Metallic Alloys: Modeling, Simulation and Experiment, Ljubljana, Slovenia, 24–29 May 2010 (co-organisers)

INTERNATIONAL PROJECTS

1. Tailoring of Tribological Interfaces for Clean and Energy-Efficient Diesel and Gasoline Power Trains
   2020 INTERFACE
   7. FP, 234324, SCP8-GA-2009-234324
   EC; Jackie Kidd, PA - Support Officer to Director of Research, Institute of Engineering Thermofluids, Surfaces and Interfaces, School of Mechanical Engineering, The University of Leeds, Leeds, Great Britain
   Asst. Prof. Matej Komelj
2. Merging Atomistic and Continuum Analysis of Nanometer Length-scale Metal-oxide Systems for Energy and Catalysis Applications
   MACAN
   7. FP, 233484, NMP3-CA-2009-233484
   EC; Prof. Wayne Kaplan, Technion - Israel Institute of Technology, Haifa, Israel
   Asst. Prof. Aleksander Rečnik
3. Improving the Gender Diversity Management in Materials Research Institutions
   DIVERSITY
   7. FP, 230253
   EC; Dr. Oliver Gutfleisch, Leibniz-Institut für Festkoerper- und Werkstoffforschung, Dresden, Germany
   Prof. Spomenka Kobe
4. Cooperation of Space NCPs as a Means to Optimise Services
   COSMOS
   7. FP, 218813
   EC; Dr. Adrien Klein, Deutsches Zentrum für Luft und Raumfahrt e.v., (DLR), Köln, Germany
   Prof. Spomenka Kobe, Dr. Boris Pukl, Dr. Špela Stres
5. Fusion Expo Activities under an EFDA
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   WP10-PIN-FUSEX
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič, Melita Lenošek Kavčič, B. Sc.
6. Development of Beta SiC Fibres with W Core - 4.1.1.1.- FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Goran Dražič
7. Development of Dense Beta SiC Matrix in 3D Preform - 4.1.1.2 – FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič
8. SiC/SiC Composite for Structural Application in Fusion Reactor - 4.1.1.2 - PS
   WP10-MAT-SiC/SiC (02-02/PS)
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association - SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič
9. Public Information; Research Unit - Administration and Services - RU-FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič, Prof. Milan Čerček
10. Fusion Expo Activities under an EFDA
    WP08-PIN-FUSEX
    EURATOM – MHEST
    7. FP, EURATOM, Slovenian Fusion Association – SFA
    3211-08-000102, FU07-CT-2007-00065
    EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
    Asst. Prof. Saša Novak Krmpotič, Melita Lenošek Kavčič, B. Sc.
11. Multifunctional Bioresorbable Biocompatible Coatings with Biofilm Inhibition and Optimal Implant Fixation
    6. FP, MEDDELCOAT
    NMP3-CT-2006-026501
    EC; Prof. Jozef Vleugels, Katholieke Universiteit Leuven, Research & Development, Leuven, Belgium
    Asst. Prof. Saša Novak Krmpotič
12. Distributed European Infrastructure of Advanced Electron Microscopy for Nanoscience
    ESTEEM
    6. FP, 026019
    EC; Prof. Gustaaf Van Tendeloo, Universiteit Antwerpen, Antwerpen, Belgium
    Prof. Miran Čeh, Asst. Prof. Sašo Šturm
13. Complex Metallic Alloys
    CMA
    6. FP, NMP3-CT-2005-500140
    EC; Centre National de la Recherche Scientifique, Paris, France
    Prof. Spomenka Kobe, Prof. Janez Dolinšek, Dr. Peter Panjan
14. Hydrogen Impermeable Nano-material Coatings for Steels
    Hy-nano-IM
    MNT ERA NET
    Asst. Prof. Paul McGuiness
15. Investigation of Electrical Mobility and Dielectric Relaxation of Bioactive Glass
    BI-HR/10-11-002
    Dr. Andrea Moguš-Milanković, Ruđer Bošković Institute, Zagreb, Croatia
    Asst. Prof. Saša Novak Krmpotič
16. Correlation of Structure and Properties of Nanostructured Perovskites
    BI-HR/10-11-027
    Dr. Andreja Gajović, Ruđer Bošković Institute, Zagreb, Croatia
    Asst. Prof. Sašo Šturm
17. Nano-crystalline Si as a Possible Candidate for Third Generation Solar Cells
    BI-HR/09-10-053
    Dr. Andreja Gajović, Ruđer Bošković Institute, Zagreb, Croatia
    Prof. Miran Čeh
18. Advanced Methods and Technologies for Processing of a New Generation of ZnO-based Varistor Ceramics
    BI-CN/09-11-017
    Dr. Zheng Liaoying, The Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China
    Asst. Prof. Slavko Bernik
19. Novel Magnetocaloric Materials for Ecological Refrigeration
    BI-CN/09-11-009
    Dr. Yan Gaolin, School of Physics and Technology, Wuhan University, Wuhan, Hubei Province, China
    Asst. Prof. Paul McGuiness

20. Nanostructural Studies of Phase Transformations and Defect Structures in Iron Oxides and Sulphides
    BI-HU/09-10-007
    Prof. Mihály Pósfai, University of Pannonia, Department of Earth and Environmental Sciences, Veszprém, Hungary
    Asst. Prof. Aleksander Rečnik
21. Nanofabrication and Advanced Characterization of Funtionalised Materials
    BI-PT/10-11-009
    Dr. Adrian M. T. Silva, Laboratory of Catalaysis and Materials, Faculty of Engineering, University of Porto, Porto, Portugal
    Asst. Prof. Goran Dražić
22. Investigation of High Temperature Reactions between Doped Perovskite Components in a Solid Oxide Fuel Cell
    BI-TR/10-12-005
    Asst. Prof. Mehmet Ali Gülgün, Sabanci University, Faculty of Engineering and Natural Science, Istanbul, Turkey
    Prof. Miran Čeh

R & D GRANTS AND CONTRACTS

1. Exploration and preservation of mineralogical heritage
   Asst. Prof. Aleksander Rečnik
2. Ecotechnological 1D Nanomaterials: Synthesis and Characterisation of 1D Titanate Nanomaterials Doped with Transition Metal Ions
   Dr. Polona Umek, Asst. Prof. Sašo Šturm
3. Physics and Chemistry of Interfaces of Nanostructured Metallic Materials
   Prof. Miran Čeh

RESEARCH PROGRAM

1. Nanostructured materials
   Prof. Spomenka Kobe

NEW CONTRACTS

1. NODISEA: Novel innovative systems for electrical equipment
   VARSI, d.o.o.
   Asst. Prof. Slavko Bernik
2. New generation magnets - high-temperature NdFeB magnets
   MAGNETI LJUBLJANA, d.d.
   Asst. Prof. Paul John McGuiness
3. WISEVAR: Varistors for protection of renewable energy systems
   VARSI, d.o.o.
   Asst. Prof. Slavko Bernik
4. Exploration and preservation of mineralogical heritage
   Municipality Litija
   Asst. Prof. Aleksander Rečnik

MENTORING

Ph. D. Thesis

1. Benjamin Podmiljšak, *Microstructural investigations of rare-earth transition-metal-based magnetocaloric materials for near-room-temperature applications* (mentor Spomenka Kobe; co-mentor Paul McGuiness)

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1. Dr. Davor Gracin, Dr. Igor Djerdj, Institut Rudjer Bošković, Zagreb, Croatia, 15 January 2010
2. Dr. Jonathan P. Winterstein, Massachusetts Institute of Technology, Cambridge, USA, 31 January – 3 February 2010
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4. Prof. Mihaly Posfai, Prof. Istvan Dodony, Ilona Nyiro Kósa, Dorottya Sára Csákberényi Nagy, University of Pannonia, Veszprém, Hungary, 19–26 February 2010
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BIBLIOGRAPHY

Original Articles

1. Jana Bezjak, Artem M. Abakumov, Aleksander Rečnik, Marjeta Maček, Boštjan Jančar, Danilo Suvorov, "The local structure and composition of $Ba_4Nb_2O_9$-based oxycarbonates", *J. solid state chem.*, vol. 183, issue 8, pp. 1823-1828, 2010.
2. Marko Bitenc, Goran Dražić, Zorica Crnjak Orel, "Characterization of crystalline zinc oxide in the form of hexagonal bipods", *Cryst. growth des.*, vol. 10, no. 2, pp. 830-837, 2010.
3. Marko Bitenc, Peter Podbrščček, Pavo Dubček, Sigrid Bernstorff, Goran Dražić, Bojan Orel, Stane Pejovnik, Zorica Crnjak Orel, "In and ex situ studies of the formation of layered microspherical hydrozinciteas precursor for ZnO", *Chemistry (Weinh., Print)*, vol.16, issue 37, pp. 11481-11488, 2010.
4. Zorica Branković, Katarina Đuriš, A. Radojković, Slavko Bernik, Zvonko Jagličić, Marko Jagodič, Katarina Vojisavljević, Goran Branković, "Magnetic properties of doped $LaMnO_3$ ceramics obtained by a polymerizable complex method", *J. sol-gel sci. technol.*, vol. 55, issue 3, pp. 311-6, 2010.
5. Zorica Branković, Zorica Marinković Stanojević, L. Mančić, Vesna Vukotić, Slavko Bernik, Goran Branković, "Multiferroic bismuth manganite prepared by mechanochemical synthesis", In: *Proceedings of the ELECTROCERAMICS XI: Piezoelectrics, 1-3 September 2008, Manchester, UK*, (Journal of the European Ceramic Society, vol. 30, no. 2), Robert Freer, ed., Colin Leach, ed., Barking, Elsevier, 2010, pp. 277-281.
6. Maja Buljan, Goran Dražić, (15 authors), "Generation of an ordered Ge quantum dot array in an amorphous silica matrix byon beam irradiation: modeling and structural characterization", *Phys. rev., B, Condens. matter mater. phys.*, vol. 81, no. 8, pp. 085321-1-085321-8, 2010.
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9. S. A. C. Carabineiro, Adrián M. T. Silva, Goran Dražić, P. B. Tavares, José Luís Figueiredo, "Effect of chloride on the sinterization of Au/CeO_2 catalysts", In: *Proceedings of the Eleventh International Symposium on Catalyst Deactivation, October 25-28, Delft, Netherlands*, (Catalysis today, Vol. 154, no. 3/4), Jorge Gascon, ed., Amsterdam, Elsevier, 2010, pp. 293-302.
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11. Miran Čeh, Hsing-Chao Chen, Miin-Jang Chen, Jer-Ren Yang, Makoto Shiojiri, "Structure and electro-optical properties of thin films grown by alternative atomic layer deposition of ZnO and Al_2O_3 on the sapphire substrate", *Mater. trans.*, vol. 51, no. 2, pp. 219-226, 2010.
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14. Damir Iveković, Andreja Gajović, Miran Čeh, Boris Pihlar, "Prussian blue-modified titanate nanotubes: A novel nanostructured catalyst for electrochemical reduction of hydrogen peroxide", *Electroanalysis*, vol. 22, no. 19, pp. 2202-2210, 2010.
15. V. D. Jović, B. M. Jović, U. Lačnjevac, Goran Branković, Slavko Bernik, Aleksander Rečnik, "An attempt to predict the mechanism of Mo-Ni-O powders electrodeposition from the results of their TEM analysis", *Electrochim. acta*, issue 13, vol. 55, pp. 4188-93, 2010.
16. Krunoslav Juraić, Miran Čeh, (9 authors), "GISAXS and GIWAXS analysis of amorphous-nanocrystalline silicon thin films", In: *X-ray techniques for advanced materials, nanostructures and thin films: from laboratory sources to synchrotron radiation: proceedings of the EMRS 2009 Spring Meeting, Strasbourg, 2009, Strasbourg, France*, (Nuclear instruments & methods in physics research, section B, Beam interactions with materials and atoms, vol. 268, no. 3/4), Federico Boscherini, ed., Amsterdam, North-Holland, 2010, pp. 259-262.
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39. Katarina Vojisavljević, Goran Branković, Tatjana Srećković, Aleksander Rečnik, Zorica Branković, "Preparation of ultrathin PZT films by a chemical solution deposition method from a polymeric citrate precursor", In: *Proceedings of the ELECTROCERAMICS XI: Piezoelectrics, 1-3 September 2008, Manchester, UK*, (Journal of the European Ceramic Society, vol. 30, no. 2), Robert Freer, ed., Colin Leach, ed., Barking, Elsevier, 2010, pp.485-488.
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44. Kristina Žužek Rožman, Janez Kovač, Paul J. McGuiness, Zoran Samardžija, Boštjan Markoli, Spomenka Kobe, "Microstructural, compositional and magnetic characterization of electrodeposited and annealed Co-Pt-based thin films", *Thin solid films*, vol. 518, no. 6, pp. 1751-1755, 2010.

Review Articles and Chapters in Books

1. Tea Toplišek, Goran Dražić, Vili Bukošek, Saša Novak, Spomenka Kobe, "Electron microscopy and microanalysis of the fiber, matrix and fiber/matrix interface in SiC based ceramic composite material for use in a fusion reactor application", In: *Ceramic materials*, Wilfried Wunderlich, ed., Rijeka, Sciyo, 2010, pp. 99-114.

Published Conference Papers

Invited Paper

1. Zorica Crnjak Orel, Marko Bitenc, Goran Dražić, "Analyses of deffects in zinc oxide bipod particles: [Elektronski vir]", In: *ICCE-18: [proceedings]*, The Eighteenth Annual International Conference on Composites or Nano Engineering, July 4-10, 2010, Anchorage, Alaska, David Hui, ed., New Orleans, International Community for Composites Engineering, 2010, 2 pp.

Regular papers

1. Marcela Achimovičová, Aleksander Rečnik, Maxym Myndyk, Martin Fabián, Vladimir Šepelák, "A one-step mechanochemical synthesis and characterization of SnSe and $SnSe_2$", *Diffus. fundam.*, vol. 75, spec. iss., pp. 75-77, 2010.
2. Slavko Bernik, Saša Nastran, Saša Rustja, Zoran Samardžija, Alojz Tavčar, Matejka Podlogar, Andrej Pirih, Mirjam Cergolj, "Slip-casting of tubular ZnO-based varistor ceramics", In: *Proceedings*, Denis Đonlagić, ed., Iztok Šorli, ed., Polona Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2010, pp. 153-158.
3. Milan Bizjak, Goran Dražić, Ladislav Kosec, Blaž Karpe, "The precipitation kinetics of rapidly solidified Al-based alloys", In: *Metalni i nemetalni materijali: proizvodnja, osobine, primjena: zbornik radova: production, properties, application: proceedings*, Zenica, Fakultet za metalurgiju i materijale, = Faculty of Metallurgy and Materials Science, 2010, pp. 62-67.
4. Milan Bizjak, Ladislav Kosec, Marko Šuler, Goran Dražić, "Phase transformations of amorphous/nanocrystalline Cu-Fe-Ti-C alloy", In: *PM 2010. Proceedings volume 1*, Powder metallurgy world congress & exhibition, Florence, Italy 10-14 October 2010, Shrewsbury, European Powder Metallurgy Association, cop. 2010, pp. 309-314.
5. S. A. C. Carabineiro, Bruno Machado, Goran Dražić, R. R. Bacsa, Philippe Serp, José Luís Figueiredo, Joaquim Luís Faria, "Photodeposition of Au and Pt on ZnO and TiO_2", In: *Scientific bases for the preparation of heterogeneous catalysts: proceedings of the 10th international symposium, Louvain-la-Neuve, Belgium, July 11-15, 2010*, (Studies in surface science and catalysis, vol. 175), E. M. Gaigneaux, ed., Amsterdam [etc.], Elsevier, 2010, pp. 629-633.
6. S. A. C. Carabineiro, Adrián M. T. Silva, Goran Dražić, José Luís Figueiredo, "Preparation of Au nanoparticles on Ce-Ti-O supports", In: *Scientific bases for the preparation of heterogeneous catalysts: proceedings of the 10th international symposium, Louvain-la-Neuve, Belgium, July 11-15, 2010*, (Studies in surface science and catalysis, vol. 175), E. M. Gaigneaux, ed., Amsterdam [etc.], Elsevier, 2010, pp. 457-461.
7. Goran Dražić, Marko Bitenc, Peter Podbrščček, Zorica Crnjak Orel, "Analytical electron microscopy of ZnO bipods", In: *Revealing the nanoworld in life and materials science: proceedings*, IMC 17, 17th International Microscopy Congress, Sepetember 19-24, Rio de Janeiro, Brazil, [S. l.], SBMM, = Sociedade Brasileria de Microscopia e Microanálise, 2010, 2 pp.
8. Goran Dražić, Marko Bitenc, Peter Podbrščček, Zorica Crnjak Orel, "Analytical electron microscopy of ZnO bipods grown from solutions", In: *Proceedings of the 68th Annual Meeting of the Microscopy Society of America ... [et al.]: August 1-5, 2010, Portland, Oregon, USA*, (Microscopy and microanalysis, vol. 16, suppl. 1/2), New York, Springer-Verlag, 2010, vol. 16, suppl. 1, pp. 1356-1357, 2010.
9. Jovica Ivkov, Matej Komelj, Ana Smontara, Janez Dolinšek, Peter Gille, "Hall effect in the Y-Al-Ni-Co and $\alpha - Al_{13}Co_4$ decagonal approximants", In: *Proceedings of the 6th International Conference on Aperiodic Crystals, APERIODIC'09, 13-18 September 2009, Liverpool, UK*, (Journal of physics, Conference series, vol. 226), Bristol, Institute of Physics Publishing, 2010, pp. 012032-1-012032-5.
10. Boštjan Jančar, Zoran Samardžija, Sašo Šturm, Oleg V. Ovchar, A. Bilous, "Cation-vacancy-induced microstructures of barium cobalt niobate perovskites", In: *Revealing the nanoworld in life and materials science: proceedings*, IMC 17, 17th International Microscopy Congress, Sepetember 19-24, Rio de Janeiro, Brazil, [S. l.], SBMM, = Sociedade Brasileria de Microscopia e Microanálise, 2010, 2 pp.
11. Katja Koenig, Saša Novak, Aljaž Iveković, Katja Rade, Decheng Meng, Aldo R. Boccaccini, Spomenka Kobe, "Fabrication of CNT-SiC/SiC

composites by electrophoretic deposition", *J. Eur. Ceram. Soc.*, vol. 30, issue 5, pp. 1131-1137, Mar. 2010.
12. Manca Logar, Boštjan Jančar, Aleksander Rečnik, Sašo Šturm, Danilo Suvorov, "Functional nanocomposites via self-assembly of polyelectrolytes", In: *Revealing the nanoworld in life and materials science: proceedings*, IMC 17, 17th International Microscopy Congress, Sepetember 19-24, Rio de Janeiro, Brazil, [S. l.], SBMM, = Sociedade Brasileria de Microscopia e Microanálise, 2010, 2 pp.
13. Andrej Pirih, Mirjam Cergolj, Slavko Bernik, Saša Rustja, Alojz Tavčar, Mitja Hariš, "Test methods to determine the current rating of Iimp for class I SPD and relations with the test parameters of applied generators", In: *Proceedings*, Denis Đonlagić, ed., Iztok Šorli, ed., Polona Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2010, pp. 89-94.
14. Benjamin Podmiljšak, Paul J. McGuiness, N. Mattern, K. Skokov, "Magnetic and structural changes in Fe-substituted $Gd_5Si_2G_2$-based alloys", In: *Proceedings of the 21st Workshop on Rare-Earth Permanent Magnets and their Applications, REPM'10, Bled, Slovenia, August 29th - September 2nd 2010*, Spomenka Kobe, ed., Paul J. McGuiness, ed., Ljubljana, Jožef Stefan Institute, 2010, pp. 90-92.
15. Sašo Šturm, Kristina Žužek Rožman, Sabina Markoli, Evangelia Sarantopoulou, Zoe Kollia, Alciviadis-Constantinos Cefalas, Spomenka Kobe, "Hollow nanospheres formation through nanoscale melt-soldification mechanism in Sm-Fe(TA)-N system", In: *Revealing the nanoworld in life and materials science: proceedings*, IMC 17, 17th International Microscopy Congress, Sepetember 19-24, Rio de Janeiro, Brazil, [S. l.], SBMM, = Sociedade Brasileria de Microscopia e Microanálise, 2010, 2 pp.
16. J. P. Winterstein, M. Sezen, Aleksander Rečnik, C. Barry Carter, "Microscopy of the spinel-forming reaction with nanoparticles", In: *Proceedings of the 68th Annual Meeting of the Microscopy Society of America ... [et al.]: August 1-5, 2010, Portland, Oregon, USA*, (Microscopy and microanalysis, vol. 16, suppl. 1/2), New York, Springer-Verlag, 2010, vol. 16, suppl. 2, pp. 1486-1487, 2010.
17. Kristina Žagar, F. Hernandez-Ramirez, Joan Ramón Morante, Miran Čeh, "Template-assisted processing, structural and electrical characterization of barium titanate nanorods", In: *Revealing the nanoworld in life and materials science: proceedings*, IMC 17, 17th International Microscopy Congress, Sepetember 19-24, Rio de Janeiro, Brazil, [S. l.], SBMM, = Sociedade Brasileria de Microscopia e Microanálise, 2010, 2 pp.
18. Kristina Žagar, Luka Suhadolnik, Miran Čeh, "Synthesis of $BaTiO_3$ nanorods: optimization of processing parameters and electron microscopy characterization", In: *Revealing the nanoworld in life and materials science: proceedings*, IMC 17, 17th International Microscopy Congress, Sepetember 19-24, Rio de Janeiro, Brazil, [S. l.], SBMM, = Sociedade Brasileria de Microscopia e Microanálise, 2010, 2 pp.
19. Kristina Žužek Rožman, Darja Pečko, Larisa Suhodolčan, Paul J. McGuiness, Spomenka Kobe, "Electrodeposited Fe-Pd-based magnetic nanostructures with reduced dimensionality", In: *Proceedings of the 21st Workshop on Rare-Earth Permanent Magnets and their Applications, REPM'10, Bled, Slovenia, August 29th - September 2nd 2010*, Spomenka Kobe, ed., Paul J. McGuiness, ed., Ljubljana, Jožef Stefan Institute, 2010, pp. 68-72.

Research Monographs

1. Aleksander Rečnik, *Mineralien Der Blei- Und Zinkerzlagerstätte Mežica*, Ljubljana, Institut Jožef Stefan, Odsek za nanostrukturne materiale, Salzhemmendorf, Bode Verlag, 2010.
2. Aleksander Rečnik, *Minerals of the lead and zinc are deposit Mežica*, Ljubljana, Institut Jožef Stefan, Odsek za nanostrukturne materiale, Salzhemmendorf, Bode Verlag, 2010.
3. Aleksander Rečnik, *Minerali svinčevo-cinkovega rudišča Mežica*, Ljubljana, Institut Jožef Stefan, Odsek za nanostrukturne materiale, Salzhemmendorf, Bode Verlag, 2010.

Thesis

Ph. D. Thesis

1. Benjamin Podmiljšak, *Microstructural investigations of rare-earth transition-metal-based magnetocaloric materials for near-room-temperature applications: doctoral dissertation*, Ljubljana, [B. Podmiljšak], 2010.

Patent Applications

1. Saša Novak, Nataša Drnovšek, *Bioactive and photocatalytic coating on metal implants and a process for preparing thereof: P-201000096*, Ljubljana, Slovenian Intellectual Property Office, 19, Mar. 2010. [COBISS.SI-ID 23782183]
2. Saša Novak, Nataša Drnovšek, Gregor Murn, *Implants having a multilayered coating and a process for preparing thereof: P-201000217*, Ljubljana, Slovenian Intellectual Property Office, 2010. [COBISS.SI-ID 23880743]
3. Benjamin Podmiljšak, Paul J. McGuiness, Spomenka Kobe, *An improved magnetocaloric material and its processing route: P-201000176*, Ljubljana, Slovenian Intellectual Property Office, 17, Jun. 2010. [COBISS.SI-ID 23777319]
4. Dejan Verhovšek, Nika Veronovski, Aljaž Selišnik, Miran Čeh, Zoran Samardžija, *Procedure for processing of anatase nanoparticles with high specific surface area and spheric morphology: P-201000342*, Ljubljana, Slovenian Intellectual Property Office, 25, Oct. 2010. [COBISS.SI-ID 23777319]

DEPARTMENT FOR MATERIALS SYNTHESIS K-8

The research of the Department for Materials Synthesis is mainly related to the synthesis of different advanced materials, especially magnetic and semiconducting oxides. Special attention is given to nanostructured materials, such as ferrofluids, functionalized nanoparticles for use in biomedicine, multifunctional nanocomposites, and magnetic coatings for use in the microwave frequency range.

Head:
Prof. Darko Makovec

In 2010 investigations were directed to three important materials, i.e., materials containing magnetic nanoparticles, microwave magnetic ceramic coatings for use in the telecommunications area, and ferroelectric materials with a high Curie temperature for the preparation of high-temperature lead-free thermistors.

The research of magnetic nanoparticles has mainly been focused on bonding different biologically-active molecules to the surfaces of functionalized superparamagnetic iron oxide maghemite nanoparticles. The nanoparticles were functionalized by bonding different organosilane molecules to their surfaces, usually through a thin surface layer of silica. The functionalization molecules provide specific functional groups for the further bonding of biologically-active molecules to the nanoparticles' surfaces. At the same time, the functionalization layer allows the nanoparticles' compatibility with physiological fluids and prevents their agglomeration. For the amino-functionalization, 3-(2-aminoethylamino)propylmethyldimethoxysilane (APMS) was grafted onto the nanoparticles' surfaces, whereas the carboxyl-functionalization was obtained by a ring-opening linker elongation reaction of the surface amines at the amino-functionalized nanoparticles with succinic anhydride in a non-aqueous medium. The functionalization was followed by measurements of the zeta-potential and a determination of the concentration of the surface amino groups with conductometric titrations. The amino- and/or carboxyl-functionalized nanoparticles were further used for the bonding of different biologically-active molecules to their surfaces.

The bonding of different biologically-active molecules (monoclonal antibodies, DNA molecules) onto the surfaces of functionalized magnetic nanoparticles has been studied.

In cooperation with the Department for Biotechnology, JSI, and the Faculty of Pharmacy, Ljubljana, we studied nanoparticles' targeting of cancer cells using the bonding of monoclonal antibodies. The antibodies were bonded to the surfaces of the amino-functionalized nanoparticles using different linker molecules; in the first place different derivates of ethylene glycol. We also studied the influence of the nanoparticles' surface electric charge on their internalization into cells. Cancer cells of the cell culture were exposed to a suspension of the amino-functionalized nanoparticles (a positive surface charge) or of the carboxyl-functionalized nanoparticles (a negative charge). For tracking using methods based on optical microscopy, fluorescent molecules of carboxyfluorescein succinimidyl ester were bonded to the nanoparticles. Internalization of the nanoparticles into the cells was followed using flow cytometry, with measurements of their magnetic properties (in a cooperation with Faculty of Physics and Mathematics, Ljubljana), and with transmission electron microscopy (in a cooperation with Medical Faculty, Ljubljana). The study revealed that the nanoparticles with a positive surface charge are internalized more then ten-times more frequently than the nanoparticles displaying a negative surface charge.

In cooperation with Prof. Marin Berovič from the Faculty of Chemistry and Chemical Technology, Ljubljana, we explored the possibilities of using functionalized magnetic nanoparticles in the field of vine production. The result was a patent application legally protecting our original procedure for the separation of used yeast biomass from a sparkling wine. The sparkling wine is prepared with the addition of sugar and yeast cells to a still wine, followed by a secondary fermentation in pressure bottles. The main problem with this traditional procedure is the lengthy and expensive separation of the yeast biomass from the wine after the secondary fermentation. The traditional procedure of yeast separation is based on rotation of the bottles with their simultaneous lifting to a vertical position. In our original procedure, the magnetic nanoparticles are adsorbed onto the yeast cells prior to the secondary fermentation, which allows fast separation of the yeast biomass using an external magnetic field.

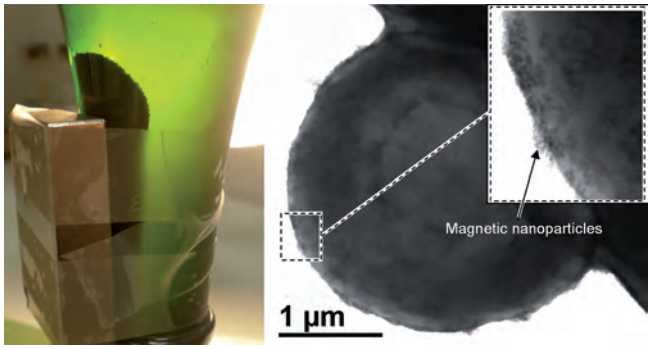

Figure 1: Magnetic separation of used biomass after secondary fermentation of a sparklingwvine in pressure bottles. Left: Yeast biomass containing yeaslscells with adsorbed magnetic nanoparticles is concentrated close to the magnet. Right: TEM image of the magnetic nanoparticles adsorbed onto the yeast cell.

In cooperation with Nanotesla Institute, Ljubljana, electrostatic bonding of DNA molecules to magnetic nanoparticles was studied. The DNA was bonded

A method for the magnetic separation of yeast biomass from sparkling wines, which is based on the adsorption of the magnetic nanoparticles on the yeast cells was patented.

to the nanoparticles for use in so-called magnetofection, i.e., introduction of the gene material into cells enhanced by an external magnetic field.

A significant part of our research has been devoted to the synthesis of nanoparticles and their stable suspensions. The research was focused on the synthesis of the nanoparticles of strontium hexaferrite ($SrFe_{12}O_{19}$) and cobalt ferrite ($CoFe_2O_4$) using the hydrothermal method. Preventing the secondary re-crystallization (Ostwald ripening) during synthesis is necessary to obtain the ultrafine nanoparticles using the hydrothermal method. The secondary re-crystallization has been completely suppressed using the addition of a surfactant of oleic acid. Due to the oleic acid bonded at the nanoparticles' surfaces, they were hydrophobic and can be dispersed in non-polar liquids to prepare relatively concentrated ferrofluids. However, to disperse such nanoparticles in water, oleic acid should be exchanged with citric acid in a ligand exchange reaction. Citric acid provides a strong surface electric charge at the nanoparticles; their hydrophilic nature and strong electrostatic repulsive forces preventing their agglomeration in the aqueous suspensions.

The synthesis of composite nanoparticles was also studied. The composite nanoparticles, composed of a core of strontium hexaferrite and a shell of spinel ferrite maghemite, are supposed to display the optimal shape of their magnetic hysteresis for use in cancer treatment with magnetic hyperthermia. They were synthesised using a heterogeneous nucleation of the maghemite at the hexaferrite nanoparticles during the precipitation of iron ions in the aqueous suspension.

Synthesized nanoparticles were dispersed in polymer matrixes to prepare (superpara)magnetic nanocomposites. Here, it is of crucial importance to disperse a high content of the nanoparticles to ensure high magnetizations, without their agglomeration. The nanocomposite was prepared by dispersing the superparamagnetic nanoparticles in a methyl methacrylate or styrene monomer, followed by its polymerization. To prepare a stable suspension of the nanoparticles in the monomer, the nanoparticles have to be coated with an appropriate surfactant, such as ricinoleic acid. The preparation of the suspension is easier when the nanoparticles are superparamagnetic and do not agglomerate due to magnetic interactions. However, it appeared that stable suspensions of small ferrimagnetic nanoparticles can also be prepared using ricinoleic acid as the surfactant. The main advantage of ferrimagnetic nanoparticles over superparamagnetic is that magnetic moment's relaxation does not occur in the absence of the magnetic field. Such nanoparticles can be structured by the external magnetic field. The magnetic field induced structure is retained by the polymerization of the monomer. The focus was on studying the control of the structuring of the nanoparticles inside the nanocomposite using an external magnetic field and understanding the magnetic properties of the structured nanocomposites.

We also continued our study of nanocomposite-particles synthesis for use in the decomposition of organic pollutants in water. The nanocomposite particles are composed of photocatalytic anatase (TiO_2) nanoparticles coated onto agglomerates of the superparamagnetic maghemite (Fe_2O_3) nanoparticles. For the photocatalytic purification, the particles are dispersed in polluted water. The surface anatase layer provides a high photocatalytic activity, while the superparamagnetic cores enable the separation of the particles from the suspension after the purification and their re-use. One of used methods for nanocomposite preparation is based on the heteroagglomeration of the anatase nanoparticles and the maghemite nanoparticles in the aqueous suspension applying attractive electrostatic forces between the nanoparticles with an opposite electric surface charge. The research in cooperation with the co-founder Cinkarna Celje and the Public Health Institute Maribor was focused on the relationship between the structure of the nanocomposite particles and their photocatalytic activity. It appeared that the photocatalytic activity of the anatase nanoparticles is even improved when they were combined with maghemite into the nanocomposite. The effect was explained based on the electronic interactions between the two semiconductors.

Nanocomposite particles were also studied in the frame of the international applicative project FOMS. The aim of this project is to develop material and technology for the production of magneto-optic fibres suitable for magnetostrictive sensors. K8 was involved in the study of the synthesis of $CoFe_2O_4$ nanoparticles and $CoFe_2O_4/SiO_2$ nanocomposites. Both the nanoparticles and the nanocomposites serve as reagents for the preparation of the magneto-optic fibres. The $CoFe_2O_4$ nanoparticles that were synthesized hydrothermally were used as the magnetic fluid in chloroform for the fibre preparation at our partner Optacore. The $CoFe_2O_4/SiO_2$ nanocomposite particles were prepared with a sol-gel method using tetraethyl orthosilicate (TEOS) as a precursor for SiO_2. We have also determined the crystallization temperature for the $CoFe_2O_4$ in the SiO_2 matrix, which is important information for the future thermal post-treatment of the optical fibres. Namely, during their production the $CoFe_2O_4$ melts and thermal post-treatment is required for its recrystallization. $CoFe_2O_4$ begins to crystallize in SiO_2 at temperatures as low as 500°C. However, a higher temperature of 900°C enables the crystallization of small enough particles with relatively good magnetic properties.

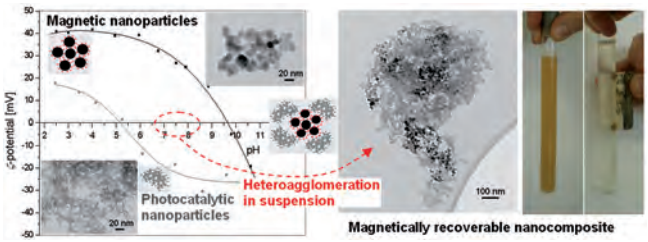

Figure 2: Mixing of suspensions of anatase nanoparticles and maghemite nanoparticles, displaying an opposite surface charge results in hetero-agglomeration and tea formation of magnetically-retractable, photocatalytic, nanocomposite particles.

The preparation of magnetically-oriented films based on $BaFe_{12}O_{19}$ with electrophoretic deposition and deposition in a magnetic field.

The studies in the field of magnetic materials for telecommunications were focused on the development of ceramic films for micro- and mm-wave applications. Our aim was to develop a simple method for the preparation of magnetically-oriented thick hexaferrite films with low magnetic losses that are suitable for self-biased non-reciprocal devices. Two parallel studies were conducted: electrophoretic deposition (EPD) and deposition in a magnetic field. For the both methods, suspensions are used as starting materials. A profound theoretical study of the particle stabilization in suspensions, supported with experimental evidence, showed that stabilization in polar solvents was only possible for particles with diameters up to 30 nm via (electro)-steric mechanism. Since the charged particles are required for the EPD, the suspensions were prepared by electro-steric stabilization in 1-butanol. The influence of particle size on the quality and the magnetic orientation of the deposits were studied. The deposits with the highest orientation degree and with the lowest porosity were obtained from the suspensions of the smaller (up to 30 nm) and larger (up to 200 nm) plate-like particles. The sintering studies showed that the magnetic orientation increases with sintering at the expense of the exaggerated grain growth that accompanies the sintering process. The large grains grow at the expenses of the small ones. This is possible since the crystallographic orientation of the $BaFe_{12}O_{19}$ coincides with the magnetic: the magnetic easy axis is perpendicular to the plane of the plate-like particles. In such a way, we obtained magnetic films with up to 90% orientation. The deposition in a magnetic field also resulted in the best orientation degree, 90%, with the use of suspensions with particles of different sizes. We found out that too high magnetic field causes particles agglomeration, which decreases the orientation degree and the density due to differential sintering of the agglomerates. The applied magnetic field should not exceed 0.7 T.

An international applicative project FERFIT under coordination of K8 started this year. The aim of the project is to develop methods for the preparation of magnetically oriented films based on $BaFe_{12}O_{19}$. Such films can be applied as self-biased nonreciprocal devices. We aim at applications in the range 30-40 GHz. Therefore, a partial substitution of Fe^{3+} in the $BaFe_{12}O_{19}$ is required. K8 studied the substitution of In^{3+} or Cr^{3+} ($BaM_xFe_{12-x}O_{19}$, M = In or Cr) using hydrothermal synthesis. A thorough study of the synthesis conditions revealed that the maximum possible substitution of In^{3+} was at x = 0.3 and x = 1.0 for the Cr^{3+}. The latter composition is suitable for applications below 40 GHz. The synthesized particles were suspended in 1-butanol and the first test deposits were made in an applied magnetic field.

Research in the field of microwave magnetic materials for non-reciprocal devices was conducted in the frame of an international applicative project IMICIMO. The aim is to develop materials and technology for a low-temperature co-fired microwave (LTCC) module. K8 developed the LTCC hard-magnetic material based on Sr hexaferrite that sinters at 1000°C. This material showed the required stability of the magnetic properties with temperature, which makes it suitable for applications in microwave modules for telecommunications base-stations. We were also involved in the preparation of the slurries from the developed LTCC materials for tape casting.

In the field of high-temperature thermistors the processes of reduction and re-oxidation related to the formation of temperature-dependent potential barriers at the grain boundaries of ferroelectric ceramics in the systems $SrNb_2O_6$–$BaNb_2O_6$ and $BaTi_3$– $Na_{0.5}Bi_{0.5}TiO_3$. In the latter systeme PTC resistors displaying a Curie temperature of 180 oC and a low room-temperature specific resistivity were developed.

Some outstanding publications in the past year

1. Sašo Gyergyek, Darko Makovec, Alenka Mertelj, Miroslav Huskić, Mihael Drofenik. Superparamagnetic nano-composite particles synthesized using the mini-emulsion technique. Colloids surf., A Physicochem. eng. asp.., 2010, issue 1-3, vol.366, str. 113-119
2. Darko Makovec , Alojz Kodre, Iztok Arčon, Mihael Drofenik. The structure of compositionally constrained zinc-ferrite spinel nanoparticles. J. nanopart. res., [in press] 2010, 10 str.
3. Mihael Drofenik, Irena Ban, Gregor Ferk, Darko Makovec, Andrej Žnidaršič, Zvonko Jagličić, Darja Lisjak. The concept of a low-temperature synthesis for superparamagnetic $BaFe_{12}O_{19}$ particles. J. Am. Ceram. Soc., 2010, vol. 93, no. 6, str. 1602-1607
4. Darja Lisjak, Mihael Drofenik. Magnetic phase formation in CoTi-substituted Ba hexaferrite coatings prepared with atmospheric plasma spraying. J. Am. Ceram. Soc., 2010, vol. 93, no. 9, str. 2579-2584
5. Simona Ovtar, Darja Lisjak, Mihael Drofenik. Surface analyses of barium hexaferrite particles for magnetic suspensions. Surf. interface anal., 2010, vol. 42, no. 6/7, str. 1217-1221

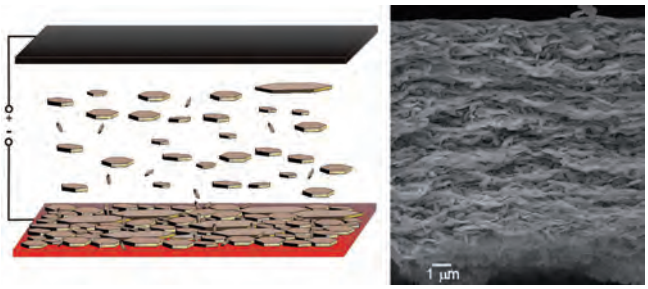

Figure 3: Assembling of the $BaFe_{12}O_{19}$ nanoparticles during electrophoresis (left) results in magnetically oriented deposits (right).

Awards and appointments

1. Prof. Dr. Miha Drofenik: Zois Award 2010 for top research achievements in the area of materials, Committee of the Republic of Slovenia for the Zois Awards and Distinctions, Ambassador of Science Awards of the Republic of Slovenia and Puh Awards.

INTERNATIONAL PROJECTS

1. Composites with Novel Functional and Structural Properties by Nanoscale Materials (Nano Composite Materials NCM)
   COST MP0701, EC
   Prof. Darko Makovec
2. Ferrite Thick Films for Integrated Circuits
   FERFIT
   MNT-ERA-NET II, 3211-10-000028
   Asst. Prof. Darja Lisjak
3. Fiber Optics Magnetostrictive Sensor
   MNT-ERA-NET, MANUNET 3, 3211-09-0000552
   FOMS
   Techno Gr srl, Piedmont, Italy
   Asst. Prof. Darja Lisjak
4. Integrated Miniature Circulators for Microwave Modules
   IMICIMO
   EUREKA, 3211-08-000092
   Chelton Telecom & Microwave FRANCE, France
   Asst. Prof. Darja Lisjak
5. Preparation of Thick Ferrite Coatings with the Deposition in Magnetic Field
   BI-BG/09-10-004
   Dr. Tatyana Koutzarova, Institute of Electronics, Bulgarian Academy of Sciences, Sofia, Bulgaria
   Asst. Prof. Darja Lisjak
6. Hexaferrite-spinel Intergrowth Nanocomposites Paricles for Cancer Treatment using Magnetic Hyperthermia
   BI-CZ/09-10-001
   Dr. Pavel Veverka, Institute of Physics ASCR, v.v.i., Prague, Czech Republic
   Prof. Darko Makovec
7. Synthesis of Superparamagnetic Hexaferite Nanoparticles using Hydrothermal Methods
   PROTEUS
   BI-FR/09-10-PROTEUS-003
   Dr. Nadine Millot, ICB, UMR 5209, CNRS/Université de Bourgogne, Dijon, France
   Prof. Darko Makovec
8. Magnetic Nanoparticles for Hyperthermia Application
   BI-HU/10-11-002
   Dr. Anna Sztaniszlav, TKI-FERRIT Development and Manufacturing Ltd., Budapest, Hungary
   Prof. Darko Makovec

R & D GRANTS AND CONTRACTS

1. Development of Photocatalytic Superparamagnetic Nanocomposites for Application in Diminishing Emissions of Harmful Pollutants into the Environment
   Prof. Darko Makovec
2. Patterns, Structural Self-organisation and Magnetoelectrics in Mixtures of Nanoparticles and Liquid Crystals
   Prof. Mihael Drofenik, Prof. Samo Kralj

RESEARCH PROGRAM

1. Advanced Inorganic Magnetic and Semiconducting materials
   Prof. Mihael Drofenik

NEW CONTRACT

1. The optimization of the production process for PTCR thermistors
   STELEM d.o.o. Žužemberk
   Dr. Igor Zajc

MENTORING

Ph. D. Theses

1. Stanislav Čampelj, *Functionalization of magnetic nanoparticles* (mentor Darko Makovec)
2. Sašo Gyregyek, *Superparamagnetic nanocomposites based on superparamagnetic iron oxide nanoparticles and polymethyl methacrylate* (mentor Mihael Drofenik; co-mentor Darko Makovec)

M. Sc. Theses

1. Valerija Dančˇ, *Synthesis and characterization of CdS and CdSe nanoparticles by sonochemical method in aqueous solution* (mentor Irena Ban; co-mentor Mihael Drofenik)
2. Anita Dančˇ, *Synthesis and characterization of CdTe nanoparticles by sonochemical method in aqueous solution* (mentor Matjaž Kristl; co-mentor Mihael Drofenik)

VISITORS FROM ABROAD

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DEPARTMENT FOR ADVANCED MATERIALS K-9

The primary activities of the department are the development of new, materials and the development of new processes for the preparation of such materials in the form of nanostructures and nanocomposites. The main objective of current projects is the synthesis of new, environmentally friendly materials with special electrical and optical properties, with the emphasis on tunable materials that exhibit a dependence of the electric polarization on external electric, mechanical or magnetic fields. A significant part of the research is devoted to the development of new ceramic dielectrics that can be used at microwave frequencies. A new field of the department's research is aimed at the synthesis of photocatalytically active and antibacterial nanocomposites because of their wide area of potential application, from domestic appliances to medicine.

Head:
Prof. Danilo Suvorov

Development of materials with special electrical properties

We have investigated the structural and electrical characteristics of the novel $Na_{0.5}Bi_{0.5}TiO_3$–$KTaO_3$ ceramic system. $Na_{0.5}Bi_{0.5}TiO_3$ is a well-known relaxor material, while $KTaO_3$ has the characteristics of an incipient ferroelectric and can thus considerably shift the phase transition of $Na_{0.5}Bi_{0.5}TiO_3$. The results of our studies showed that in the investigated system a solid solutions exist across the whole concentration range of compositions. We observed that the formation of the matrix phase initially starts with the formation of $Na_{0.5}Bi_{0.5}TiO_3$- and $KTaO_3$-rich phases, which than react towards nominal compositions at higher temperatures. Due to the different elements present in the system additional firings at high temperatures were required in order to sufficiently improve the homogeneity of the resultant perovskite phase. However, using a solid-state reaction method it was not possible to obtain single-phase ceramics. In order to decrease the amount of secondary phases different synthesis conditions were tested, including surpluses of elements and the pre-reaction of intermediate phases. The dielectric and ferroelectric properties of samples from the investigated system showed that the addition of $KTaO_3$ shifts $Na_{0.5}Bi_{0.5}TiO_3$ phase transitions towards lower temperatures. In addition, the pronounced effect of phase homogeneity on different electrical properties was observed. Specifically, typical relaxor properties of the samples were observed only after high-temperature reactions led to the formation of a single phase $Na_{0.5}Bi_{0.5}TiO_3$–$KTaO_3$ solid solution. Electric measurements showed that samples change from ferroelectric through relaxor to paraelectric with the increasing content of $KTaO_3$.

Extensive studies of new piezoelectric materials have been focused on the development of lead-free perovskite solid solutions. Among them also the solid solution of the $Na_{0.5}Bi_{0.5}TiO_3$-based compositions. It is well known that some perovskite solid solutions form morphotropic phase boundaries (MPB) with the coexistence of two different structures, where the electromechanical properties of a piezo-material are enhanced. Such characteristics were observed for the $(1-x)Na_{0.5}Bi_{0.5}TiO_3$-$xK_{0.5}Bi_{0.5}TiO_3$ solid-solution system. Local crystal and domain structures were studied in detail in order to reveal the origin of the enhanced properties. Based on x-ray diffraction (XRD) the MPB was determined for the composition $x = 0.2$, with the coexistence of the rhombohedral and the tetragonal structures. However, detailed domain-structure analyses using transmission electron microscopy (TEM) and selected-area electron diffraction (SAED) methods, performed on various $(1-x)Na_{0.5}Bi_{0.5}TiO_3$-$xK_{0.5}Bi_{0.5}TiO_3$ solid-solution compositions, revealed some structural changes at/near the MPB. Based on the occurrence of the superstructure reflections in the SAED patterns, on the characteristic splitting of the reflections and on the domain morphology observations, the crystal structure in/near the boundary region was determined as a tetragonal structure with an in-phase oxygen octahedral tilt system. Further TEM investigations should confirm the nature and the origin of this structure.

During the synthesis of $K_{0.5}Bi_{0.5}TiO_3$ ceramics the volatilization of prone components (K,Na,Bi) and the formation of secondary phases are often observed, which result in a slow densification process. Thus, accurate knowledge of the synthesis parameters and the structure–electrical properties relations of these materials are of great importance. With the control of the parameters of the solid-state synthesis we were able to prepare dense ceramics with a minor content of secondary phases that exhibit better dielectric properties compared to the literature data. The properties were further enhanced by using finer powders and chemicals as raw materials that possess a higher reactivity. The use of amorphous or nano-crystalline TiO_2 results in a smaller concentration of secondary phases, a higher density of ceramics and an additional

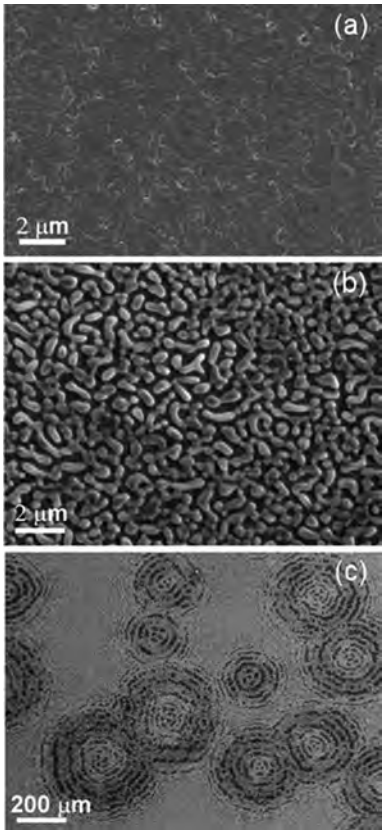

Figure 1: Microstructural development of BSO thin films deposited from sols using different precursors:
a) $Bi(NO_3)_3 \cdot 5H_2O$: well-defined dense microstructure with uniform grain size,
b) $Bi(CH_3COO)_3$: low solubility of the precursor after thermal treatment yields porous thin film
c) $Bi(C_7H_{15}COO)_3$: inhomogeneous dense microstructure with porous areas as a result of sol self-assembly process.

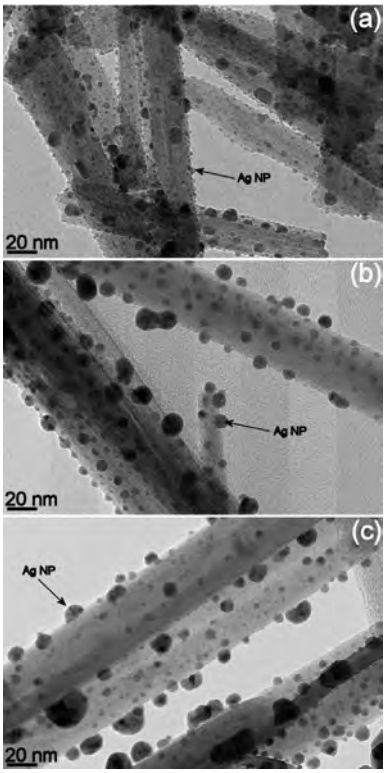

Figure 2. Composite Ag/Ti-nanobelts formed with the in-situ precipitation of Ag nanoparticles in a polyelectrolyte matrix on the surface of Ti-nanobelts after: (a) one, (b) two and (c) three precipitation cycles of Ag nanoparticles after annealing at 600°C. The average Ag nanoparticle size is increasing with the number of reaction precipitation cycles in contrast to the surface density of Ag nanoparticles, which is decreasing.

improvement of dielectric properties. The best results were obtained with the use of KNO_3 instead of K_2CO_3, which decomposes slowly and is therefore hard to control. In these samples no secondary phases were observed in the microstructure, the density was further improved and the dielectric properties were additionally enhanced.

In the process of miniaturization bulk ceramic components are being replaced by thin films. The $70mol\%Na_{0.5}Bi_{0.5}TiO_3$–$30mol\%NaTaO_3$ thin films were synthesized using the sol-gel method and deposited by spin coating onto sapphire and $Pt/TiO_2/SiO_2/Si$ substrates. The decomposition of the sol-gel system occurred in two steps: the organic matter decomposition between 250°C -400°C and the perovskite crystallization with removal of the remaining carbon dioxide at 550°C. The structural and surface morphology were observed to be very sensitive to the processing parameters, such as the addition of DCCA, pyrolysis and annealing. Well-crystallized films were obtained at relatively low temperatures, i.e. below 650°C. The microwave measurements performed at 15 GHz using a split-resonator measurement configuration showed values of the dielectric constant of 170 and the dielectric loss of 0.1.

In the scope of an applied project with EPCOS OHG, Deutschlandsberg, Austria, in investigations of potential materials for PTC tunable applications several ferroelectrics with the Curie temperature (T_c) between 130°C and 150°C, and dielectric constant maximum ε_r greater than 10 000 have been developed. The focus was on the perovskite ceramics based on $(1-x-y)Pb(Zn_{1/3}Nb_{2/3})O_3$–$xBaTiO_3$–$yPbTiO_3$ system. It was found that the addition of $BaTiO_3$ ($0.05 \leq x \leq 0.2$) and $PbTiO_3$ ($0 \leq y \leq 0.2$) to the $Pb(Zn_{1/3}Nb_{2/3})O_3$ suppressed the formation of the pyrochlore phase, which causes lowering of the dielectric constant ε_r maximum. The T_c changed with the amount of $PbTiO_3$ and $BaTiO_3$; namely, T_c shifts to lower temperatures with the increase of $BaTiO_3$ and the decrease of the $PbTiO_3$ content.

Development of microwave dielectrics

In the scope of low-dielectric-constant materials suitable for low-temperature co-fired ceramic (LTCC) processes, we investigated scheelite (MWO_4; M=Ca, Sr, Ba) ceramics and the $Mg_2B_2O_5$ compound that crystallizes as the main phase from the MgO–B_2O_3–SiO_2 glass. In the investigated glass system we studied the nucleation and crystallization processes formed by non-isothermal methods. For MgO–B_2O_3–SiO_2 glass nucleation occurred in the temperature range from 600°C to 750°C with the maximum nucleation rate at 700°C, whereas the nucleation and crystal growth processes overlapped at temperatures from 700°C to 750°C. The analyses of the non-isothermal data by the most common models (Ozawa, Kissinger, modified Kissinger, Ozawa-Chen) revealed that the crystallization of $Mg_2B_2O_5$ was three-dimensional bulk with diffusion-controlled crystal growth rate with n=m=1.5 and activation energy for crystallization (E) of 420–450 kJ/mol. The addition of TiO_2 to the MgO–B_2O_3–SiO_2 glass in the amount of 1–10 wt % was found to facilitate the formation of nuclei and changed the crystallization mechanism to bulk crystallization with an increasing number of nuclei (m=3, n=4). Both, permittivity and quality factor (Qxf), increased with the TiO_2 content. The improvement of the Qxf-values was attributed to the enhanced crystallization. The highest Qxf-value of 16,500 GHz was measured for the glass-ceramics with 10 wt % of TiO_2 sintered at 1050°C. The MgO–B_2O_3–SiO_2-based glass-ceramics sintered in the range from 850°C to 950°C exhibited somewhat lower Qxf-values of 5000–8000 GHz and a permittivity of 6.1–6.9.

The investigations of the low-temperature sintering of scheelite (MWO_4; M=Ca, Sr, Ba) ceramics revealed that the Li- or Na-containing sintering aids increased the susceptibility of the scheelites to water. It was found that already very low concentrations of Li or Na (<0.2 wt %) in the sintered ceramics caused the degradation of the ceramics in the presence of moisture and increased the solubility of tungstate in water by more than 50-times. The results showed that the physical and chemical properties of the ceramic materials meant for application in electronics should also be carefully considered in the case of additives in very low concentrations.

In $Bi_{12}SiO_{20}$ thin-film preparation we studied the influence of a bismuth precursor on the microstructural development. A sol was prepared using $Bi(NO_3)_3 \cdot 5H_2O$, $Bi(CH_3COO)_3$ or $Bi(C_7H_{15}COO)_3$ as the precursor. We observed that the choice of the precursor has a great influence on the microstructural development of $Bi_{12}SiO_{20}$ thin films. A different bismuth precursor has a different gelation path, which resulted in different microstructural development. In the case of the $Bi(NO_3)_3 \cdot 5H_2O$ precursor, the formation of a dense microstructure appeared. Thin films deposited from sols where $Bi(CH_3COO)_3$ was used as a precursor showed a rather porous microstructure development. While $Bi_{12}SiO_{20}$ thin films, deposited from sols where $Bi(C_7H_{15}COO)_3$ was used as precursor, exhibited inhomogeneous self-assembly microstructural development. In the future, the process will be thoroughly investigated with the use of a molecular LEGO approach to explain different gelation paths of sols and thin films.

In collaboration with Epcos OHG several ferroelectric materials for PTC tunable applications based on the perovskite $(1-x-y)Pb(Zn_{1/3}Nb_{2/3})O_3$–$xBaTiO_3$–$yPbTiO_3$ ceramic system with a Curie temperature between 130°C and 150°C, and dielectric constant maximum ε_r greater than 10,000 have been developed.

In the field of phase relations in ternary oxide systems where new compounds and/or solid solutions are stable and exhibit pronounced electric properties, we identified new compounds in tha La_2O_3–TiO_2–GeO_2 system and determined their composition. Additionally, in the La_2O_3–TiO_2–Ta_2O_5 system we prepared single-phased ceramics based on the new compound $LaTaTiO_6$ and determined the high-temperature monoclinic and low-temperature orthorhombic crystal structure and phase-transformation temperature.

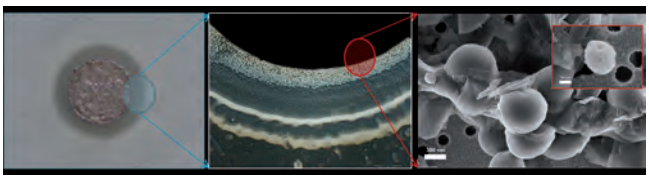

Figure 3. Antibacterial activity of Ag against Gram positive bacteria: (a) growth inhibition zone of Staphyloccocus aureus bacterial colony around hydroxyapatite/silver (HAp/Ag) nanocomposite, (b) gradient change in the density of modified bacterial colony within the zone of growth inhibition (c) morphological changes of individual bacteria induced by antibacterial action of silver in HAp/Ag composite in the zone of growth inhibition.

Research of nanostructured materials and nanocomposites

a.) Nanoparticles and nanopowders

The material synthesis approach turns out to be the key parameter in obtaining improved properties of the ceramics. Among other synthesis approaches is also a hydrothermal synthesis. The research of nanostructured materials has been focused on the synthesis of the relaxor perovskite $Na_{0.5}Bi_{0.5}TiO_3$, $Na_{0.5}Bi_{0.5}TiO_3$–$K_{0.5}Bi_{0.5}TiO_3$ and high-surface-area TiO_2 nanopowders.

The hydrothermal method was employed for the preparation of phase-pure nano-sized $Na_{0.5}Bi_{0.5}TiO_3$ particles as a separate component for their further integration in the form of thick or thin films. Considering that the $Na_{0.5}Bi_{0.5}TiO_3$-based solid solution exhibits enhanced piezoelectric properties, we further aimed to hydrothermally prepare $Na_{0.5}Bi_{0.5}TiO_3$–$K_{0.5}Bi_{0.5}TiO_3$ nano-powders. The synthesis of the $Na_{0.5}Bi_{0.5}TiO_3$–$K_{0.5}Bi_{0.5}TiO_3$ system requires a mixed alkaline environment of NaOH and KOH mineralizer, where the final stoichiometry of the obtained powders is controlled by the NaOH/KOH ratio of the starting solution. We observed that the starting solution NaOH/KOH ratio and preferential intercalation of sodium over calium cations induce the formation of secondary phases. The secondary-phase-free $Na_{0.5}Bi_{0.5}TiO_3$–$K_{0.5}Bi_{0.5}TiO_3$ composition was obtained with a NaOH/KOH ratio of 1:1.

Crystalline TiO_2 nano-powders were prepared using the sol-gel synthesis approach, followed by annealing at temperatures between 500 and 800°C. The sol-gel-derived precipitates were modified with triethanolamine, which affected the rate of the anatase-to-rutile phase transformation. As-prepared TiO_2 nano-powders consisted of anatase phase particles and rutile phase particles. Depending on the temperature of the thermal treatment the size of the two-phased nanoparticles varied between 11 and 36 nm for the anatase, and between 24 and 45 nm for the rutile phase particles. The photocatalytic activity of the prepared TiO_2 nano-powders was evaluated by monitoring the photocatalytic oxidation of isopropanol into acetone. TiO_2 nano-powders thermally treated at 700°C exhibit the highest photocatalytic activity under visible light irradiation. This sample was a mixture of anatase, with a particle size of 36 nm and rutile, with a particle size of 45 nm.

We also synthesized Zr- and Ce-doped anatase nanoparticles. The doping of the anatase crystal lattice resulted in stability of the anatase phase up to 1000°C. The doped nanoparticles sintered at this temperature showed enhanced photocatalytic activity.

b.) Nanocomposites

Besides the enhanced efficiency of nanocomposite materials obtained by combining two different components, the ability to achieve a high specific surface area is the key parameter that dictates the research of nanocomposites with improved applicable properties. In the scope of photocatalytically active and bio materials we synthesized nanocomposite materials composed of various metallic nanoparticles and metal-oxide nanostructures.

Nanostructured metallic (Ag) nanoparticle loaded titanate-based one-dimensional (1D) nanobelts were synthesized by the in-situ-precipitation of Ag nanoparticles on the surface of Ti-nanobelts. A polyelectrolyte multilayer was first formed on the surface of Ti-nanobelts by the sequential deposition of appositively charged polyelectrolyte chains. As the polyelectrolyte multilayer-coated Ti-nanobelts are exposed to the silver cation solution, Ag_2O nanoparticles are formed between Ag+ cations and OH^- ions due to the diffusion of OH^- groups detached from the surface of Ti-nanobelts. The control over the concentration and the size of the particles within the polymer matrix was obtained by cycling the synthesis process. By subsequent thermal treatment at 600°C for 30 minutes the polyelectrolyte multilayer is removed, which yields composite Ag/Ti-nanobelts with different concentrations and sizes of Ag-nanoparticles on the surface of Ti-nanobelts. The enhanced UV photo-efficiency was observed for the Ag/Ti-nanobelts nanocomposites in comparison to pure Ti-NBs. The As-fabricated Ag/Ti-nanobelts also exhibited visible photo-activity, assisted by the near-field amplitudes of the localized surface plasmon resonance (LSPR) of the silver nanoparticles in the 1D nanocomposite.

Nanocrystalline Ag/TiO_2 composite thin films were synthesized using a two-step synthesis methodology: the in-situ precipitation of Ag nanoparticles

We developed a synthesis method for composite metal (Ag)/1D titanate nanostructure fabrication. By controlling the size and concentration of the metallic nanoparticles on the surface of 1D titanate nanostructures we were able to obtain enhanced photocatalytic activity for such nanocomposites.

followed by an in-situ sol-gel reaction of titanium iso-propoxide in a weak-polyelectrolyte-multilayer template formed by the layer-by-layer self-assembly of polyacryllic acid and polyallylamine. The polyelectrolyte-multilayer template assembled from weak polyions contains non-ionized carboxylic groups that are able to react with the inorganic precursors, resulting in the formation of a homogeneous Ag/TiO_2-polyion-multilayer precursor film. The content of Ag in the precursor film is controlled by repeating the Ag loading cycle. The subsequent annealing of the precursor yields nano-structured Ag/TiO_2 films with the thicknesses controlled by the polyion-multilayer template on the nanometre scale. The formed Ag/TiO_2 composite thin films exhibit high Ag nanoparticle/TiO_2 crystallite inter-contact area. Due to electron traps centres and a localized near field induced by the localized surface plasmon resonance (LSPR) of Ag nanoparticles in Ag/TiO_2 composite thin films enhanced UV and visible photo-catalytic behaviour of the as-synthesized Ag/TiO_2 films was obtained.

The sonochemical method was utilized for the synthesis of silver (Ag), gold (Au) and platinum (Pt) nanoparticulate/hydroxyapatite composites. The influence of different synthesis precursors on the morphological and structural properties of as formed composites was analyzed. The antibacterial activity of the composites was tested by the application of Gram-positive and Gram-negative bacteria. The results show that silver has the strongest effect against Gram-negative bacteria. In addition to the peptidoglycan layer onto the surface of Gram-negative bacteria their outer membrane contains lipopolysaccharides together with porins proteins which allow the transfer of small and hydrofile molecules and ions. According to the obtained difference in antibacterial effects these proteins may have an important role in the transport of silver ions inside bacteria.

Some outstanding publications in the past year

1. Mojca Otoničar, Srečo D. Škapin, Matjaž Spreitzer, Danilo Suvorov. Compositional range and electrical properties of the morphotropic phase boundary in the $Na_{0.5}Bi_{0.5}TiO_3$-$K_{0.5}Bi_{0.5}TiO_3$ systems. J. Eur. Ceram. Soc.. [Print ed.], 2010, vol. 30, no. 4, p. 971-979.
2. Manca Logar, Boštjan Jančar, Sašo Šturm, Danilo Suvorov. Weak polyion multilayer-assisted in situ synthesis as a route toward a plasmonic Ag/TiO_2 photocatalyst. Langmuir, 2010, vol. 26, issue 14, p. 12215-12224.
3. Asja Veber, Špela Kunej, Romana Cerc Korošec, Danilo Suvorov. The effects of solvents on the formation of sol-gel-derived $Bi_{12}SiO_{20}$ thin films. J. Eur. Ceram. Soc.. [Print ed.], 2010, vol. 30, no. 12, p. 2475-2480.
4. Boštjan Jančar, Jana Bezjak. High-temperature decomposition of B-site-ordered perovskite $Ba(Zn_{1/2}W_{1/2})O_3$. J. Am. Ceram. Soc., 2010, issue 3, vol. 93, p. 758-764.
5. Urban Došler, Marjeta Maček, Boštjan Jančar, Danilo Suvorov. A high-Q microwave dielectric material based on $Mg_3B_2O_6$. J. Am. Ceram. Soc., 2010, vol. 93, no. 11, p. 3788-3792.

Patents granted

1. Keramisches Material, gesinterte Keramik, Verfahren zur Herstellung und Verwendung der Keramik
   Pavol Dudešek, Christian Hoffmann, Danilo Suvorov, Matjaž Valant
   Patent No. DE 102006024231 (B4)
2. Ceramic material, sintered ceramic and component made therefrom, production method and use of the ceramic
   Pavol Dudešek, Christian Hoffmann, Danilo Suvorov, Matjaž Valant
   Patent No. US 7816293 (B2)

Awards and appointments

1. Mojca Otoničar: LOTTE-IEEE-UFFC Student Award at the 7th Asian Meeting on Ferroelectricity (AMF-7) and the 7th Asian Meeting on Electroceramics (AMEC-7), Jeju Island, Korea, granting by associations IEEE and UFFC, oral presentation "Morphotropic phase boundary in the $(Na_{1-x}K_x)_{0.5}Bi_{0.5}TiO_3$ system with its enhanced electrical properties".
2. Mojca Otoničar: Best contribution award at the 'European Conference Junior EUROMAT 2010', Lausanne, Switzerland, award granted by the Euromat Committee for the poster and oral presentation entitled 'In-situ-TEM and SAED analysis of the domain structure in $K_{0.5}Bi_{0.5}TiO_3$ perovskite ceramics'.
3. Vojka Žunič: The best presentation among young researchers, research field: Nanomaterials and Nanotechnologies, at the 18th Conference on Materials and Technology, Portorož, granting by Institute of Metals and Technology, oral presentation "Visible light active TiO_2 nano-powders prepared by sol-gel synthesis".

Organization of conferences, congress and meetings

1. Slovenia – Brazilian workshop Electron Microscopy Workshop, Ljubljana, 16 – 30 June 2010.
2. Materials Science & Technology 2010 Conference and Exhibition, Houston, ZDA, 17 – 21 October 2010 (co-organizers).
3. 18th Conference on Materials and technologies, Portorož, 15 – 17 November 2010 (co-organizers).

INTERNATIONAL PROJECTS

1. Development of Wear Resistant Coatings based on Complex Metallic Alloys for Functional Applications
   AppliCMA
   7. FP, 214407
   EC; Susanne Fuchs, Austrian Research Centers GmbH - ARC, Functional Materials, Seibersdorf, Austria; Aerospace & Advanced Composites GmbH, Wiener Neustadt, Austria
   Dr. Srečo D. Škapin, Dr. Miha Čekada, Prof. Janez Dolinšek, Dr. Kristoffer Krnel
2. Controlled Production of High Tech Multifunctional Products and their Recycling
   SAPHIR
   6. FP, NMP2-CT-2006-026666
   EC; Laurence Demoor, Christophe Goepfert, Compagne Industrielle des Lasers Cilas SA, Orleans, France
   Prof. Danilo Suvorov
3. Microwave Tunable Materials, Composites and Devices (Project Proposal)
   NATO SfP 984091
   NATO, North Atlantic Treaty Organisation, Brussels, Belgium
   Dr. Boštjan Jančar
4. Functional Nanostructured Ceramic Materials
   BI-AR/09-11-001
   Prof. Noemí Elisabeth Walsöe de Reca, CINSO (Centro de Investigaciones en Sólidos), CITEFA-CONICET, Buenos Aires, Argentine
   Prof. Danilo Suvorov
5. High Dielectric Constant Ferroelectric Material; Thermoelectric Oxide Materials
   Agreement IJS/EPCOS, NBT
   Dr. Guenter Engel, Dr. Andrea Testino, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
   Prof. Danilo Suvorov, Dr. Marjeta Maček Kržmanc, Dr. Boštjan Jančar
6. High K Dielectrics for Mobile Phone Base Stations
   Agreement IJS/EPCOS, Microwave Ceramics
   Dr. Christian Hoffmann, Pavol Dudesek, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
   Prof. Danilo Suvorov, Dr. Boštjan Jančar
7. High K Dielectrics for Mobile Phone Base Stations
   Agreement IJS/EPCOS, Microwave Ceramics
   Dr. Christian Hoffmann, Pavol Dudesek, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
   Prof. Danilo Suvorov
8. Biomimetic Preparation of Inorganic Nanomaterials
   BI-HR/09-10-037
   Dr. Ivan Sondi, Ruđer Bošković Institute, Zavod za raziskovanje morja in okolja, Zagreb, Croatia
   Dr. Srečo Davor Škapin
9. Ultra-low Dielectric Constant LTCC Material
   BI-CN/09-11-013
   Dr. Xing Hu, South China University of Technology, Guangzhou, China
   Dr. Srečo Davor Skapin
10. Synthesis of Piezoelectric Thin Films and Magnetoelectic Composites by a Layer-by-layer Self Assembly
    BI-KR/09-11-001
    Dr. Jae-Ho Jeon, Korea Institute of Materials Science, Changwon, Korea
    Prof. Danilo Suvorov
11. Mixed Rare Earth Oxide Nanoparticles: Synthesis, Characterisation, Applications
    BI-SR/10-11-016
    Dr. Bratislav Antić, "Vinča" Institute of Nuclear Sciences, Belgrade, Serbia
    Dr. Boštjan Jančar
12. Electric-field Tunable Ferroelectric Materials Based on $Na_{0.5}Bi_{0.5}TiO_3$
    BI-UA/09-10-007
    Prof. Anatolii Belous, SPE "Oxid" of V.I. Vernadskii Institute of General & Inorganic Chemistry NAS of Ukraine - Solid State Chemistry Department, Kyiv, Ukraine
    Prof. Danilo Suvorov
13. Materials World Network: Improved Lanthanide-based Filters for Mobile Telekommunications
    BI-US/08-10-005
    Prof. Rick Ubic, Boise State University, Boise, Idaho, USA
    Prof. Danilo Suvorov

R & D GRANTS AND CONTRACTS

1. Physis and Chemistry of Porous Aliminium for Al Panels, Capable of Highly Efficient Energy Absorbtion
   Prof. Danilo Suvorov
2. Functionalization of the Surface of Organic Pigments for Durable, Efficient and Colour-stable Paints
   Asst. Prof. Srečo Davor Škapin
3. Nanoengineering of Self-assembled Materials
   Prof. Danilo Suvorov
4. Self-cleaning Antibacterial Fotocatalitic Coating in Whitewear Production
   Prof. Danilo Suvorov

RESEARCH PROGRAM

1. Contemporary Inorganic Materials and Nanotechnologies
   Prof. Danilo Suvorov

NEW CONTRACTS

1. Antibacterial surface protection in water based media
   Gorenje Household Appliances d.d.
   Prof. Danilo Suvorov
2. Antibacterial surface protection in refrigirators
   Gorenje Household Appliances d.d.
   Prof. Danilo Suvorov
3. Self-Cleaning Antibacterial Fotocatalitic Coatings in whitewear productions
   Gorenje Household Appliances d.d.
   Prof. Danilo Suvorov

MENTORING

Ph. D. Thesis

1. Asja Veber, S*ynthesis and characterization of* $Bi_{12}SiO_{20}$ *thin films prepared by sol-gel method* (mentor Danilo Suvorov)

VISITORS FROM ABROAD

1. Dr. Wolfgang Athenstaedt, Pavol Dudešek, B. Sc., Dr. Günter Engel, Dr. Christian Hoffmann, EPCOS OHG, Deutschlandsberg, Austria, 8 March 2010.
2. Prof. Peter Day, University College London and Royal Institution of Great Britain, Great Britan, 22 March 2010.
3. Dr. Ivan Sondi, Institut Rudjer Bošković, Zagreb, Croatia, 14 May 2010.
4. Carl Hatton, B. Sc., Veeco Instruments, Plainview, USA, 27 May 2010.
5. Prof. Jose Arana Varela, UNESP´s Institute of Chemistry, Araraquara , Brazil, 17 - 20 June 2010.
6. Dr. Aleksandr Babak, Tomilino Electronic Factory, TEF-SPE Ltd., Moscow, Russia, 13 July 2010.
7. Dr. Smilja Marković, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade, Serbia, 14 – 28 July 2010.
8. Pavol Dudašek, B. Sc., EPCOS, Deutschlandsberg, Austria, 27 July 2010.
9. Dr. Mario Bianchetti, Centro de Investigaciones en Solidos, Buenos Aires, Argentina, 4 – 18 August 2010.
10. Dr. Jae Ho Jeon, Korea Institute of Materials Science, Changwon, Korea, 10 - 14 September 2010.
11. Stefan Thumser, B. Sc., Netzsch GmbH, Selb, Germany, 13 - 14 October 2010.
12. Dr. Cristina Giordano, Max Planck Institute of Colloids and Interfaces, Potsdam, Germany, 21 October 2010.
13. Dr. Gertjan Koster, University of Twente, Enschede, Netherlands, 21 October 2010.
14. Dr. Bratislav Antić, Dr. Aleksandar Kremenović, Institute Vinča, Belgrade, Serbia, 8 – 13 November 2010.
15. Walter König, B. Sc., Ruben Zowada, B. Sc., Cascade Microtech, Munich, Germany, 23 – 25 November 2010.
16. Dr. Aleksandr Babak, Tomilino Electronic Factory, TEF-SPE Ltd., Moscow, Russia, 23 November 2010.
17. Prof. Egon Matijević, Clarkson University, Potsdam, USA, 25 November 2010.
18. Dr. Smilja Marković, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade, Serbia, 29 November - 11 December 2010.

Visiting Researchers:

1. Dr. Jyoti Prosad Guha, University of Rolla, Rolla, USA, 27 May – 31 August 2010.
2. Mag. Marija Vukomanović, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade, Serbia, 1 January – 31 December 2010.

STAFF

Researchers

1. Asst. Prof. Boštjan Jančar
2. Dr. Marjeta Maček Kržmanc
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4. Asst. Prof. Srečo Davor Škapin

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5. Dr. Jakob König
6. Dr. Uroš Kunaver*
7. Dr. Špela Kunej
8. Dr. Manca Logar
9. Dr. Matjaž Spreitzer
10. Dr. Marko Udovič*
11. Dr. Asja Veber

Postgraduates

12. Ines Bračko, B. Sc.
13. Urban Došler, B. Sc.
14. Sonja Makević, B. Sc.
15. Mojca Otoničar, B. Sc.
16. Andreja Šestan, B. Sc.
17. Tina Šetinc, B. Sc.
18. Vojka Žunič, B. Sc.

Technical and administrative staff

19. Maja Šimaga Saje, M. Sc.
20. Silvo Zupančič

Note:
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BIBLIOGRAPHY

Original Articles

1. Gabriela Ambrožič, Igor Đerđ, Srečo D. Škapin, Majda Žigon, Zorica Crnjak Orel, "The double role of p-toluenesulfonic acid in the formation of ZnO particles with different morphologies", *CrystEngComm (Camb., Online)*, issue 6, vol. 12, pp. 1862-1868, 2010.
2. Gabriela Ambrožič, Srečo D. Škapin, Majda Žigon, Zorica Crnjak Orel, "The synthesis of zinc oxide nanoparticles from zinc acetylacetonate hydrate and 1-butanol or isobutanol", *J. colloid interface sci.*, vol. 346, no. 2, pp. 317-323, 2010.
3. Bratislav Antić, Aleksandar Kremenović, Milica Vučinić-Vasić, Zorana D. Dohčević-Mitrović, A. S. Nikolić, M. Gruden-Pavlović, Boštjan Jančar, Anton Meden, "Composition related properties of $(Yb, Y)_2O_3$ nanoparticles synthesized bycontrolled thermal degradation of AA complexes", *Mater. chem. phys.*, issue 2-3, vol.122, pp. 386-391, 2010.
4. Anatolii Belous, Oleg V. Ovchar, A. V. Kramarenko, Boštjan Jančar, Jana Bezjak, Danilo Suvorov, "Effect of nonstoichiometry on the structure and microwave dielectric properties of $Ba(Co_{1/3}Nb_{2/3})O_3$", *Inorg. mater.*, vol. 46, no. 5, pp. 529-533, 2010.
5. Jana Bezjak, Artem M. Abakumov, Aleksander Rečnik, Marjeta Maček, Boštjan Jančar, Danilo Suvorov, "The local structure and composition of $Ba_4Nb_2O_9$-based oxycarbonates", *J. solid state chem.*, vol. 183, issue 8, pp. 1823-1828, 2010.
6. Urban Došler, Marjeta Maček, Boštjan Jančar, Danilo Suvorov, "A high-Q microwave dielectric material based on $Mg_3B_2O_6$", *J. Am. Ceram. Soc.*, vol. 93, no. 11, pp. 3788-3792, 2010.
7. Urban Došler, Marjeta Maček, Danilo Suvorov, "The synthesis and microwave dielectric properties of $Mg_3B_2O_6$ and $Mg_2B_2O_5$ ceramics", In: *Proceedings of the ELECTROCERAMICS XI: Piezoelectrics, 1-3 September 2008, Manchester, UK*, (Journal of the European Ceramic Society, vol. 30, no. 2), Robert Freer, ed., Colin Leach, ed., Barking, Elsevier, 2010, pp. 413-418.
8. Andreja Gajović, Sašo Šturm, Boštjan Jančar, Ana Šantić, Kristina Žagar, Miran Čeh, "The synthesis of pure-phase bismuth ferrite in the Bi-Fe-O system under hydrothermal conditions without a mineralizer", *J. Am. Ceram. Soc.*, vol. 93, no. 10, pp. 3173-3179, 2010.
9. Matjaž Godec, Barbara Šetina, Djordje Mandrino, Aleš Nagode, Vojteh Leskovšek, Srečo D. Škapin, Monika Jenko, "Characterization of the carbides and the martensite phase in powder-metallurgy high-speed steel", *Mater. charact.*, vol. 61, no. 4, pp. 452-458, April 2010.
10. Mathias Herrmann, Zhijian Shen, Ingrid Schulz, Jianfeng Hu, Boštjan Jančar, "Silicon nitride nanoceramics densified by dynamic grain sliding", *J. mater. res.*, vol. 25, no. 12, pp. 2354-2361, 2010.
11. Boštjan Jančar, Jana Bezjak, "High-temperature decomposition of B-site-ordered perovskite $Ba(Zn_{1/2}W1/2)O_3$", *J. Am. Ceram. Soc.*, issue 3, vol. 93, pp. 758-764, 2010.
12. Ednan Joanni, Raluca Savu, Boštjan Jančar, Paulo R. Bueno, José A. Varela, "Low-temperature sputtering deposition of aligned polycrystalline $CaCu_3Ti_4O_{12}$ nanorods", *J. Am. Ceram. Soc.*, vol. 93, no. 1, pp. 51-54, 2010.
13. Varužan Kevorkijan, Srečo D. Škapin, "Characterisation of Mg − B_4C composites with a high volume fraction of fine ceramic reinforcement fabricated by pressureless infiltration of porous ceramic preforms", *J. adv. mater.*, vol. 42, no. 1, pp. 35-47, 2010.
14. Varužan Kevorkijan, Srečo D. Škapin, "Preparation and study of Mg_2Sn- based composites with different compositions", *Mater. tehnol.*, vol. 44, no. 5, pp. 251-259, 2010.
15. Varužan Kevorkijan, Srečo D. Škapin, "Studies of Mg_2Sn-based composites", *Metalurgija*, vol. 16, no. 1, pp. 47-61, 2010.
16. Varužan Kevorkijan, Srečo D. Škapin, Irena Paulin, Borivoj Šuštaršič, Monika Jenko, "Synthesis and characterisation of closed cells aluminium foams containing dolomite powder as foaming agent", *Mater. tehnol.*, vol. 44, no. 6, pp. 363-371, 2010.
17. Jakob Koenig, Matjaž Spreitzer, Boštjan Jančar, Danilo Suvorov, "Uniaxial stress dependence of the dielectric properties in the $Na_{0.5}Bi_{0.5}TiO_3$ − NaTaO[sub]3 system", *J. mater. res.*, vol. 25, no. 9, pp. 1784-1792, 2010.
18. Manca Logar, Boštjan Jančar, Aleksander Rečnik, Danilo Suvorov, "Polyelectrolyte multilayer template assisted in-situ synthesis of the inorganic nanostructures", *Contemporary materials*, vol. 1, no. 1, pp. 4-18, 2010.
19. Manca Logar, Boštjan Jančar, Danilo Suvorov, "Nanocrystalline TiO_2 thin films fabricated via a polyelectrolyte multilayer-assisted sol-gel reaction", *J. Am. Ceram. Soc.*, vol. 93, issue 11, pp. 3679-3685, 2010.
20. Manca Logar, Boštjan Jančar, Sašo Šturm, Danilo Suvorov, "Weak polyion multilayer-assisted in situ synthesis as a route toward a plasmonic Ag/TiO_2 photocatalyst", *Langmuir*, vol. 26, issue 14, pp. 12215-12224, 2010.
21. Mojca Otoničar, Srečo D. Škapin, Boštjan Jančar, Rick Ubic, Danilo Suvorov, "Analysis of the phase transition and the domain structure in $K_{0.5}Bi_{0.5}TiO3$ perovskite ceramics by in situ XRD and TEM", *J. Am. Ceram. Soc.*, vol. 93, issue 12, pp. 4168-4173, 2010.
22. Mojca Otoničar, Srečo D. Škapin, Matjaž Spreitzer, Danilo Suvorov, "Compositional range and electrical properties of the morphotropic phase boundary in the $Na_{0.5}Bi_{0.5}TiO_3$ − $K_{0.5}Bi_{0.5}TiO_3$ systems", *J. Eur. Ceram. Soc.*, vol. 30, no. 4, pp. 971-979, 2010.
23. Srečo D. Škapin, Ivan Sondi, "Synthesis and characterization of calcite and aragonite in polyol liquids: control over structure and morphology", *J. colloid interface sci.*, vol. 347, no. 2, pp. 221-226, 2010.
24. Neda Vdović, Irena Jurina, Srečo D. Škapin, Ivan Sondi, "The surface properties of clay minerals modified by intensive dry milling - revisited", *Appl. clay sci.*, vol. 48, no. 4, pp. 575-580, 2010.
25. Asja Veber, Špela Kunej, Romana Cerc Korošec, Danilo Suvorov, "The effects of solvents on the formation of sol-gel-derived $Bi_{12}SiO_{20}$ thin films", *J. Eur. Ceram. Soc.*, vol. 30, no. 12, pp. 2475-2480, 2010.
26. Asja Veber, Špela Kunej, Danilo Suvorov, "Synthesis and microstructural characterization of $Bi_{12}SiO_{20}$ (BSO) thin films produced by the sol-gel process", *Ceram. int.*, vol. 36, no. 1, pp. 245-250, 2010.
27. Ljiljana Veselinović, Ljiljana Karanović, Zoran Stojanović, Ines Bračko, Smilja Marković, Nenad Ignjatović, Dragan Uskoković, "Crystal structure of cobalt-substituted calcium hydroxyapatite nanopowders prepared by hydrothermal processing", *J. Appl. Crystallogr.*, vol. 43, no. 2, pp. 320-327, 2010.

28. Marko Viršek, Matthias Krause, Andreas Kolitsch, Aleš Mrzel, Ivan Iskra, Srečo D. Škapin, Maja Remškar, "The transformation pathways of $Mo_6S_2I_8$ nanowires into morphology-selective MoS_2 nanostructures", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 114, no. 14, pp. 6458-6463, 2010.
29. Marija Vukomanović, Miodrag Mitrić, Srečo D. Škapin, Ema Žagar, Janez Plavec, Nenad Ignjatović, Dragan Uskoković, "Influence of ultrasonic processing on the macromolecular properties of poly (D,L-lactide-co-glycolide) alone and in its biocomposite with hydroxyapatite", *Ultrason. sonochem.*, vol. 17, no. 5, pp. 902-908, 2010.

Review Articles and Chapters in Books

1. Ivan Sondi, Srečo D. Škapin, "A biomimetic nano-scale aggregation route for the formation of submicron-size colloidal calcite particles", In: *Biomimetics learning from nature*, Aminatava Mukherjee, ed., Rijeka, InTech, cop. 2010, pp. 241-255.

Published Conference Papers

Invited Papers

1. Jakob Koenig, Mojca Otoničar, Srečo D. Škapin, Danilo Suvorov, Jinhui Yu, "Synthesis, structural and electrical properties of the $Na_{0.5}Bi_{0.5}TiO_3 - K_{0.5}Bi_{0.5}TiO_3$ ceramic system", In: *Advances in electroceramic materials II: Materials Science and Technology Conference, MS and T'09, October 25, 2009, Pittsburgh, Pennsylvania*, (Ceramic transactinos, vol. 221), K. M. Nair, ed., Shashank Priya, ed., Hoboken, Wiley, Danvers, The American Ceramic Society, 2010, vol. 221, pp. 29-38, 2010.

Regular papers

1. Urban Došler, Marjeta Maček, Danilo Suvorov, "Nucleation and crystallization of $MgO - B_2O_3 - SiO_2$ glass", In: *Programme and book of manuscripts*, First International Conference for Students and Young Scientists on Materials Processing Science, 10-13 October 2010, Tbilisi, Georgia, [S. l.], Georgian Ceramic Society, 2010, pp. 126-130.
2. Boštjan Jančar, Zoran Samardžija, Sašo Šturm, Oleg V. Ovchar, A. Bilous, "Cation-vacancy-induced microstructures of barium cobalt niobate perovskites", In: *Revealing the nanoworld in life and materials science: proceedings*, IMC 17, 17th International Microscopy Congress, Sepetember 19-24, Rio de Janeiro, Brazil, [S. l.], SBMM, = Sociedade Brasileria de Microscopia e Microanálise, 2010, 2 pp.
3. Manca Logar, Boštjan Jančar, Aleksander Rečnik, Sašo Šturm, Danilo Suvorov, "Functional nanocomposites via self-assembly of polyelectrolytes", In: *Revealing the nanoworld in life and materials science: proceedings*, IMC 17, 17th International Microscopy Congress, Sepetember 19-24, Rio de Janeiro, Brazil, [S. l.], SBMM, = Sociedade Brasileria de Microscopia e Microanálise, 2010, 2 pp.
4. Luka Škrlep, Srečo D. Škapin, Andrijana Sever Škapin, "The effect of doping with cerium, silicon and zirconium on the growth of titania particles", In: *Conference proceedings*, 3rd International Conference on Advanced Plasma Technologies (iCAPT-III), June 14th - 16th 2010, Lake Bohinj, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2010, pp. 187-191.

Theses

Ph. D. Theses

1. Asja Veber, *Synthesis and characterization of $Bi_{12}SiO_{20}$thin films prepared by sol-gel method: doctoral dissertation*, Ljubljana, [A. Veber], 2010.

Patents

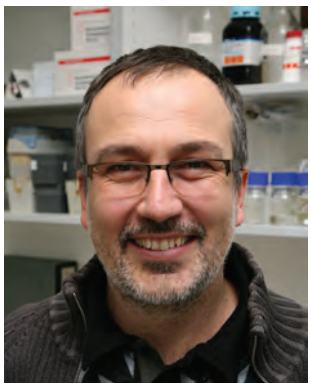
1. Pavol Dudešek, Christian Hoffmann, Danilo Suvorov, Matjaž Valant, *Keramisches Material, gesinterte Keramik, Verfahren zur Herstellung und Verwendung der Keramik: DE 102006024231 (B4),* [S. l.], Deutsches Patent- und Markenamt, 28. jan. 2010.
2. Pavol Dudešek, Christian Hoffmann, Danilo Suvorov, Matjaž Valant, *Ceramic material, sintered ceramic and component made therefrom, production method and use of the ceramic: US7816293 (B2)*, [S. l.], United States Patent and Trademark Office, 19. okt. 2010.

Patent Applications

1. Aleš Dakskobler, Andraž Kocjan, Manca Logar, *Postopek priprave nosilnega koloidnega prahu z visoko specifično površino: P-201000330*, Ljubljana, Urad RS za intelektualno lastnino, 20. okt. 2010.
2. Aleš Dakskobler, Andraž Kocjan, Manca Logar, *Postopek priprave nosilnega koloidnega prahu z visoko specifično površino (dopolnilna prijava k prijavi P-201000330): P-201000433*, Ljubljana, Urad RS za intelektualno lastnino, 9. dec. 2010

DEPARTMENT OF BIOCHEMISTRY, MOLECULAR AND STRUCTURAL BIOLOGY B-1

The research activities of the members of the department are largely focused on studies of the physiological role of proteases in normal and pathological conditions, the mechanism of their action and regulation, as well as their properties and structure.



Head:
Prof. Boris Turk

Proteases, which were long considered as primarily protein-degrading enzymes, are extremely important signalling molecules involved in numerous vital processes, such as cell-cycle regulation, proliferation, cell death and immune response. Their catalytic activities are precisely regulated, the most important ways being zymogen activation and inhibition by their endogenous protein inhibitors. Any imbalance of this regulation can lead to pathologies, such as autoimmune, neurological and cardiovascular disorders, cancer and osteoporosis.

The development of specific tools for non-invasive, in-vivo imaging of disease-related molecular events is of high relevance for disease detection, the monitoring of disease progression, developing animal models of human disease and evaluating novel therapies. Optical imaging is optimally suited for this task as it provides excellent sensitivity and allows the visualizing at molecular events via a fluorescent signal. Near-infrared fluorophore (NIRF) labelled imaging probes are therefore becoming increasingly important in bio-molecular imaging applications, including in animal models for tumour imaging or inflammation studies. Since proteases are a class of enzymes that is frequently highly up-regulated in diseases, they represent suitable targets for the development of such fluorescent activity-based probes.

Proteases, including the caspases and the cathepsins, are critically involved in the immune response. Caspase-1, a pro-inflammatory member of the caspase family that is critically involved in the processing of a number of cytokines, such as interleukin-1 beta and interleukin-18, is one of the major enzymes in immune response following a number of stimuli. Its role in inflammation has been studied intensely over recent years. However, the research of caspase-1 has remained difficult mainly due to the lack of sensitive and selective tools to monitor not only its abundance but also its activity. Using the Reverse Design concept, where chemically optimized protease inhibitors are turned into selective substrate activity-based probes (ABPs), we have, in collaboration with Sanofi-Aventis, developed a bioluminescent ABP for caspase-1. The probe exhibits excellent selectivity for caspase-1 and an approximately 1000-fold increase in sensitivity compared to the available fluorogenic peptidic caspase-1 substrates. Moreover, we have been able to monitor and quantify the specific caspase-1 activity directly in cell lysates. The activity correlated well with the processing of prointerleukin-1β and prointerleukin-18 in phorbol 12-myristate 13-acetate (PMA) stimulated cells. A detectable caspase-1 activity was also present in nonstimulated cells, consistent with the processing of constitutively expressed prointerleukin-18. These findings may be important for our understanding of the regulation of inflammatory processes, in which caspase-1 participates.

Together with coworkers from Germany and the UK we have been able to demonstrate that the same Reverse Design concept (see above) also represents an efficient strategy for the generation of selective probes for cysteine cathepsins from chemically optimized protease inhibitors for investigations in proteomic lysates as well as for in-vivo molecular imaging studies. The newly developed activity-based probe AW-091 was demonstrated to be highly selective for cathepsin S in vitro and proved useful in monitoring cysteine cathepsin activity in vivo, that is, in the zymosan-induced mouse model of inflammation. The AW-091 showed higher signal-to-background ratios at earlier time points than the commercially available polymer-based ProSense680 (VisEn Medical) and thus represents an efficient new tool for studying early proteolytic processes leading to various diseases, including inflammation, cancer, and rheumatoid arthritis. In addition, the fluorescent signal originating from the cleaved AW-091 was shown to be reduced by the administration of an anti-inflammatory drug, dexamethasone and by the cathepsin inhibitor E-64, providing a valuable system for the evaluation of small-molecule inhibitors of cathepsins. Moreover, these findings were confirmed in clinical samples of patients with rheumatoid arthritis (RA) or osteoarthritis (OA). Cathepsin S was found to be the predominant cysteine cathepsin in the synovial fluid from these patients, consistent with its critical role in the immune response. Furthermore, the activity of cathepsin S was significantly higher in the samples of RA patients as compared to the OA patients, in agreement with RA being predominantly an inflammatory disease. These further suggest that cysteine cathepsins have a major role in inflammation, at least in RA. In addition to proteases, interleukin-6 was detected at significant levels in most samples, suggesting that pro-inflammatory cytokines might be involved in the stimulation of expression of these proteases during inflammation.

Important findings were also obtained about the role of cysteine cathepsins in the processing of perforin, a critical component of natural killer (NK) cells and cytotoxic T lymphocytes (CTLs). The pore-forming protein perforin

is synthesized as an inactive precursor in natural killer cells and cytotoxic T lymphocytes, and becomes active when a short C-terminal peptide is cleaved within the acidic lysosome-like cytotoxic granules. We have shown that the incubation of human NK cells and primary antigen-restricted mouse CTLs with the cathepsin L (CatL) inhibitor L1 resulted in a marked inhibition of perforin-dependent target cell death and reduced perforin processing. In vitro, CatL preferentially cleaved a site on full-length recombinant perforin close to its C terminus. The NK cells of mice deficient in CatL showed a reduction, but not a complete absence of processed perforin, indicating that cysteine proteases other than CatL are also able to process perforin. We conclude that granule-bound cathepsins are essential for processing perforin to its active form, and that CatL is an important, but not exclusive, participant in this process.

We have also continued our work on protease inhibitors, in particular the members of the cystatin family. Stefin B (cystatin B) is an endogenous inhibitor of cysteine proteinases localized in the nucleus and the cytosol. Loss-of-function mutations in the stefin B (CSTB) gene were reported in patients with Unverricht-Lundborg disease (EPM1). We have identified an interaction between stefin B and nucleosomes, specifically with histones H2A.Z, H2B, and H3. In synchronized T98G cells, stefin B co-immunoprecipitated with histone H3, predominantly in the G(1) phase of the cell cycle. Stefin B-deficient mouse embryonic fibroblasts entered the S phase earlier than wild-type mouse embryonic fibroblasts. In contrast, the increased expression of stefin B in the nucleus delayed cell cycle progression in the T98G cells. The delay in cell cycle progression was associated with the inhibition of cathepsin L in the nucleus, as judged from the decreased cleavage of the CUX1 transcription factor. In vitro, the inhibition of cathepsin L by stefin B was potentiated in the presence of histones, whereas histones alone did not affect the cathepsin L activity. On this basis, stefin B was suggested to play an important role in regulating the proteolytic activity of cathepsin L/V in the nucleus, protecting substrates such as transcription factors from its proteolytic processing.

In the group of structural biology they have, in addition solved, the structures of several new proteins and/or protein complexes. Part of the work was focused on cysteine cathepsins. Cathepsin B is one of the most versatile human cysteine cathepsins. It is important for intracellular protein degradation under normal conditions and is involved in a number of pathological processes. The occluding loop makes cathepsin B unique among cysteine cathepsins. This ~20-residue-long insertion imbedded into the papain-like protease scaffold restricts access to the active site cleft and endows cathepsin B with its carboxydipeptidase activity. Nevertheless, the enzyme also exhibits endopeptidase activity and is inhibited by stefins and cystatins. To clarify the structural properties of the occluding loop upon the binding of stefins, we determined the crystal structure of the complex between wild-type human stefin A and wild-type human cathepsin B at a 2.6-Å resolution. The papain-like part of the cathepsin B structure remains unmodified, whereas the occluding loop residues are displaced. The part enclosed by the disulfide bridge containing histidines 110 and 111 (i.e., the 'lasso' part) is rotated by ~45° away from its original position. A comparison of the structure of the unliganded cathepsin B with the structure of the proenzyme, its complexes with chagasin and stefin A, shows that the magnitude of the shift of the occluding loop is related to the size of the binding region. It is smallest in the procathepsin structures and increases in the series of complexes with stefin A and chagasin, although it has no impact on the binding constant. Hence, cathepsin B can dock inhibitors and certain substrates regardless of the size of the binding region. These findings thus contribute importantly to our understanding of protease regulation.

We participate in two FP7 projects, being the coordinators of one of them (LIVIMODE). We are also involved in two Slovenian Centers of Excellence, the Center for Integrative approaches for Chemistry and Biology of Proteins (CIPKEBIP) that we also coordinate, and Nanosciences and Nanotechnologies. We are partners in the new competence center BRIN, which, like both Centers of Excellence, brings together researchers from both industry and academia. In addition, there are many other international collaborations with excellent research teams from different countries, including Belgium, Germany, France, Sweden, Switzerland, UK, USA, Australia and Japan, which resulted in joint publications. In 2010 we organized the traditional 12th International Symposium on Proteases, Inhibitors and Biological Control, one of the most important specialized protease meeting worldwide. Several members of the department were invited to give lectures at international symposia and foreign universities, including at the Gordon Conference on Proteolytic Enzymes.

Some outstanding publications in the past year

1. Kindermann, M., Roschitzki-Voser, H., Caglič, D., Repnik, U., Miniejew, C., Mittl, P.R., Kosec, G., Grütter, M.G., Turk, B., Wendt, K.U. Selective and sensitive monitoring of caspase-1 activity by a novel bioluminescent activity-based probe. Chem Biol. 2010, 17, 999-1007.
2. Škerget, K., Taler-Verčič, A., Bavdek, A., Hodnik, V., Čeru S., Tušek-Žnidarič, M., Kumm, T., Pitsi, D., Pompe-Novak, M., Palumaa, P., Soriano, S., Kopitar-Jerala, N., Turk, V., Anderluh, G., Žerovnik, E. Interaction between oligomers of stefin B and amyloid-beta in vitro and in cells. J. Biol. Chem. 2010, 285, 3201-3210.

3. Taler-Verčič, A., Žerovnik E. Binding of amyloid peptides to domain-swapped dimers of other amyloid-forming proteins may prevent their neurotoxicity. BioEssays, 2010, 32, 1020-1024.
4. Renko, M., Sabotič, J., Mihelič, M., Brzin, J., Kos, J., Turk, D. Versatile loops in mycocypins inhibit three protease families. J. Biol. Chem. 2010, 285,308-316.

Organization of conferences and meetings

1. 26th Winter School on Proteinases and their Inhibitors, Recent Developments, Tiers, Italy, 24 to 28 Feb. 2010 (coorganisers)
2. 12th International Symposium on Proteinase inhibitors and Biological control, Portorož, Slovenia, 25 to 3 Sept. 20

INTERNATIONAL PROJECTS

1. Light-based Functional in Vivo Monitoring of Diseases Related Enzymes
   LIVIMODE
   7. FP, 241919, EC
   Prof. Boris Turk, Prof. Vito Turk, Dr. Urška Repnik, Dr. Marko Fonovič
2. Understanding and Fighting Metastasis by Modulating the Tumour Microenvironment through Interference with the Protease Network
   MICROENVIMET
   7. FP, 201279
   EC; Universite de Liege, Liege, Belgium
   Dr. Olga Vasiljeva, Prof. Boris Turk
3. Intracellular Protease Signaling induced by Homopolymeric Amino Acid (HPAA) Tracts
   RG105, 0024/2006-C
   HFSP - International Human Frontier Science Program, Strasbourg, France
   Prof. Boris Turk
4. Supply of DPPI Enzyme and the Non-exclusive License Rights
   PROZYMEX A/S, Horsholm, Denmark
   Prof. Dušan Turk
5. Development of New Algorithms for the Analysis of Protein Active Sites
   Razvoj novih alogoritama za analizu aktivnih mjesta proteina
   BI-HR/09-10-040
   Dr. Zoran Štefanić, Ruđer Bošković Institute, Zagreb, Croatia
   Prof. Dušan Turk
6. Function of Proteases in TRAIL/DR5-induced Apoptosis Pathway
   BI-CN/09-11-006
   Dr. Juan Shi, National Laboratory of Medical Molecular Biology, Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China
   Prof. Boris Turk
7. The Role of Cysteine Proteinases and Their Inhibitors in Endotoxin Tolerance and Cancer
   BI-CN/09-11-024
   Dr. Tao Sun, Liaoning Cancer Hospital & Institute, Shanghaj, China
   Dr. Nataša Kopitar Jerala

R & D GRANTS AND CONTRACTS

1. Cathepsin E: Characterisation and Biological Role
   Prof. Vito Turk
2. Cathepsin F: New Cysteine Proteinase Involved in Neuronal Ceroid Lipofuscinosis
   Asst. Prof. Veronika Stoka
3. Proteomic Identification of Extracellular Substrates of Cysteine proteases
   Asst. Prof. Marko Fonović
4. Differences Between Mouse and Human Endosomal Immune Response Pathway: Crystal Structures of Protein Comlexes and Their Analysis
   Prof. Dušan Turk
5. The Role of Cysteine Cathepsins and Caspases in Neurodegeneration
   Asst. Prof. Veronika Stoka
6. Role of Cysteine Cathepsins in Regulation of Proliferation and Cell Death
   Prof. Boris Turk
7. The Role of Nuclear Cystatins in the Regulation of Interleukin-10 Synthesis during Endotoxin Tolerance
   Asst. Prof. Nataša Kopitar-Jerala
8. The Role of Lysosomes and Lysosomal Proteases in Sellular Signalling
   Prof. Boris Turk

RESEARCH PROGRAMS

1. Proteolysis and Its Regulation
   Prof. Boris Turk
2. Structural Biology
   Prof. Dušan Turk

MENTORING

Ph. D. Theses

1. Špela Konjar, *Role of cysteine cathepsins in the processing, activation and inactivation of perforin* (mentor Nataša Kopitar Jerala)
2. Urška Požgan, *Regulation of cysteine proteases cathepsins B, S and K and their role in inflammatory processes* (mentor Boris Turk)
3. Miha Renko, *Comperative view into protease - inhibitor interaction* (mentor Dušan Turk)

VISITORS FROM ABROAD

1. Georgy Mikhaylov, Siberian State Medical University , Tomsk, Siberia, Russia, 1 Jan.-31 Dec.. 2010, (Scholarship IJS)
2. Dušana Majera, Bački Petrovac, Serbia, 1 Jan.- 30 Jun. 2010, (Scholarship IJS)
3. prof.dr. Achim Kruger, Technische Universitet Munich, Germany , 22 Apr. 2010
4. prof.dr Florian Schelter, Technische Universitet Munich, Germany, 22 Apr. .2010
5. prof. dr Matthew Bogy, department of Pathology, Stanford University School of Medicine, USA, 30 Jun – 3 July 2010
6. dr Alla Gutschina, Protein Structure Section, Macromolecular Crystallography Laboratory NCI-Frederick, Frederick, USA, 24-25 Sept 2010
7. dr Alexander Wlodawer, Macromolecular Crystallography Laboratory NCI-Frederick, Frederick, USA, 24-25 Sept. 2010
8. prof.drBonnie F. Sloan, Wayne State University, School of Medicine, Department of Pharmacology Barbara Ann Karmanos Cancer Institute, Detroit, USA, 24-25 Sept. 2010
9. prof.dr Kazuo Umezawa, Nami Miyanishi, Keio University, Yokohama, Japan , 9–11 Oct. 2010
10. dr Sun Tao,dr Bai He, dr Song Chun, Liaoning Cancer Hospital Institute, Shenyang, China, 25-28Oct. 2010 and 3-4 Nov. 2010
11. prof. Imre Berger, Group Leader, Joint appointment in the genome Biology Unit,EMBL, Grenoble, France, 9- 11 Nov. 2010

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28. Mira Polajnar, B. Sc.
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43. Dejan Pelko
44. Polonca Pirš Kovačič
45. *Zvonka Vadnjal, retired 01.08.10*
46. Barbara Vrtačnik

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

1. Katarina Černe, Katarina Kristan, Metka Budihna, Lovro Stanovnik, "Mechanisms of changes in coronary arterial tone induced by bee venom toxins", *Toxicon (Oxford)*, vol. 56, no. 3, pp. 305-312, 2010.
2. Slavko Čeru, Špela Konjar, Katarina Maher, Urška Repnik, Igor Križaj, Mojca Benčina, Miha Renko, Alain Nepveu, Eva Žerovnik, Boris Turk, Nataša Kopitar-Jerala, "Stefin B interacts with histones and cathepsin L in the nucleus", *J Biol Chem*, vol. 285, no. 13, pp. 10078-10086, 2010.
3. Slavko Čeru, R. Layfield, Tina Zavašnik-Bergant, Urška Repnik, Nataša Kopitar-Jerala, Vito Turk, Eva Žerovnik, "Intracellular aggregation of human stefin B: confocal and electron microscopy study", *Biol. cell*, vol. 102, no. 2, pp. 319-334, 2010.
4. Kristina Eleršič, Ita Junkar, Aleš Špes, Nina Hauptman, Marta Klanjšek Gunde, Alenka Vesel, "Degradation of bacteria Escherichia coli by treatment with Ar ion beam and neutral oxygen atoms", *Mater. tehnol.*, vol. 44, no. 3, pp. 153-156, 2010.
5. B. Heras, M. Totsika, R. Jarrott, S. R. Shouldice, Gregor Gunčar, M. E. Achard, T. J. Wells, M. P. Argente, A. G. McEwan, M. A. Schembri, M. A. Schembri, "Structural and functional characterization of three DsbA paralogues from Salmonella enterica serovar typhimurium", *J Biol Chem*, vol. 285, no. 24, pp. 18423-18432, 2010.
6. R. Jarrott, S. R. Shouldice, Gregor Gunčar, M. Totsika, M. A. Schembri, B. Heras, "Expression and crystallization of SeDsbA, SeDsbL and SeSrgA from Salmonella enterica serovar Typhimurium", *Acta crystallographica. Section F, Structural biology and crystallization communications*, vol. 66, no. 5, pp. 601-604, 2010.
7. Maik Kindermann, et al. (10 authors), "Selective and sensitive monitoring of caspase-1 activity by a novel bioluminescent activity-based probe", *Chemistry & Biology*, vol. 17, no. 9, pp. 999-1007, 2010.
8. Špela Konjar, Vivian R. Sutton, Sabine Hoves, Urška Repnik, Hideo Yagita, Thomas Reinheckel, Christoph Peters, Vito Turk, Boris Turk, Joseph Trapani, Nataša Kopitar-Jerala, "Human and mouse perforin are processed in part through cleavage by the lysosomal cysteine proteinase cathepsin L", *Immunology (Oxf.)*, vol. 131, issue 2, pp. 257-267, 2010.
9. Špela Konjar, Fangfang Yin, Matthew Bogyo, Boris Turk, Nataša Kopitar-Jerala, "Increased nucleolar localization of SpiA3G in classically but not alternatively activated macrophages", *FEBS lett.*, issue 11, vol.584, pp. 2201-2206, 2010.
10. Gojmir Lahajnar, Barbara Sobotič, Ana Sepe, Vojko Jazbinšek, Slavko Pečar, "Influence of sodium nitroprusside on human erythrocyte membrane water permeability: an NMR study", *Gen. physiol. biophys.*, vol. 29, no. 4, pp. 373-380, 2010.
11. Radoslav Matej, Georgö Botond, Lajos László, Nataša Kopitar-Jerala, Robert Rusina, Herbert Budka, Gabor Kovacs, "Increased neuronal Rab5 immunoreactive endosomes do not colocalize with TDP-43 in motor neuron disease", *Exp. neurol.*, vol. 225, issue 1, pp. 133-139, 2010.
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13. Urška Požgan, Dejan Caglič, Blaž Rozman, Hideaki Nagase, Vito Turk, Boris Turk, "Expression and activity profiling of selected cysteine cathepsins and matrix metalloproteinases in synovial fluids from patients with rheumatoid arthritis and osteoarthritis", *Biol Chem*, vol. 391, no. 5, pp. 571-579, 2010.
14. Tilen Praper, Mojca Podlesnik Beseničar, Helena Istinič, Zdravko Podlesek, Sunil Metkar, Christopher J. Froelich, Gregor Anderluh, "Human perforin permeabilizing activity, but not binding to lipid membranes, is affected by pH", *Mol. immunol.*, issue 15, vol. 47, pp. 2492-2504, 2010.
15. Miha Renko, Jerica Sabotič, Marko Mihelič, Jože Brzin, Janko Kos, Dušan Turk, "Versatile loops in mycocypins inhibit three protease families", *J Biol Chem*, vol. 285, no. 1, pp. 308-316, 2010.
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17. Lisa Sevenich, Olga Vasiljeva, (12 authors), "Synergistic antitumor effects of combined cathepsin B and cathepsin Z deficiencies on breast cancer progression and metastasis in mice", *Proc. Natl. Acad. Sci. U. S. A.*, vol. 107, no. 6, pp. 2497-2502, 2010.

18. Veronika Stoka, Vito Turk, "A structural network associated with the kallikrein-kinin and renin-angiotensin systems", In: *Proceedings of the 3rd International Symposium on Kallikreins and Kallikrein-Related Peptidases, 30 August - 2 September, 2009, Munich, Germany*, (Biological chemistry, vol. 391, no. 4), 2010, pp. 443-454.
19. Katja Škerget, et al. (15 authors), "Interaction between oligomers of stefin B and amyloid-beta in vitro and in cells", *J Biol Chem*, vol. 285, no. 5, pp. 3201-3210, 2010.
20. Ajda Taler-Verčič, Eva Žerovnik, "Binding of amyloid peptides to domain-swapped dimers as opposed to monomers", *BioEssays*, vol. 32, issue 12, pp. 1020-1024, 2010.
21. Sofia Tedelind, et al. (12 authors), "Nuclear cysteine cathepsin variants in thyroid carcinoma cells", *Biol Chem*, vol. 391, issue 8, pp. 923-35, 2010.
22. Danijela Vujošević, Boban Mugoša, Uroš Cvelbar, Miran Mozetič, Urška Repnik, Tina Zavašnik-Bergant, Danijela Rajković, Sanja Medenica, "Bactericidal effects of low-temperature oxygen plasma on Bacillus stearothermophilus and Staphylococcus aureus", *Nat. Monten.*, vol. 10, no. 1, pp. 57-70, 2010.
23. Eva Žerovnik, "Protein conformational pathology in Alzheimer's and other neurodegenerative diseases: new targets for therapy", *Current Alzheimer research*, vol. 7, no. 1, pp. 74-83, 2010.

Review Articles and Chapters in Books

1. Mojca Podlesnik Beseničar, Gregor Anderluh, "Preparation of lipid membrane surfaces for molecular interaction studies by surface plasmon resonance biosensors", In: *Surface plasmon resonance: methods and protocols*, (Methods in molecular biology, vol. 627), Nico J. de Mol, ed., Marcel J. E. Fischer, ed., New York [etc.], Springer, 2010, chapter 12, pp. 191-200, 2010.
2. Urška Repnik, Boris Turk, "Lysosomal-mitochondrial cross-talk during cell death", *Mitochondrion*, vol. 10, no. 6, pp. 662-669, 2010.
3. Eva Žerovnik, Rosemary A. Staniforth, Dušan Turk, "Amyloid fibril formation by human stefins: structure, mechanism & putative function", *Biochimie (Paris)*, vol. 92, issue 11, pp. 1597-1607, 2010.

Published Conference Papers

Regular paper

1. Danijela Vujošević, Boban Muguša, Uroš Cvelbar, Miran Mozetič, Urška Repnik, Tina Zavašnik-Bergant, Danijela Rajković, Sanja Medenica, "Fluorescence viability analysis of exygen plasma treated Escherichia coli", In: *Conference proceedings*, 3rd International Conference on Advanced Plasma Technologies (iCAPT-III), June 14th - 16th 2010, Lake Bohinj, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2010, pp. 102-105.

Textbooks and Lecture Notes

1. Eva Žerovnik, *The mechanism of amyloid-fibril formation: case study of stefins: uvodno predavanje 90 minut*, Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2010.
2. Eva Žerovnik, *Mehanizem in biološke implikacije agregacije proteinov: učno gradivo*, Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2010.
3. Eva Žerovnik, *Stabilnost, zvijanje in agregacija proteinov: učno gradivo: dopolnitev predmetnika: podrobne vsebine in literature*, Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2010.

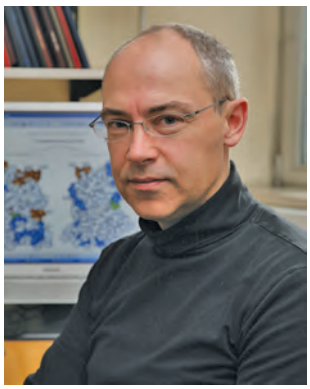
Theses

Ph. D. Theses

1. Urška Požgan, *Regulation of cysteine proteases cathepsins B, S and K and their role in inflammatory processes: doctoral dissertation*, Ljubljana, [U. Požgan], 2010.
2. Miha Renko, *Comperative view into protease - inhibitor interaction: doctoral dissertation*, Ljubljana, [M. Renko], 2010.

DEPARTMENT OF MOLECULAR AND BIOMEDICAL SCIENCES B-2

The research program of the Department of Molecular and Biomedical Sciences is focused mainly on basic research in protein biochemistry, molecular and cellular biology, and genetics. The primary goal of our investigations is the acquisition of a new understanding of mammalian pathophysiology, with the aim of improving human and animal health.



Head:
Prof. Igor Križaj

Secreted phospholipases A_2 ($sPLA_2$s)

The major research topic of the department is $sPLA_2$s originating from animal toxins as well as those found in humans. We are studying molecular mechanisms of the action of toxic $sPLA_2$s, particularly those endowed with presynaptic neurotoxicity, and the role of endogenous $sPLA_2$s in pathological and physiological processes in mammals.

After we successfully demonstrated the translocation of ammodytoxin (Atx), a presynaptically neurotoxic $sPLA_2$ from the nose-horned viper (*Vipera ammodytes ammodytes*) venom, into the cytosol of a nerve cell, in the past year we made another step forward with the analysis of the stabilization and the enzymatic activity augmentation of Atx in this cellular environment (L. Kovačič et al., *Protein Engineering, Design & Selection*, 23 (2010), 479–487). We found that, for the stabilization as well as for the potentiation of enzymatic activity of Atx in the reducing environment of the cytosol, the interaction of Atx with calmodulin (CaM), a protein in the cytosol of eukaryotic cells, is crucial. By measuring the binding affinity between the different mutants of AtxA and CaM, and mapping of the interaction surface between Atx and CaM in the complex using a photoreactive derivative of AtxC, we set the constraints for the computer modelling of a structural model of the complex between these two molecules. The energetically most stable structural model of the AtxA–CaM complex is displayed in two different representations in Figure 1. We verified the relevance of the model in such a way that we exchanged the coordinates of AtxA in the complex for the coordinates of the structurally related $sPLA_2$s of either snake or mammalian origin and, wherever possible, generated the structural model of a complex by computer modelling. Then we experimentally examined whether the complex between each of the studied $sPLA_2$ and CaM was formed or not. In addition, we measured the ratio of the initial enzymatic activity for each $sPLA_2$ in the presence and absence of CaM. The characteristics of $sPLA_2$s, which had been predicted from the $sPLA_2$–CaM modelling, were in all cases in accordance with the experimentally obtained data, confirming the correctness of our model. The AtxA–CaM structural model clearly shows why AtxA bound to CaM remains completely stable in reducing conditions, in spite of the fact that it contains as many as seven intramolecular disulphide bonds. It also shows that the entrance to the active site of $sPLA_2$ is not restricted in the complex and that the surface area of the complex contacting the membrane is larger than that of the $sPLA_2$ alone, which nicely explains the increase in the enzymatic activity of $sPLA_2$, in either reducing or non-reducing conditions. With the model, we thus provided a new tool for studying the role of CaM in the process of $sPLA_2$ neurotoxicity. Even more importantly, by revealing the positive influence of CaM on the stability and enzymatic activity of certain endogenous $sPLA_2$s, such as group V an X $sPLA_2$s, we suggested a completely new way to regulate these enzymes and processes dependent on their activity in the cytosol of mammalian cells. The significance of our discovery is best reflected in the fact that it was announced on the cover page of the journal publishing our paper (Figure 2).

New substances and molecular tools to improve human and animal health.

In collaboration with our colleagues from the Pasteur Institute in Paris, we determined three-dimensional structures of AtxA and AtxC by means of protein crystallography and published the results (F.A. Saul et al., *Journal of Structural Biology*, 169 (2010), 360–369). The problem that we had been tackling for several years, before we finally succeeded in solving it, was the crystallization of these two toxic $sPLA_2$s. A comparison of the crystal structures of AtxA and AtxC revealed structural reasons for the substantial difference in their enzymatic activity, neurotoxicity and anticoagulant action.

In 2010, we also continued with our research in the field of endogenous human $sPLA_2$s and their role in breast cancer. In humans, ten structurally different $sPLA_2$ enzymes are known to be involved in various physiological and

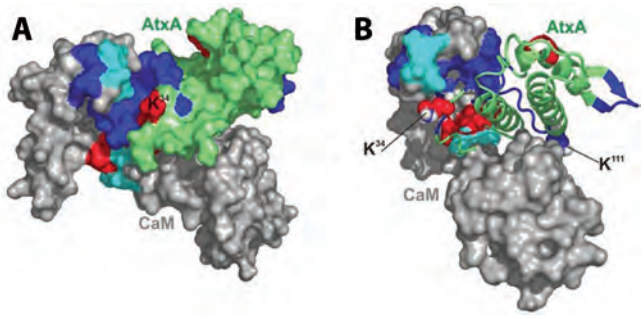


Figure 1: Structural model of the AtxA–CaM complex. From the model it is evident that CaM (gray) 'clamps' the AtxA (green) between its N- and C-terminal domains, which is the most likely reason for the stabilization of AtxA in the complex. Regions that we identified at the rim of the interaction surface of both molecules are coloured blue, turquoise and red. The AtxA molecule is shown in the space-filling mode (A) and in the ribbon mode (B). In Figure 1B, Lys34 and Lys111 are labelled, being the most likely candidates to carry the photoreactive group in the Atx derivative. The figure is reproduced from the Doctoral Thesis of L. Kovačič (University of Ljubljana, 2010).

pathophysiological processes: they participate in phospholipid digestion and homeostasis, in host defence against infections, influence the development of acute and chronic respiratory disorders, are important in lipoprotein remodelling and the development of atherosclerosis, and, what has been observed particularly in recent times, they influence cell proliferation, apoptosis and cancer diseases. Namely, recent studies have shown a correlation between the expression of different $sPLA_2$s and pathological changes in stomach, colorectal and prostate cancer, with their roles in either tumour promotion or inhibition, depending on the tissue and biochemical micro-environment of the particular tumour involved. The role of $sPLA_2$s in breast cancer has not been studied to a considerable extent yet. There are, however, some earlier reports describing the increased expression of the group IIA enzyme ($sPLA_2$-IIA), mainly in the more invasive parts of breast-cancer tissues.

Our previous studies have also shown that $sPLA_2$s may stimulate or inhibit cell proliferation, induce cell death and are cytotoxic or neurotoxic, depending on the cell or tissue model system that we used. In our initial study of the involvement of $sPLA_2$s in the mechanisms that regulate the development and progression of breast cancer, we determined the expression profile of all the $sPLA_2$ family members in seven human breast-cancer cell models representing different stages in the progression of the disease. A validated method for quantitative PCR (qPCR) expression analysis of the whole set of human $sPLA_2$s in cells and tissue samples was set up through a collaboration with the PLA_2 laboratory from the Institut de Pharmacologie Moléculaire et Cellulaire, CNRS, France. In this way we identified the members of the $sPLA_2$ family whose differential expression depends on the tumourigenic properties of the cell model that is used, indicating the different roles of particular $sPLA_2$s at different levels of cancer progression. Further work in 2010 was focused on studying the impact of individual $sPLA_2$s on the proliferation and invasion of breast-cancer cells (Figures 3 and 4). To this end, we have selected among the identified group IIA, III, V and X $sPLA_2$s the latter ($sPLA_2$-X) as a priority. A gain-of-function study was performed by overexpressing the $sPLA_2$-X in the selected cell line with highly invasive and tumourigenic properties and recombinant $sPLA_2$s were prepared to examine the effect of the exogenously added $sPLA_2$s on breast-cancer cells.

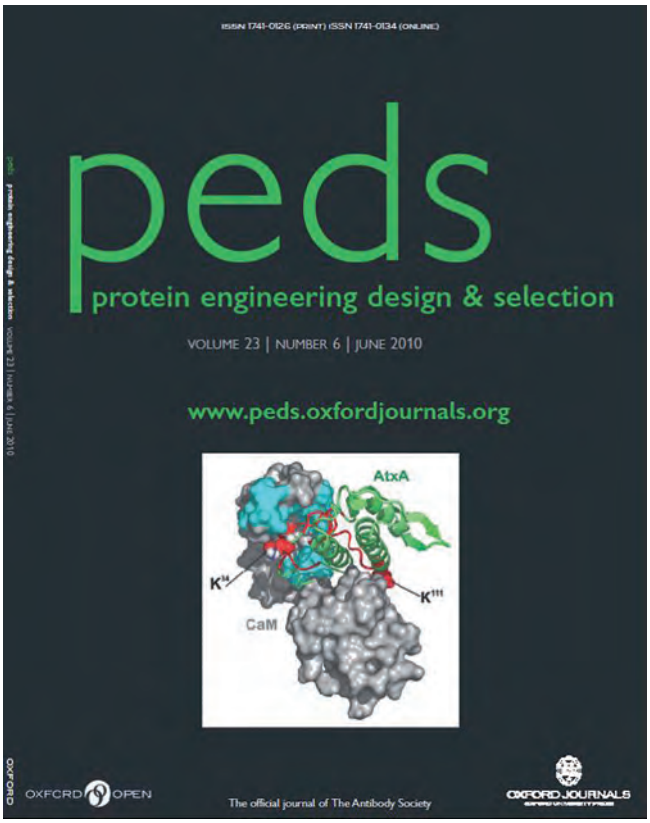


Figure 2: Cover page of Issue 23 of the Protein Engineering, Design & Selection journal, decorated by the model of the AtxA–CaM complex. The important discovery of the possibility of the new mode of regulation of the enzymatic activity of $sPLA_2$s and all the processes related to this activity in the cytosol of mammalian cells with CaM was announced on the cover page of the issue publishing our paper.

By using the method for determining cell viability based on the reduction of a methyl-thiazolyl-tetrazolium (MTT) dye and the proliferation assay based on the incorporation of a nucleoside analogue 5-ethenyl-2'-deoxyuridine (EdU) into the newly synthesized DNA of dividing cells, we found that ectopically expressed $sPLA_2$-X reduces the viability and high proliferation rate of the invasive cancer cells MDA-MB-231. We were also interested whether the exogenously added $sPLA_2$ affected the growth of these cells since the most recent findings showed that the extracellular and intracellular actions of $sPLA_2$s can be completely different. In our case, recombinant $sPLA_2$-IIA and $sPLA_2$-X, which we successfully prepared in a bacterial expression system, effectively reduced the viability and proliferation rate when exogenously added to the highly invasive breast-cancer cells. To obtain additional information on the proliferative properties of transfected cells, we used flow cytometry and a DNA dye (DAPI) to determine the ploidy of the analyzed cells and their percentage in different phases of the cell cycle. Measurements were performed in the laboratory of flow cytometry at the Institute of Oncology, Ljubljana. The assays showed that the cells overexpressing $sPLA_2$-X stopped their growth at the G_2/M stage of the cell cycle, which is consistent with the slower growth and the morphological changes observed. Therefore, we will proceed with a further analysis by flow cytometry to better understand the influence of $sPLA_2$-X on the cell cycle, cell death and cellular senescence. Our first studies on the role of $sPLA_2$s in breast cancer thus show that $sPLA_2$-X inhibits the cell proliferation rate, probably by causing an arrest in cell division at the G_2/M phase of the cell cycle, suggesting also a potential *in vivo* role of $sPLA_2$-X in the growth inhibition of breast-cancer cells.

We continued with the *in vitro* determination of the chemotactic migration (invasiveness) of cells through the extracellular matrix, which allows us to assess the impact of $sPLA_2$s in the migratory and invasive abilities of cancer cells, which are key features in the formation of metastases. After careful optimization of the conditions of incubation and the detection of cells in passing through the polycarbonate membrane, to which a basement membrane extract (Matrigel) was applied, we found that the cells expressing $sPLA_2$-X show a lower degree of invasiveness in comparison to unmodified cells MDA-MB-231. These results indicate that the expression of $sPLA_2$-X in a highly invasive tumour tissue would impede the transition of cancer cells through the extracellular matrix and, consequently, reduce their invasiveness and consequently metastatic ability.

Our first results, aimed at studying the impact of $sPLA_2$s on the growth and invasiveness of breast-cancer cells, are very promising and indicate the role of the phospholipase enzyme $sPLA_2$-X as a potential tumour suppressor. In the future, we would like to extend our studies to the mechanisms by which $sPLA_2$s affect the proliferation and invasion of breast-cancer cells, with an emphasis on determining the role of the $sPLA_2$ enzymatic activity in those processes.

In the past year we published a procedure for the preparation and purification of human $sPLA_2$-X that makes it possible to obtain larger, milligram quantities of the protein by a bacterial expression system (B. Jerman and J. Pungerčar, *Acta Chimica Slovenica*, 57 (2010), 888–894). Recombinant human group V and X $sPLA_2$s were added exogenously to a mouse motor neuron cell line and their influence monitored by various methods depending on the concentration of each $sPLA_2$ and the differentiation of cells over time. The results were compared to the effects of the better studied presynaptically neurotoxic $sPLA_2$s. We observed cytotoxic effects of both human $sPLA_2$s, with the largest influence a few hours after the addition. The effects of the two human $sPLA_2$s were similar to those of neurotoxic snake $sPLA_2$s, but were about 10-fold less toxic. To determine whether the cytotoxic effect is due to enzymatic activity and/or $sPLA_2$-binding to specific binding proteins, we developed an expression system for the production of two mutant human $sPLA_2$-X proteins, i.e., an enzymatically inactive (H48Q) and a cysteine (N79C) mutant. We assume that in this way we could clarify whether exogenously added mammalian $sPLA_2$s also internalize into the cells of motor neurons, presumably in a similar way to some structurally related, neurotoxic snake $sPLA_2$s, and whether enzymatic activity is required for their cytotoxic action. The results will significantly contribute to the understanding of both endogenous as well as snake $sPLA_2$s in the (peripheral) nervous system.

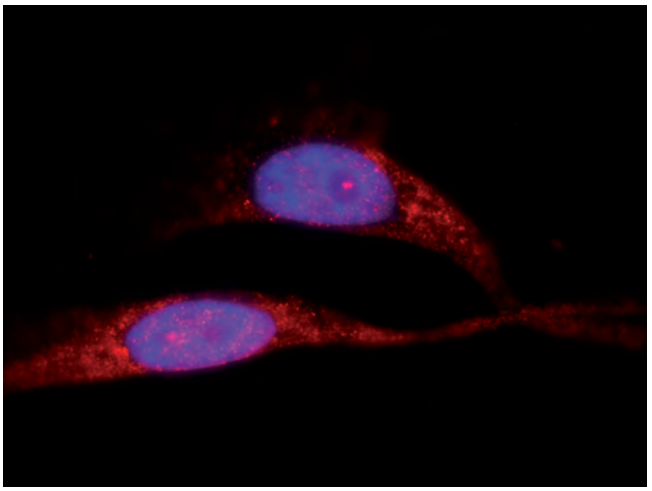


Figure 3: Observation of the localization of $sPLA_2$s in cancer cells by fluorescence microscopy. The cell nucleus is labelled blue.

In the scope of a bilateral project with researchers from the Institute of Immunology in Zagreb, Croatia, we were optimizing the procedure for the preparation of antiserum for the treatment of the nose-horned viper envenomation. We found a high correlation between the quantity of Atx in venom samples and immunogenicity of these samples (B. Halassy et al., *Comparative Biochemistry and Physiology, Part C*, 151 (2010), 455–460). The content of Atx in a particular venom is therefore a good prognostic factor for the suitability of this venom for the preparation of highly effective anti-venom by animal immunisation.

Together with colleagues from the Biotechnical Faculty of the University of Ljubljana, we finalized and published in 2010 the isolation, structural and functional characterization of an $sPLA_2$ from the venom of the Northern Pacific sea anemone, *Urticina crassicornis* (Figure 5) (A. Raspotnik et al., *FEBS Journal*, 277 (2010), 2641–2653). An analysis of the complete amino acid sequence of this protein was forecasting the discovery of a new type of $sPLA_2$. Namely, this molecule has a unique cysteine pattern, different from all known $sPLA_2$s, which also means a unique disulphide bonding (Figure 6). However, based on an extensive analysis of the origin, distribution, diversity, evolution and classification of the metazoa-specific group I $sPLA_2$ family and Asn27 $sPLA_2$s we finally decided not to propose the introduction of a new group of $sPLA_2$s in the classification of these molecules. By searching all the available metazoan genomic, proteomic and transcriptomic databases, we found that Asn27 $sPLA_2$s are not limited to the sea anemone *Urticina crassicornis*. The distribution of Asn27 $sPLA_2$s in metazoans is quite interesting, because they are present in diverse marine organisms (anthozoans, placozoans, mollusks and sea lampreys), in some freshwater organisms (crustaceans and planarians), and even in a few terrestrial invertebrates (centipedes and tardigrades). By phylogenomic analysis we demonstrated that group I $sPLA_2$s are present in all the major metazoan taxonomic groups. The invertebrate group I $sPLA_2$s have undergone complex and dynamic evolution by numerous gene duplications (forming diverse multigene families), resulting in the greatest diversity of group I $sPLA_2$s in invertebrate genomes. A phylogenetic analysis provided evidence that, in invertebrates, a large number of species-specific multigene families evolved from a single ancestral group I $sPLA_2$ and became highly diversified by adaptive evolution, like group II $sPLA_2$s in snake venoms. Although orthologous relationships can be easily reconstructed for vertebrate group I $sPLA_2$s, our phy-

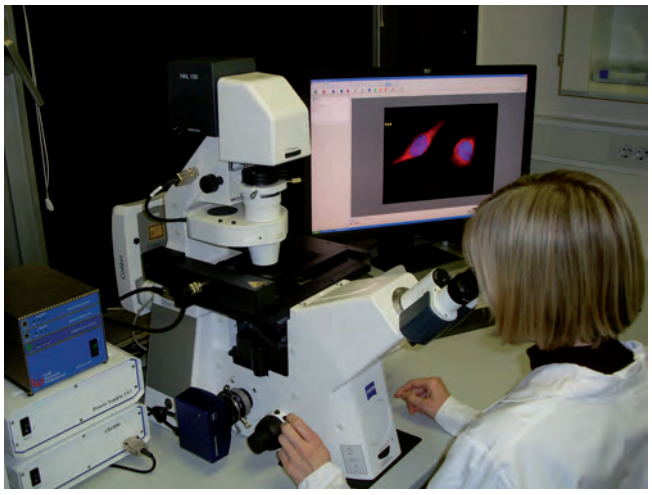


Figure 4: Work with a new epifluorescence microscope. The inverted fluorescence microscope Axio Observer (Zeiss) is a fully motorized system with two independent light sources, a conventional mercury lamp and a Colibri LED light source system that supports a multiparameter analysis to monitor very fast processes. The microscope has an extreme sensitivity, with temporal and spatial resolution, which is essential for a high-performance sub-cellular fluorescent visualization of biological macromolecules in eukaryotic cells, both in cell cultures and tissue preparations. It also offers monitoring of the cellular processes such as cell cycle, cell signalling, integrity and changes in the membrane structures, intracellular localization of the macromolecules and the interactions between macromolecules. The system will soon be upgraded with an incubator and modules that allow the monitoring of processes in living cells.

Figure 5. The Northern Pacific sea anemone, Urticina crassicornis, in whose venom we discovered a sPLA$_2$ with a unique structure.

logenetic analysis failed to obtain any evidence for orthologous groups within the invertebrate group I sPLA$_2$s. Nevertheless, due to its structural uniqueness, the sPLA$_2$ from *Urticina crassicornis* remains extremely interesting for further functional studies. Its haemolytic and neurotoxic activity on human erythrocytes and murine neuromuscular junction was negative.

Other pharmacologically active components from natural toxins

In 2010 we also intensively studied the components of the nose-horned viper venom that affect the coagulation of blood – haemostasis. The venom was fractionated by means of different chromatographic techniques. In collaboration with colleagues from the University Medical Centre Ljubljana, Division of Pediatrics, we tested the influence of venom fractions on different components of the haemostatic system. We were focused, in particular, on the metalloproteinases (MPs) in the venom. We succeeded in determining most of the amino acid sequence of ammodytase, a fibrinolytic MP with a molecular mass of about 70 kDa, a potential antithrombotic agent. Based on the elements of the primary structure of ammodytase and related MPs we synthesized oligonucleotide probes to isolate their cDNAs from a snake-venom gland cDNA library. We were able to amplify, clone and sequence cDNAs encoding several related MPs; however, we are still trying to find that coding for ammodytase.

As one of the 20 partners in the EU 6FP integrated project "Conco" we have been involved in the analysis of the genome, transcriptome and venom proteome of the piscivorous marine snail *Conus consors* and related snails. In the past year we also continued to work on the preparation of a recombinant novel conotoxin, which presumably contains six intramolecular disulphide bonds, whose function and biological role are not yet known. We amplified the section encoding mature conotoxin in the appropriate cDNA, coding for a longer peptide precursor, and inserted it into an expression plasmid under the control of a strong promoter that enabled its expression in the form of inclusion bodies in the cytoplasm of bacterial cells. Currently, we are focused on the isolation and attempted renaturation of insoluble and incorrectly folded recombinant conotoxin from bacterial cells. We also continued the proteomic analysis of the *Conus consors* venom in the range of molecular masses exceeding 10 kDa and identified many new components. We performed phylogenetic and biogeographic analyses of diverse Indo-Pacific and endemic South African venomous cone snails (S. Kauferstein et al., *Toxicon*, accepted for publication). A phylogenetic analysis of the 16S RNA from numerous *Conus* species collected in the South Africa and deep-sea waters of New Caledonia, Marquesas, Tahiti, Takapoto Island and Philippines has been made. The 16S RNA phylogenetic analysis confirmed that *Conasprella* represents the most basal lineage of *Conus* species and that the endemic South African *Conus* snails belong to a few *Conus* clades only. They most likely originated from the Indo-Pacific, but not from the West Atlantic species. Widely distributed *Conus* species disperse through planktonic larvae, while endemic species reproduce with non-planktonic larvae. It is apparent that the endemic South African *Conus* species originated from the Indo-Pacific species after the shift in the mode of their development. The species evolution and geographic spreading may have been hindered by ecological constraints such as the effect of ocean currents, e.g., the Agulhas current. These peculiar ecological conditions may constitute barriers preventing further spreading of the local species and may favour neoendemism resulting in allopatric speciation.

High-throughput genetics and functional genomics in yeast Saccharomyces cerevisiae

In the future, genomic data will enable a more accurate prediction of the development of diseases and their treatment in humans, and advanced biotechnological processes. The inference of new and useful hypotheses from heterogeneous sources of genome-scale experimental data, however, requires new computational methods that can integrate different types of data. In collaboration with the Bioinformatics Laboratory of the Faculty of Computer and Information Science, University of Ljubljana, we developed an integrative data-analysis approach, which, rather than correlating the findings from different types of data sets, uses each type of data independently to identify the components of molecular pathways and combines them into a single directed network. Our computational genomics approach is based on a set of inference rules, traditionally used for reasoning on genetic experiments, which we have formalized and implemented in a software tool. With the approach using chemogenetic interaction and expression data and by using previous knowledge on the set of genes whose expression the transcription factor in question regulates, we have successfully inferred the models for the action of the drug rapamycin and of a DNA-damaging agent on their molecular targets and pathways in yeast cells. The developed method was published in one of the leading journals in the field of functional genomics (M. Mattiazzi et al., *OMICS: a Journal of Integrative Biology*, 14 (2010), 357–367) and is available as a web-based tool at http://www.ailab.si/perturbagen.

Modulation of the composition and shape of the biological membranes is an emerging mode of regulation for cellular processes. Phospholipases A$_2$ (PLA$_2$s), an extensively studied group of proteins at our department for many years,

exert their biological activities through affecting both membrane composition and shape. The aim of the study, which was carried out in collaboration with a laboratory from the University of California at San Francisco, was to investigate the global effects that such perturbations have on a model eukaryotic cell. Our genome-wide analysis of cellular effects of a PLA_2 in the yeast *Saccharomyces cerevisiae* demonstrated functional genetic and biochemical interactions between PLA_2 activity and the Rim101 signalling pathway. Our results suggested that the composition and/or the shape of the endosomal membrane affect the Rim101 pathway. We described a genetically and functionally related network, consisting of components of the Rim101 pathway and the prefoldin, retromer and SWR1 complexes, and predicted its functional relation to PLA_2 activity in a model eukaryotic cell. This published study (M. Mattiazzi et al., *Molecular Genetics and Genomics*, 283 (2010), 519–530) provided a list of the players involved in the global response to changes in the membrane composition and shape in a model eukaryotic cell.

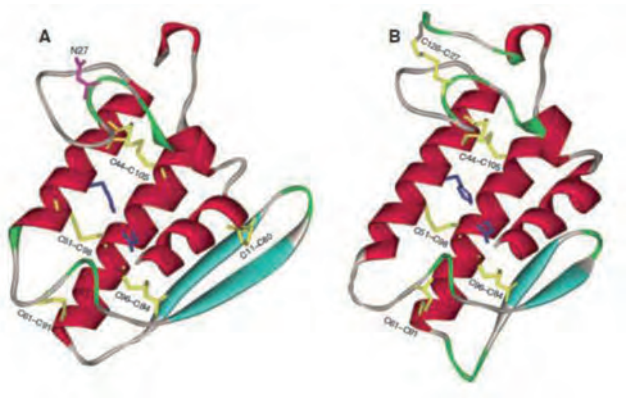


Figure 6: Structural models of sPLA2s from see anemones Urticina crassicornis (A) and Adamsia carciniopados (B). The structural uniquenesses of Uc sPLA2 in comparison to other group I sPLA2s (e.g. Ad sPLA2) are the substitution of the conserved Cys27 with Asn (purple N27) and shorter C-terminus of the molecule, therefore Cys126 is not present. Cys27 and Cys126 of the canonical group I sPLA2s form a disulphide bond (labelled yellow), which restricts the flexibility of the C-terminal end of the molecule. As no such restraint is present in Uc sPLA2, interesting biological features of this enzyme can be expected. The figure is reproduced from A. Raspotnik et al., FEBS Journal, 277 (2010), 2641–2653.

Evolutionary genomics of transposable elements and functional studies of retrotransposons

Transposable elements (TEs) have profound effects on the structure, function and evolution of their host genomes. Our knowledge about these agents of genomic change in sauropsids, a sister group of mammals that includes all extant reptiles and birds, was very limited. The large amount of recently accumulated genome-wide data on TEs in diverse lineages of sauropsids has provided a remarkable opportunity to review the current knowledge about TEs of sauropsids in their genomic context (D. Kordiš, *Cytogenetic and Genome Research*, 127 (2009), 94–111 - published in 2010). Avian and reptilian genomes differ significantly in the classes of TEs present, their fractional representation in the genome and by the level of TE activity. In sauropsid genomes TEs have been active for hundreds of millions of years, and as such have had a huge impact on the overall architecture of the genomes, such as contracting or expanding the size of the genomes and providing regions of sequence identity for recombination events that could generate genetic diversity in reptilian genomes.

Other subjects

In 2010 we also collaborated in several projects out of the thematic scope of our department or the programme group "Toxins and biomembranes".

The methodology of preparation of the photoreactive derivative of AtxC was successfully used to prepare photoreactive derivatives of human procathepsin K to map the interaction surface between procathepsin K and heparin in order to build a structural model of the complex between these two molecules (M. Novinec et al., *Biochemical Journal*, 429 (2010), 379–389). By analysis of the DNA and RNA samples of patients with unipolar depression we participated in a pharmacogenetic study of the alternative antidepressant response of these people (R. Uher et al., *American Journal of Psychiatry*, 167 (2010), 555–564; K. Malki et al., *Biological Psychiatry*, (2010), doi:10.1016/j.biopsych.2010.08.011). With a structural analysis we participated at the identification of protein interactors of stefin B, an inhibitor of cysteine proteinases, in the nucleus of mammalian cells. We discovered that stefin B binds to nucleosome, specifically to histones H2A.Z, H2B and H3, in the nucleus of mammalian cells, which may be important for the occurrence of the Unverricht-Lundborg disease (S. Čeru et al., *Journal of Biological Chemistry*, 285 (2010), 10078–10086). We participated in unravelling the reason for the anomalous cellular localization of TDP-43 protein in the case of amyotrophic lateral sclerosis and TDP-43 proteinopathies. In these diseases, TDP-43 localizes and aggregates in the cytosol rather than in the cell nucleus. We suggested the explanation for the improper translocation of TDP-43 (A.L. Nishimura et al., Brain, 133 (2010) 1763–1771).

Some outstanding publications in the past year

1. Kovačič, L., Novinec, M., Petan, T. and Križaj, I. (2010): Structural basis of the significant calmodulin-induced increase in the enzymatic activity of secreted phospholipases A_2. Protein Eng. Des. Sel. 23, 479–487.
2. Razpotnik, A., Križaj, I., Šribar, J., Kordiš, D., Maček, P., Frangež, R., Kem, W.R. and Turk,T. (2010): A new phospholipase A_2 isolated from the sea anemone *Urticina crassicornis* – its primary structure and phylogenetic classification. FEBS J. 277, 2641–2653.
3. Saul, F.A., Prijatelj, P., Vuilliez-le Normand, B., Villette, B., Raynal, B., Pungerčar, J., Križaj, I. and Faure, G. (2010): Comparative structural studies of two natural isoforms of ammodytoxin, phospholipases A_2 from *Vipera ammodytes ammodytes* which differ in neurotoxicity and anticoagulant activity. J. Struct. Biol. 169, 360–369.

4. Mattiazzi, M., Jambhekar, A., Kaferle, P., DeRisi, J.L., Križaj, I. and Petrovič, U. (2010): Genetic interactions between a phospholipase A_2 and the Rim101 pathway components in *S. cerevisiae* reveal a role for this pathway in response to changes in membrane composition and shape. Mol. Genet. Genomics 283, 519–530.
5. Mattiazzi, M., Curk, T., Križaj, I., Zupan, B. and Petrovič, U. (2010): Inference of the molecular mechanism of action from genetic interaction and gene expression data. OMICS 14, 357–367.

Awards and appointments

1. Lidija Kovačič: Maks Samec Award of the Faculty of Chemistry and Chemical Tehnology, University of Ljubljana, for the best Doctoral Thesis in biochemistry in 2010
2. Igor Križaj: Toxicon Journal Award: Elsevier Top Reviewer in 2010
3. Toni Petan: Lapanje Award for Young Scientists of the Slovenian Biochemical Society in 2010 for outstanding achievements in biochemical sciences

INTERNATIONAL PROJECTS

1. Applied Venomics of the Cone Snail Species Conus Consors for the Accelerated, Cheaper, Safer and More Ethnical Produdction of Innovative Biomedical Drugs
   CONCO
   6. FP, EC, Integrated Project
   037592, LSHB-CT-2007-03792
   EC; Dr. Reto Stöcklin, Atheris Laboratories, Plan-les-Quates, Geneve, Switzerland
   Prof. Igor Križaj
2. Identification of Essential Proteins Involved in Peroxisome and Lipid Droplet Biogenesis in Yeast
   BI-AT/09-10-019
   Prof. Dr. Sepp D. Kohlwein, University of Graz, Institute of Molecular Biosciences, Graz, Austria
   Asst. Prof. Uroš Petrovič
3. Isolation of Long-Nosed Viper (Vipera Ammodytes Ammodytes) Venom Components and Analysis of their Immunogenicity
   BI-HR/10-11-025
   Dr. Beata Halassy, Imunološki zavod, d.d., Odjel za istraživanje i razvoj, Zagreb, Croatia
   Prof. Igor Križaj

R & D GRANTS AND CONTRACTS

1. Proteins of the Long-nosed Viper Venom Acting on Haemostasis - Development of Innovative Biomedical Antithrombotics
   Prof. Igor Križaj
2. Photostability of Selected Industrial Chemicals and Their Influence on the Environment
   Prof. Polonca Trebše, Asst. Prof. Uroš Petrovič
3. Data and Knowledge Integration Methods for Network Systems Biology
   Prof. Blaž Zupan, Asst. Prof. Uroš Petrovič
4. Antiretroviral APOBEC3 Proteins and Their Role in Retroelement Defense
   Dr. Marija Nika Lovšin, Asst. Prof. Dušan Kordiš
5. Regulatory Genomics: Origin and Evolution of the Complex Transcriptional Regulatory Network in Vertebrates
   Asst. Prof. Dušan Kordiš
6. Knowledge Technology Approaches in Drug Discovery: Analysis and Experiment Planning in High-throughput Genetics
   Prof. Blaž Zupan, Asst. Prof. Uroš Petrovič
7. The Role of Secretory Phospholipases A2 in Breast Cancer
   Prof. Jože Pungerčar

RESEARCH PROGRAM

1. Toxins and biomembranes
   Prof. Igor Križaj

MENTORING

Ph. D. Theses

1. Adrijana Leonardi, *Structural and biological characterization of Vipera a. ammodytes venom protein components affecting the blood coagulation process* (mentor Igor Križaj)
2. Mojca Mattiazzi Ušaj, *Homeostasis of biological membranes in eukaryotic cells: role of phospholipase A2 and zinc* (mentor Igor Križaj; co-mentor Uroš Petrovič)

VISITORS FROM ABROAD

1. Prof. Igor Stagljar, University of Toronto, Canada, 10–12 January 2010
2. Prof. Michael Hanscho, Prof. David Ruckerbauer, University of Graz, Austria, 17–18 June 2010
3. B. Sc.Tihana Kurtović, Institute of Immunology, Zagreb, Croatia, 06–17 September 2010
4. Berta Avila Gratacos, University of Barcelona, Faculty of Pharmacy, Spain, 27 September 2010–31 March 2011
5. B. Sc. Kristina Radošević, Faculty of Food Technology, University of Zagreb, Croatia, 19 October 2010

STAFF

Researchers
1. Asst. Prof. Dušan Kordiš
2. **Prof. Igor Križaj, Head**
3. Asst. Prof. Uroš Petrovič
4. Prof. Jože Pungerčar

Postdoctorial associates
5. Dr. Lidija Kovačič
6. Dr. Adrijana Leonardi
7. Dr. Mojca Mattiazzi Ušaj
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14. Jernej Oberčkal, B. Sc.
15. Anja Pucer, B. Sc.
16. Tamara Sajevic, B. Sc.

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Original Articles

1. Slavko Čeru, Špela Konjar, Katarina Maher, Urška Repnik, Igor Križaj, Mojca Benčina, Miha Renko, Alain Nepveu, Eva Žerovnik, Boris Turk, Nataša Kopitar-Jerala, "Stefin B interacts with histones and cathepsin L in the nucleus", *J Biol Chem*, vol. 285, no. 13, pp. 10078-10086, 2010.
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3. Borut Jerman, Jože Pungerčar, "Bacterial expression and simple purification of human group X secretory phospholipase A_2", *Acta chim. slov.*, vol. 57, no. 4, pp. 888-894, 2010.
4. Lidija Kovačič, Marko Novinec, Toni Petan, Igor Križaj, "Structural basis of the significant calmodulin-induced increase in the enzymatic activity of secreted phospholipases A_2", *Protein engineering, design & selection*, vol. 23, no. 6, pp. 479-487, 2010.
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6. Mojca Mattiazzi, Ashwini Jambhekar, Petra Kaferle, Joseph DeRisi, Igor Križaj, Uroš Petrovič, "Genetic interactions between a phospholipase A_2 and the Rim101 pathway components in S. cerevisiae reveal a role for this pathway in response to changes in membrane composition and shape", *Molecular genetics and genomics*, vol. 283, no. 6, pp. 519-530, 2010.
7. Marko Novinec, Lidija Kovačič, Brigita Lenarčič, Antonio Baici, "Conformational flexibility and allosteric regulation of cathepsin K", *Biochem. j. (Lond., 1984)*, vol. 429, no. 2, pp. 379-389, 2010.
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10. Rudolf Uher, Tina Žagar, Borut Jerman, (28 authors), "Genome-wide pharmacogenetics of antidepressant response in the GENDEP project", *Am J Psychiatr*, issue 5, vol.167, pp. 555-564, 2010.

Theses

Ph. D. Theses

1. Adrijana Leonardi, *Structural and biological characterization of Vipera a. ammodytes venom protein components affecting the blood coagulation process: doctoral dissertation*, Ljubljana, [A. Leonardi], 2010.
2. Mojca Mattiazzi, *Homeostasis of biological membranes in eukaryotic cells: role of phospholipase A_2 and zinc: doctoral dissertation*, Ljubljana, [M. Mattiazzi], 2010.

B. Sc. Thesis

1. Jernej Oberčkal, *Identification of ammodytoxin C-binding proteins in mammalian neuronal cells: undergraduate thesis*, Ljubljana, [J. Oberčkal], 2010.

DEPARTMENT OF BIOTECHNOLOGY
B-3

At the Department of Biotechnology we investigate biological molecules of microbiological, fungal, plant and animal origin using modern biotechnological methods. We would like to apply them for diagnostic and therapeutic purposes in human and veterinary medicine, for plant protection, the preparation of high-quality and safe food and for the protection of the environment, contributing to the improvement of peoples' health and of the environment in which we live. Our research work is focused on the processes of cancer progression and immune response, the biology of fungi, plant stress response and in the search for sweet proteins and natural pesticides.

Head:
Prof. Janko Kos

In the field of research on fungal protease inhibitors we have continued with the characterization of mycocypins, cysteine protease inhibitors from clouded agaric (*Clitocybe nebularis*) and parasol mushroom (*Macrolepiota procera*). The expression of these proteins was evaluated at the level of mRNA and protein for different promoter regulation. The expression profiles for mycocypins reveal that they have different functions in mushrooms, besides the regulation of protease activity also the protection against different pests and pathogens. Similarly, the functional analysis of serine protease inhibitors, i.e., cnispin from *Clitocybe nebularis* and cospin from *Coprinopsis cinerea*, also showed their involvement in protection against pests. In collaboration with the Department of Biochemistry, Molecular and Structural biology (B1) the crystal structure of cospin was determined, which enables the identification of the reactive site, responsible for trypsin inhibition, for both serine protease inhibitors. Site-directed mutagenesis revealed that in the inhibition mechanism of trypsin, different amino acid residues are involved in cospin than in cnispin. On the basis of the structure of reactive sites of both inhibitors a new inhibitor was prepared, which is capable of inhibiting trypsin and chymotrypsin. These studies added a new knowledge to understand the function of fungal protease inhibitors with the same 3D structure. Micocypins, cospin and cnispin all possess trefoil fold, consists of beta barrel with 11 extended variable loops. These loops enable the inhibition of various classes of proteases with distinct inhibitory mechanisms.

- **With the determined 3D structure the mechanism of the action of micocypins was defined**
- **The role of the DNA binding protein TDP-43 in amyotrophic lateral sclerosis was determined**
- **Lectins from mushrooms and lectin DC SIGN were shown to regulate the function of dendritic cells**
- **26 scientific papers in journals with an impact factor were published in 2010**

In the field of glycobiology we studied lectins from the mushroom clouded agaric (*Clitocybe nebularis*) and evaluated their insecticidal and bactericidal activities. Also, our work was focused on ricin B-like lectin from *C. nebularis* (CNL) and its immunomodulatory effects on leukemic T lymphocytes and dendritic cells. To understand the mechanism of action of the dimeric lectin, several mutants were designed on the basis of the crystal structure of CNL in a complex with lactose or *N,N'*-diacetyllactosediamine (GalNAcβ1–4GlcNAc). A mutant with an additional sugar-binding site introduced a mutant that does not bind sugars and mutants that do not form dimeric structures were expressed in the bacteria *Escherichia coli*. It was shown that mutants that do not dimerize or bind sugars do not elicit biological effects, which suggests that multiple sugar-binding sites are essential for the biological activity of CNL.

Moreover, novel lectins such as sepharose-, galactose-, and lactose-specific lectins were isolated from the parasol mushroom (*Macrolepiota procera*). The lectins were characterized biochemically and using molecular-biology techniques the gene and cDNA, encoding the ricin B-like lectins, were obtained. The interactions of lectins with endogenous protease inhibitors were also demonstrated, suggesting their biological function in the mushroom. Our research on lectins was also dealing with the role of DC SIGN lectin and its antagonists in the regulation of dendritic cells.

An important part of our research in 2010 was focused on the role of proteases and protease inhibitors in malignant, immune and neurodegenerative processes. In dendritic cells we continued our studies on the role of endogenous protease inhibitors during the cell maturation. We determined the selective action of the endogenous inhibitor cystatin F on cathepsins S and

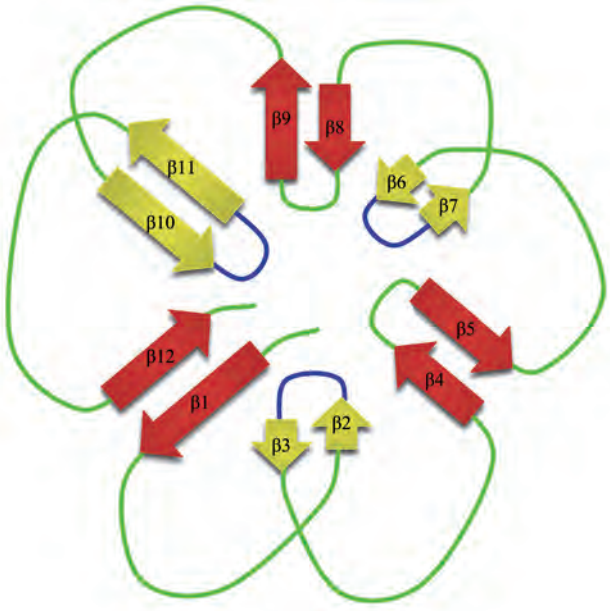

Figure 1: Loops and trfoil fold of the inhibitor cospin.

Figure 2: The surface of the parasol mushroom Macrolepiota procera (Cover page of Journal of Biological Chemistry 285, vol. 1, January 2010)

L, which are involved in the dendritic cells in antigen presentation and cell adhesion, respectively. In clinical studies on patients with ovarian cancer we evaluated the serum levels of cystatin C and cathepsins B and L for the prediction of diagnosis and prognosis. Serum levels of cathepsins and inhibitors were also evaluated in patients with rheumatoid arthritis. For dodekapeptide, which was synthesized with regard to the amino-acid sequence of membrane fraction of cytokeratin, we demonstrated that it potentiates the activation of plasminogen with urokinase and tissue type of plasminogen activator. In the field of neurodegenerative diseases we investigated in collaboration with UK partners the adoptive protein X11α, which in the transgenic mouse model of Alzheimer disease reduces the memory dysfunction. We also revealed the function of DNA binding protein TDP-43 in amyotrophic lateral sclerosis.

In the field of lactic acid bacteria, we have continued with the work on the basis of the determined surface proteome of bacterium *Lactococcus lactis* NZ9000. We made a comparison between experimentally determined and software predicted proteins. On the basis of established criteria, we selected 7 candidate proteins from among 80 experimentally determined proteins. We have amplified their genes and inserted them in the genetic construct, which enables fusion with hexa-histidine peptide. After over-expression of the selected proteins in *L. lactis* we monitored their surface exposure with specific antibodies and flow cytometry. We observed that among the selected proteins, protein BmpA is exposed on the bacterial surface at the highest level. BmpA is therefore appropriate as a carrier protein for the new type of surface display. We have demonstrated this with the surface display of the B domain of the staphylococcal protein A.

Additionally, we have prepared genetic constructs for the expression of antigen of the hepatitis A virus in bacterium *L. lactis*, with the aim being oral vaccination. Expressed antigen was detained either inside the cells, on the cell surface, or on the cell surface in fusion with a molecular adjuvant. The bacteria with antigen varieties were used for the supplementation of the laboratory mice's diet. The mice's serum was taken to monitor the immune response. We have also prepared and purified a larger quantity of hepatitis A antigen, which will be used in assaying the mice's immune response to antigen varieties.

Our research on the response of plants to water stress has been focussed on a study of the model plant *Ramonda serbica*, which is able to survive complete desiccation of its vegetative tissue, and African violet *Saintpaulia ionantha* from the same family, which has no such ability. We optimised conditions for two-dimensional gel electrophoresis, which provided an insight into the changes of protein content in leaves during drought stress. The results pointed to great differences in the changes of the protein profiles of both species, especially at the stage of complete desiccation. In *R. serbica* drought caused the *de novo* synthesis of a number of proteins, which probably play a key role in the ability of this plant to revive upon rehydration. Desiccation of the African violet caused the expression of the majority of proteins to decrease, although the expression of some increased prior to desiccation. Until now, using mass spectrometry, the β subunit of proteasome and pectin methylesterase in African violet and the large subunit of Rubisco in *R. serbica* were identified among the proteins whose expression increased.

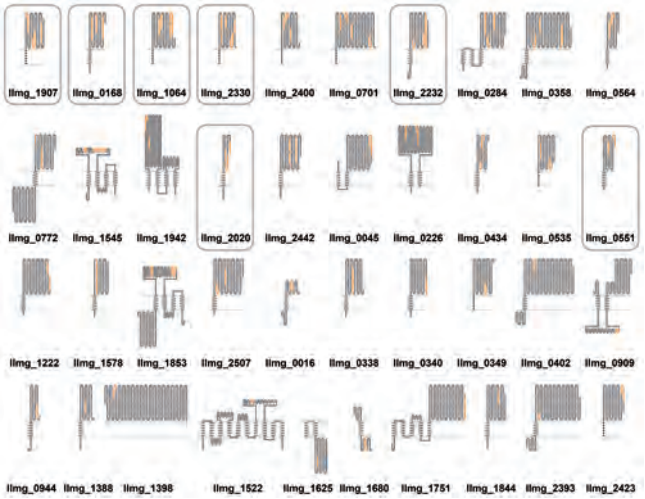

Figure 3: Schematic representation of surface proteins of bacterium Lactococcus lactis NZ9000. The peptides, which were identified with mass spectrometry, are highlighted in orange. Horizontal lines represent the cell membrane. The figure was published in the article Berlec at al. (2010), Appl. Environ. Microbiol.

The results of the research work at the Department of Biotechnology in 2010 were published in 26 scientific papers in journals with an impact factor, in two chapters in books, and presented in scientific conferences as lectures and posters. Two international patent applications have been filed and four national patents have been granted in 2010. The members of the department were also very active in pedagogical work as lecturers and mentors to students preparing diploma and doctoral theses at the University of Ljubljana, the University of Maribor and the Jožef Stefan Postgraduate School. The following awards were given to members of the department in 2010: Gold medal of Jožef Stefan (Nataša Obermajer), Gold plaquette of the University of Ljubljana (Borut Štrukelj), Award Innovation 2010 and the award of the rector of the University of Ljubljana for the best innovation (Borut Štrukelj, Mojca Lunder, Matjaž Ravnikar, Aleš Berlec).

Some outstanding publications in the past year

1. Nishimura, Agnes L., Župunski, V., Troakes, C., Kathe, C., Fratta, P., Howell, M., Gallo, J.M., Hortobagyi, T., Shaw, C. E., Rogelj, B. Nuclear import impairment causes cytoplasmic trans-activation response DNA-binding protein accumulation and is associated with frontotemporal lobar degeneration. Brain, 2010, 133, 1763-1771.
2. M. Renko, J. Sabotič, M. Mihelič, J. Brzin, J. Kos, D. Turk. Versatile loops in mycocypins inhibit three protease families. J. Biol. Chem. 2010, 285(1): 308-16
3. N. Obermajer, B. Doljak, J. Pohleven, J. Kos. A dodecapeptide deduced from cytokeratin sequence strongly enhances uPA/tPA-mediated plasminogen activation. Br. J. Haematol., 2010, 150, 121-124.

Awards and appointments

1. Dr. Aleš Berlec, Prof Dr. Borut Štrukelj, Matjaž Ravnikar, Assist. Prof. Mojca Lunder, Prof. dr. Boris Čeh: Gold Award for innovation "Development of recombinant probiotics for the treatment of chronic inflammatory bowel disease", Innovation Fair 2010
2. Dr. Aleš Berlec, Prof Dr. Borut Štrukelj, Matjaž Ravnikar, Assist. Prof. Lunder, Prof. Dr. Boris Čeh: Prize for Innovations in Economy (4th place) for "Functional yoghurt as a cure: Development of recombinant probiotics for the treatment of inflammatory bowel disease«. 3th International Conference on Technology Transfer
3. Dr. Aleš Berlec, Prof. Dr. Borut Štrukelj, Matjaž Ravnikar, Assist. Pprof. Mojca Lunder, Prof. Dr. Boris Čeh: Dean's award for the second best innovation at the University of Ljubljana in 2010 for the development of the recombinant probiotics for the treatment of inflammatory bowel disease
4. Dr. Aleš Berlec, Prof. Dr. Borut Štrukelj, Petra Zadravec: Faculty Prešeren Award to the students of Biotechnical Faculty in 2010: Petra Zadravec the graduation thesis »Display of antigen varieties of hepatitis A on the surface of a recombinant lactic acid bacterium Lactococcus lactis«
5. Prof. Dr. Borut Štrukelj: Gold medal of the University of Ljubljana for exceptional merits in developing scientific and pedagogical work at the University of Ljubljana and for strengthening its reputation
6. Prof. Dr. Borut Štrukelj: Fulbright Award for visiting professor in 2010

INTERNATIONAL PROJECT

1. Bioactive Substances in Endemo-Relict Plants of the Balkan Peninsula
   BI-SR/10-11-014
   Dr. Branka Stevanović, University of Belgrade, Faculty of Biology, Belgrade, Serbia
   Prof. Janko Kos

R & D GRANTS AND CONTRACTS

1. Functional Analysis of Proteins Resistant to Drought and Insects
   Prof. Jana Žel, Dr. Jerica Sabotič
2. Expression and Functional Analysis of Non-coding RNA in Parkinson Disease
   Dr. Boris Rogelj
3. New Biotechnological Drugs Obtained by Phage Display
   Prof. Borut Štrukelj
4. Regulation of T-cell Functions with Alpha Type 1-polarised (alphaDC1) and Standard Dendritic Cells (sDC).
   Asst. Prof. Nataša Obermajer

RESEARCH PROGRAM

1. Pharmaceutical Biotechnology: Knowledge for Health
   Prof. Janko Kos

MENTORING

Ph. D. Theses

1. Dominik Gaser, *Lipases peptide design and development through phage display technology* (mentor Borut Štrukelj; co-mentor Mojca Lunder)
2. Zala Jevnikar, *Cathepsin X affects T lymphocyte migration and morphology through integrin regulation* (mentor Janko Kos)
3. Nataša Radić, *The effect of medicinal mushroom and plant extracts on gene expression in model cell lines* (mentor Borut Štrukelj)
4. Nuša Resman, *Immune response activation through TLR4/MD-2 receptor complex* (mentor Roman Jerala; co-mentor Janko Kos)

M. Sc. Thesis

1. Jana Hribar, *Development and validation of method for biological activity determination of recombinant darbepoetin alfa* (mentor Borut Štrukelj)

VISITOR FROM ABROAD

1. Živko Jovanović, Institute of Molecular Genetics and Genetic Engineering (IMGGE), University of Belgrade, Republic of Serbia, 5.–17. 9 .2010

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4. Prof. Borut Štrukelj*

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12. Darja Žunič Kotar

Note:
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BIBLIOGRAPHY

Original Articles

1. Urška Čepin, Ion Gutierrez-Aguirre, Leonida Balažic, Maruša Pompe Novak, Kristina Gruden, Maja Ravnikar, "A one-step reverse transcription real-time PCR assay for the detection and quantitation of Grapevine fanleaf virus", *J. virol. methods*, vol. 170, issues 1-2, pp. 47-56, 2010.
2. David Dobnik, Dany Morisset, Kristina Gruden, "NAIMA as a solution for future GMO diagnostics challenges", *Anal. bioanal. chem.*, vol. 396, no. 6, pp. 2229-2233, 2010.
3. Polona Kogovšek, Maruša Pompe Novak, Špela Baebler, Ana Rotter, Lisa Gow, Kristina Gruden, Gary D. Foster, Neil Boonham, Maja Ravnikar, "Aggressive and mild Potato virus Y isolates trigger different specific responses in susceptible potato plants", *Plant Pathol.*, vol. 59, issue 6, pp. 1121-1132, 2010.
4. Eva Kolwijck, Leon F.A.G Massuger, Chris M.G. Thomas, Paul Span, Marta Krašovec, Janko Kos, Fred Sweep, "Cathepsins B, L and cystatin C in cyst fluid of ovarian tumors", *J Cancer Res Clin Oncol*, vol. 136, no. 5, pp. 771-778, 2010.
5. Eva Kolwijck, Nataša Obermajer, Janko Kos, Paul Span, Chris M.G. Thomas, Leon F.A.G Massuger, Fred Sweep, "The balance between extracellular cathepsins and cystatin C is of importance for ovarian cancer", *Eur. j. clin. investig. (Print)*, issue 7, vol. 40, pp. 591-599, 2010.
6. Jacqueline C. Mitchell, Michael S. Perkinton, Darran M. Yates, Kwok-Fai Lau, Boris Rogelj, C. C. Miller, Declan M. McLoughlin, "Expression of the neuronal adaptor protein X11α protects against memorydysfunction in a transgenic mouse model of Alzheimer's disease", *J. Alzheimer's dis.*, vol. 20, no. 1, pp. 31-36, 2010.
7. Petra Nikolić, Nataša Mehle, Kristina Gruden, Maja Ravnikar, Marina Dermastia, "A panel of real-time PCR assays for specific detection of three phytoplasmas from the apple proliferation group", *Mol. cell. probes*, vol. 24, pp. 303-309, 2010.
8. Agnes L. Nishimura, Vera Župunski, Boris Rogelj, (10 authors), "Nuclear import impairment causes cytoplasmic trans-activation response DNA-binding protein accumulation and is associated with frontotemporal lobar degeneration", *Brain*, issue 6, vol. 133, pp. 1763-1771, 2010.
9. Nataša Obermajer, Bojan Doljak, Jure Pohleven, Janko Kos, "A dodecapeptide deduced from cytokeratin sequence strongly enhances uPA/tPA-mediated plasminogen activation", *Br. J. Haematol.*, issue 1, vol. 150, pp. 121-124, 2010.
10. Nataša Obermajer, Urban Švajger, Matjaž Jeras, Sara Sattin, Anna Bernardi, Marko Anderluh, "An assay for functional dendritic cell-specific ICAM-3-grabbing nonintegrin (DC-SIGN) inhibitors of human dendritic cell adhesion", *Anal. biochem.*, vol. 406, pp. 222-229, 2010.
11. Nina Papazova, David Zhang, Kristina Gruden, Jana Vojvoda, Litao Yang, Meti Buh Gašparič, Andrej Blejec, Stephane Fouilloux, Marc De Loose, Isabel Taverniers, "Evaluation of the reliability of maize reference assays for GMO quantification", *Anal. bioanal. chem.*, vol. 396, no. 6, pp. 2189-2201, 2010.
12. Roman Paškulin, Polona Jamnik, Nataša Obermajer, Marija Slavić, Borut Štrukelj, "Induction of energy metabolism related enzymes in yeast Saccharomyces cerevisiae exposed to ibogaine is adaptation to acute decrease in ATP energy pool", *Eur. J. Pharmacol.*, vol. 627, no. 1/3, pp. 131-135, 2010.
13. Marko Petek, Špela Baebler, Drago Kuzman, Ana Rotter, Zdravko Podlesek, Kristina Gruden, Maja Ravnikar, Uroš Urleb, "Revealing fosfomycin primary effect on Staphylococcus aureus transcriptome: modulation of cell envelope biosynthesis and phosphoenolpyruvate induced starvation", *BMC Microbiol*, vol. 10, no. 159, 28, [7] pp., 2010.
14. Nataša Radić, Zala Jevnikar, Nataša Obermajer, Jernej Kristl, Janko Kos, Franc Pohleven, Borut Štrukelj, "Infuence of culinary-medicinal maitake mushroom, grifola frondosa (dicks.: fr.) s.f. gray (aphyllophoromycetideae) polysaccharides on gene expression in jurkat t lymphocytes", *Int. j. medic. mushrooms*, vol. 12, iss. 3, pp. 245-255, 2010.
15. Matjaž Ravnikar, Borut Štrukelj, Nataša Obermajer, Mojca Lunder, Aleš Berlec, "Engineered lactic acid bacterium Lactococcus lactis capable of binding antibodies and tumor necrosis factor alpha", *Appl. environ. microbiol.*, vol. 76, no. 20, pp. 6928-6932, 2010.
16. Miha Renko, Jerica Sabotič, Marko Mihelič, Jože Brzin, Janko Kos, Dušan Turk, "Versatile loops in mycocypins inhibit three protease families", *J Biol Chem*, vol. 285, no. 1, pp. 308-316, 2010.
17. Ana Rotter, Petra Kralj Novak, Špela Baebler, Nataša Toplak, Andrej Blejec, Nada Lavrač, Kristina Gruden, "Gene expression data analysis using closed itemset mining for labeled data", *Omics (Larchmt. N.Y.)*, vol. 14, no. 2, pp. 177-186, 2010.
18. Urban Švajger, Nataša Obermajer, Matjaž Jeras, "Dendritic cells treated with resveratrol during differentiation from monocytesgain substantial tolerogenic properties upon activation", *Immunology (Oxf.)*, issue 4, vol. 129, pp.525-535, 2010.
19. Regina Tavano, Daniela Segat, Elena Reddi, Janko Kos, Matija Rojnik, Petra Kocbek, Selma Iratni, Dietrich Scheglmann, Mario Colucci, Iria Maria Rio Echevarria, Francesco Selvestrel, Fabrizio Mancin, Emanuele Papini, "Procoagulant properties of bare and highly PEGylated vinyl-modified silica nanoparticles", *Nanomedicine (Lond., Print)*, vol. 5, no. 6, pp. 881-896, 2010.
20. Metoda Zorič Peternel, Andreja Čanžek Majhenič, Helge Holo, Ingolf Nes, Zhian Salehian, Aleš Berlec, Irena Rogelj, "Wide-inhibitory spectra bacteriocins produced by Lactobacillus gasseri K7", *Probiot. antimicrob. proteins (Print)*, vol. 2, no. 4, pp. 233-240, 2010.

Review Articles and Chapters in Books

1. Aleš Berlec, Borut Štrukelj, "Nova generacija tehnik določanje nukleotidnega zaporedja: korak k osebni medicini", *Farm. vestn.*, vol. 61, no. 4, pp. 203-208, 2010.
2. Meti Buh Gašparič, Torstein Tengs, Jose Luiz La Paz, Arne Holst-Jensen, Maria Pla, Teresa Esteve, Jana Žel, Kristina Gruden, "Comparison of nine different real-time PCR chemistries for qualitative and quantitative applications in GMO detection", *Anal. bioanal. chem.*, vol. 396, no. 6, pp. 2023-2029, 2010.
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4. Bojana Mirković, Tamara Lah Turnšek, Janko Kos, "Nanotehnologija pri zdravljenju raka", *Zdr. vestn. (Online)*, vol. 79, no. 2, pp. 146-155, 2010.
5. Matija Rojnik, Janko Kos, "Fotodinamično zdravljenje raka", *Farm. vestn.*, vol. 61, no. 1, pp. 9-13, 2010.
6. Ana Rotter, Matjaž Hren, Björn Usadel, Kristina Gruden, "Visualisation of transcriptomics data in metabolic pathways", In: *Methodologies and results in grapevine research*, Serge Delrot, ed., Hipólito Medrano, ed., Etti Or, ed., Luigi Bavaresco, ed., Stella Grando, ed., Dordrecht [etc.], Springer, 2010, pp. 335-342.
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8. Urban Švajger, Nataša Obermajer, Matjaž Jeras, "Novel findings in drug-induced dendritic cell tolerogenicity", *Int. rev. immunol. (Print)*, vol. 29, no. 6, pp. 574-607, 2010.

Published Conference Papers

Regular papers

1. Dragana Miljković, Claudio Mihăilă, Vid Podpečan, Miha Grčar, Kristina Gruden, Tjaša Stare, Nada Lavrač, "Workflow-based information retrieval to model plant defence response to pathogen attacks", In: *Third generation data mining: towards service-oriented knowledge discovery: SoKD'10, September 24, 2010, Barcelona, Spain*, Melanie Hilario, ed., Nada Lavrač, ed., Vid Podpečan, ed., Joost N. Kok, ed., [S. l., s. n.], 2010, pp. 51-60.
2. Igor Mozetič, Nada Lavrač, Vid Podpečan, Petra Kralj Novak, Helena Motaln, Marko Petek, Kristina Gruden, Hannu Toivonen, Kimmo Kulovesi, "Bisociative knowledge discovery for microarray data analysis", In: *Proceedings of the International Conference on Computational, ICCC-X, Creativity, 7-9 January 2010, Lisbon, Portugal*, Dan Ventura, ed., Coimbra, Departament of Informatics Engineering, University of Coimbra, 2010, pp. 190-199.

Theses

B. Sc. Thesis

1. Maja Štalekar, *Preparation of recombinant cathepsin B in E. coli and inhibition of its activity by low molecular weight inhibitors: undergraduate thesis*, Ljubljana, [M. Štalekar], 2010.

Patents

1. Nataša Obermajer, Bojan Doljak, Janko Kos, *Peptide uroaktivin as an activator of enzyme urokinase: SI22865 (A),* Ljubljana, Urad RS za intelektualno lastnino, 31. mar. 2010.
2. Nataša Obermajer, Zala Jevnikar, Urša Pečar Fonović, Bojan Doljak, Janko Kos, *Inhibition of cathepsin X as a tool for treatment of neurodegenerative diseases: SI22890 (A)*, Ljubljana, Urad RS za intelektualno lastnino, 30. apr. 2010.
3. Borut Štrukelj, Samo Kreft, Andrej Umek, Damjan Janeš, *Antioxidative extract obtained from pine and fir bark: SI22882 (A),* Ljubljana, Urad RS za intelektualno lastnino, 30. apr. 2010.

Patent Applications

1. Mojca Lunder, Matjaž Ravnikar, Borut Štrukelj, Aleš Berlec, Boris Čeh, *Genetically modified food grade microorganism for treatment of inflammatory bowel disease: P003127EP*, München, Europäisches Patentamt, 7. January 2010.
2. Bojana Mirković, Samo Turk, Izidor Sosič, Zala Jevnikar, Nataša Obermajer, Stanislav Gobec, Janko Kos, *8-hydroxyquinolones as inhibitors of cathepsin B: P003135EP*, München, Europäisches Patentamt, 3 February 2010.

DEPARTMENT OF ENVIRONMENTAL SCIENCES O-2

The basic characteristic of the Department of Environmental Sciences is multidisciplinarity, as our researches involve different fields in natural and sociological sciences, especially the physical, chemical, geological and biological processes that create our environment, society and human activity. Above all, we wish to explain the connections between natural processes and human activity, and the influences of those activities on human and environmental health. We are combining the scientific excellence of our research work with solving concrete technological problems in industry, education and development that are interplayed with research in the fields of analytical chemistry, radiochemistry and radioecology, biological and geochemical cycles of elements, nutrition and the health of humans, animals and plants, waste management, mathematical and GIS modelling of environmental processes and risk, and environmental impact assessment.

Head:
Prof. Milena Horvat

In the field of **chemical speciation** the research work on the use of monolithic chromatography was continued. A new analytical method for the speciation of organotin compounds (OTC) in a complex matrix of landfill leachates was developed. It was demonstrated that methyltins are the prevailing OTC species in these samples. The extraction method for the simultaneous determination of butyl-, phenyl- and octyltin compounds in sewage sludge was also developed by the use of GC-MS.

The modalities of the appropriate preparation of stable isotopes of hexavalent and trivalent chromium species were investigated. From stable isotopes of chromium oxides (^{50}Cr and ^{53}Cr) hexavalent chromium was prepared by alkaline melting, while for the preparation of trivalent chromium microwave-assisted digestion was applied. The preparation of stable chromium isotopes in hexavalent and trivalent oxidation states without the use of oxidizing agents (e.g. hydrogen peroxide) is the only way of preparing the tracers that are used in investigations of oxidation–reduction processes.

The refinement and optimization of the use of radiotracer 197-Hg prepared from enriched 196-Hg were implemented, particularly in the area of understanding mercury behaviour in natural aqueous solutions.

The micro-diffusion procedure of **nitrate extraction** from seawater for stable isotope analysis of nitrate-N was optimised.

Between **INAA** methods we take great care for the additional development of the k_0-method. We re-measured the neutron flux in typical irradiation channels of the TRIGA reactor and validated MATSSF software (developed at the JSI) for the calculation of self-shielding factors (thermal and epithermal). We participated in the re-evaluation of the Q_0 and k_0 factors for the Se-75 needed for the update of the KAYZERO library, which are validated by adding a mass of certified standard solution on a cellulose pellet. Together with colleagues from the SS. Cyril and Methodius University from Skopje, Macedonia, we analyzed iron and copper minerals from their country and we concluded that the introduced technique of k_0-RNAA or k_0-INAA is also an appropriate tool for such a very complicated matrix.

In the field of **organic analytical chemistry** we have devoted most of our research to studying the fate of pharmaceutical residues and endocrine disrupting compounds in the environment. We introduced a series of new analytical procedures to determine the representatives of different groups of pharmaceutical compounds, like antiepileptics (carbamazepine), tranquilisers (diazepame, oksazepame in bromazepame) and steroid estrogens (estrone, 17β-estradiol, 17α-ethnylestradiol and estriol) in various matrices, including surface and waste water. Also, we introduced in our investigations a new group of pharmaceuticals, termed cytostatics, which, due to their potential toxicity, require a dedicated laboratory protocol.

In the area of **steroid estrogens** we have introduced a biological method for testing estrogenicity (test ER-Calux®, Biodetection Systems b.v., Amsterdam, Netherlands) and integrated it in a single protocol with a chemical analysis based on gas chromatography-mass spectrometry. Our initial results using real samples (surface and waste waters) are promising and show a good correlation between both the individual methods.

Outstanding achievements:

- **The source and transformation pathways of organic matter using an analysis of organic geochemical markers combined with a compound-specific isotopic composition were determined in anoxic eutrophic Alpine lake Bled, which represents a new field of research in Slovenia and worldwide.**
- **It was confirmed that high levels of non-bound radon decay products in Postojna Cave are due to a dominating fraction of the <50 nm particles in the total aerosol concentration during the summer season.**
- **New nuclear constants for Q0 and k0 for Se-75 were calculated.**
- **The effect of rutin on the stability of Se compounds in plant samples was investigated for the first time.**
- **In the framework of the National Metrology System, the department was given the status of the holder of the National Etalon for the amount of substances in soil, sediments and sewage sludge.**

Center for Mass Spectrometry in O2 participates in research projects and the applications of many research groups at the JSI, Slovenian universities, the National Institute of Chemistry, Krka, Lek and others with mass-spectrometric measurements of organic compounds, metal complexes and biomolecules, and fundamental studies in the gas phase of the mass spectrometer. The Q-Tof Premier mass spectrometer, with electrospray ionization (ESI), which is coupled with a liquid chromatograph, we used for the identification of drug residues and their metabolites in the environment, the simultaneous release of a drug and a prodrug (clindamycin and clindamycin phosphate in the human body, quantitative determination of steroids during enzymatic transformation, characterization of novel ruthenium complexes with histamine, etc). With a high-temperature mass spectrometer we measured the new thermodynamic data of a liquid Al-Cu-Sn alloy, which could potentially replace lead solder.

Metrology in chemistry:

In the framework of the national metrology system, the department was nominated as the holder of the etalon for the amount of substance/soil (soil, sediment, sewage sludge).

We participated in the certification process of four new reference materials – ISPRA RM021 Sediment, IRMM ERM-CZ120 Fine Dust Powder, INCT-OBTL-5 Oriental Basma Tobacco Leaves and INCT-PVL-6 Polish Virginia Tobacco Leaves – and participated in a Stability test for Br in ERM-EC590 Polyethylene in ERM-EC591 Polypropylene. We also tested the stability and homogeneity of the mass fractions of mercury in ERM CC 144 in sewage sludge and the homogeneity of mercury in BCR 579 (Mercury in coastal sea water).

We participated in three international intercomparison exercises of the FIT-PTS Proficiency Testing Scheme "Food analysis using isotopic techniques" for the isotope analyses of food stuffs (wine, fruit juices, honey, vinegar, proteins), organised by EUROFINS Scientific Analytics (France). Furthermore, we took part in the intercomparisons scheme for the stable isotope analysis of vanillin in foodstuffs, organised by the German Chemical Society, and in IPE PER2010.2 for the determination of $\delta^{15}N$ and $\delta^{13}C$ in plants (Wageningen Evaluating Programmes for Analytical Laboratories).

The department also has an active representative in Technical Committee CEN/TC264/WG31, which is preparing two documents for the standardisation of biomonitoring methods using lichens and mosses.

To give support to the enlargement and integration of the European Union, a series of workshops on radiochemistry were organized in cooperation with the Joint Research Centre for the participants eligible under the EU Enlargement and Integration Action.

ENVIRONMENT, NUTRITION AND HEALTH

Stable isotopes of carbon and nitrogen were used as tracers of the **geographical origin and authenticity of different food products**, such as honey, oils, wine, fruit juices, milk and bottled water. The potential for the use of nitrogen stable isotopes to differentiate between organically and conventionally grown vegetables was investigated. It was found that in spite of some limitations, the $\delta^{15}N$ signature can be used as a supporting tool for other methods to verify organic vegetable production.

Although **selenium** has not been confirmed to be an essential micronutrient in higher plants, it is known that they are capable of accumulating higher amounts of the element. These plants can be a key factor in achieving a satisfactory intake of Se in human and animal diets. However, not the total Se content, but its species present, parallels the Se bioavailability. Two species of cabbage commonly used in Slovenia were treated with Na selenate: cabbage (*Brassica oleracea* var. *capitata* L.) and red cabbage (*Brassica oleracea* var. *capitata* L. f. rubra). The cabbage was foliarly sprayed with 20 mg $Se.L^{-1}$, while the red cabbage was fertilized with 0.5 mg $Se.L^{-1}$. Despite the high dose of Se there were no toxic effects observed on plants. The Se-species were determined in enzymatic extracts using ion exchange HPLC-ICP-MS. The main Se species found in all parts of the cabbage and red cabbage was SeMet. The uptake of Se (VI) and its effects on the physiological characteristics were studied on two aquatic plants *Myriophyllum spicatum* L. and *Ceratophyllum demersum* L. The plants were cultivated outdoors in semi-controlled conditions and in two concentrations of Na selenate (20 μg $Se.L^{-1}$ and 10 mg $Se.L^{-1}$). The Findings showed that both species could take up a large amount of Se. The main soluble species in both plants was selenate (~ 37 %), while SeMet and SeMeSeCys were detected at trace levels.

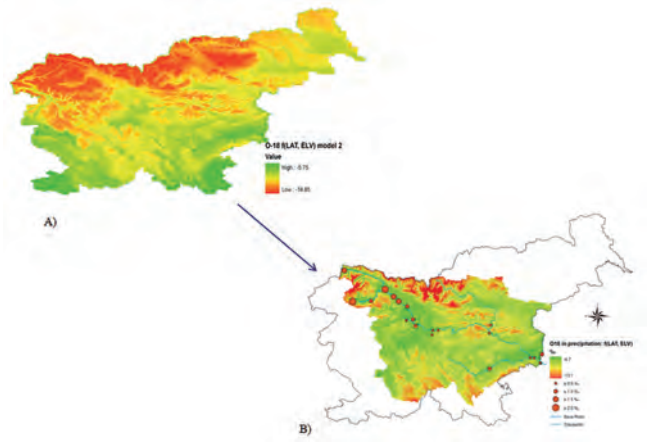

Figure 1: A) Continuous digital map of the $d^{18}O$ distribution as a function of latitude and elevation in precipitation using GIS. B) Continuous digital map of the $d^{18}O$ distribution as a function of latitude and elevation in precipitation in the River Sava watershed. The values for individual data-collection sites are given as points, which are different in size depending on the size of the difference between the surface water and the precipitation values.

In collaboration with the Clinical Center Ljubljana we are still working on **arsenic metabolism** in cancer patients treated with arsenic trioxide. In 2010 the influence of arsenic on the serum and urine selenium decrease in patients with APL or multiple myeloma was confirmed. Low levels of Se (<30 ng/g) in serum can represent an important indicator of possible side effects

during therapy. Studies on commercial cancer-cell lines (astrocytoma U87) were focused on the in vivo inactivation of arsenic trioxide through arsenite oxidation by different media itself, the addition of vitamin C and the deprivation of fetal bovine serum. Regarding the cells expression of protective proteins metallothioneins (MTs), different isoforms were analysed using the previously optimized (q)RT-PCR method. Arsenic was found to suppress or induce isoforms expression, depending on the concentration used for the treatment. Arsenite oxidation and MTs induction can lead to a depressed effectiveness of arsenic trioxide.

Together with oncologists from the Oncology Institute in Ljubljana, the distribution and kinetics of **metalodrugs** that contain Ru or Pt in experimental animals and humans was further investigated by the use of CIM DEAE-1 weak anion-exchange monolithic column coupled to ICP-MS. The potential of the use of ferromagnetic nanoparticles was evaluated by the determination of Fe and Co in various samples from pre-clinical studies.

In the framework of the EU project PHIME we continued studies on the health effects of low-dose, long-term **exposure to mercury** in Slovenian, Northern Italian, Croatian and Aegean population group of new born children (1700 mother–child pairs). Neuro-developmental testing in the Slovenian population was conducted by the paediatricians from the University Clinical Centre of Ljubljana.

BIOGEOCHEMICAL CYCLES

In 2010 we further investigated the content of **radioactive iodine** (^{129}I) in samples from the environment of Slovenia. From the terrestrial environment, samples of precipitation, pine needles and soil from open field and coniferous forest were analyzed. The method was found to be suitable to notice differences in the ^{129}I and ^{127}I levels in soil samples collected in a forest or open field. The soil sample collected in coniferous forest, where more organic matter is present, contained more ^{129}I and ^{127}I than soil from an open field collected at the same location.

In studies performed jointly with Marine Biological Station Piran we continued with an investigation of metal binding on DOM (dissolved organic matter), particularly **mercury**. In the framework of MIRACLE, coordinated by the University of Trieste, mercury transport and fate was investigated in the Grado and Marano Lagoons. In collaboration with Japanese scientists from the University of Kagoshima, Nagasaki, and Fukuoka the fate and transport of mercury entering the Gulf of Trieste through the Soča inflow were investigated.

Investigations on the transfer of **natural radionuclides** in ecosystems with enhanced levels of natural radioactivity, as exemplified in the case of a former uranium mine Žirovski vrh, were carried out. Fractionation of the natural radionuclides in the soil as well as their transfer into the ecosystem and food chain were studied. Environmental radiological risks were estimated using the ERICA Tool. At the same time, measurement procedures for the determination of alpha emitters, particularly Ra-226 in water, were upgraded.

Our **radon** research has been focused on the number concentration of general aerosols and their size distribution in the range 10–1100 nm, together with radioactive aerosols of radon decay products (^{218}Po, ^{214}Pb, ^{214}Bi in ^{214}Po) in the unattached (0–10 nm) and attached (100–800 nm) forms in Postojna Cave. The concentration of aerosols, both general and radioactive, was significantly higher in the summer than in the winter, being mostly contributed by the <50 nm particles (to which the unattached decay products are associated) in the first period and >50 nm particles in the second. This is the reason for the fraction of unattached decay products to be significantly higher in the summer than in the winter. Besides that, the influence of the meteorological conditions and emissions from traffic on the concentration and size of aerosols has been studied in two environments: in the vicinity of a road and in an urban area. The research has been continued on the effect of seismic activity on the radon levels at tectonic faults in the Postojna and Kostanjevica caves. A new measurement station to continuously measure the radon concentration in soil gas was established at Bovec. These kinds of measurements has been underway already for several years also at the Mt. Etna flank and in Friuli, Italy. Time series of the data obtained in these measurements are analysed using classical statistics as well as machine learning methods. Within the bilateral project with the Hokkaido University, Sapporo, the sources and transport of radon and carbon dioxide have been studied in a seismically active terrain in Hokkaido and in several geologically different grounds in Slovenia. Radon was introduced in a study aimed at identifying the contributions of various sources of carbon dioxide in its total flux in karst. Here, radon is used as a tracer in estimating the contribution from the underground system. Continuous measurements of the radon concentration in the outdoor air at a fly ash pile and in its vicinity (as a reference) have been continued in order to understand how hydrometeorological conditions, including synoptic parameters, influence radon transport and, vice versa, how radon as a tracer may be used in studying the movements of air masses on a local and global scale.

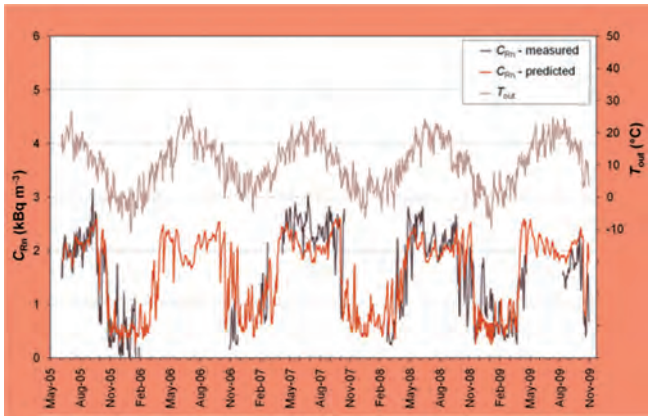

Figure 2: Comparison of the measured and predicted radon concentration (based on the outdoor-air temperature) in Postojna Cave

Cycling of biogenic elements in nature: The influence of catchment area, trophic state and anthropogenic activities on the variability of the composition of sedimentary organic matter in high alpine lakes in the Julian Alps was

studied. Significant differences between the individual lakes were observed regarding the biogeochemical cycling of carbon and nitrogen, related to the increased atmospheric deposition of these elements. In Lake Bled we investigated the sources of sedimentary organic matter using lipid biomarkers and their stable isotope composition.

The sources of nitrate in the Bay of Trieste, as well as its main Slovenian tributaries, the Rižana and Dragonja rivers, were estimated using the stable isotope composition of dissolved nitrate in the water. The seasonal variations of autochthonous marine (microbial) and allochtonous (river-borne) nitrate were determined; it was found that the main contribution of anthropogenic nitrate derives from the Dragonja river, which drains agriculturally intensive areas.

The recharge mode and the age of the groundwater in the Ljubljana area were studied using stable isotope compositions of oxygen and hydrogen, as well as the $^{3}He/^{3}H$ ratios. Based on the O and H isotope composition of the precipitation, a GIS-supported 3D model of the isotope composition of precipitation in Slovenia was elaborated, which was used in modelling the isotope composition of the Sava river water, but can be used for other river catchments, too.

In collaboration with the National Institute of Biology, the relation of hydrochemical composition and biota in alpine springs was investigated.

Response of natural systems to environmental change: The influence of anthropogenic CO_2 emissions in the Šalek alley, as well as their impacts on carbon cycling in the natural environment (atmosphere, water) were investigated.

The carbon stable isotope composition of soil CO_2 was used to estimate the net carbon exchange in grasslands in karst areas, which is important for the overall carbon budget of Slovenia.

The abundance of ^{13}C in tree rings was used to study the annual response of trees to climate forcing and increasing anthropogenic CO_2 concentration in the atmosphere. The direct influence of temperature regime on the growth and isotope composition of carbon and nitrogen in beech seedlings roots and mychorrizae was investigated as a basis for modelling the carbon dynamics in changing climate conditions.

The investigation of the uncertainties of terrigenous carbonates as palaeotemperature archives was focused on the geochemical and isotope proxies for the Dinaric carbonate platform and a comparison with related archives from the Iberian Peninsula. An attempt at *in-situ* calibration of isotope palaeothermometer was made using stalagmites in Postojna cave. Not only the temperature and kinetic isotope affects during precipitation, but the isotopic equilibrium in the speleothem – water film – atmosphere system, and ventilation of the cave causing cyclic condensation and evaporation of water on carbonate surfaces, were confirmed to be the governing factors affecting the uncertainties of palaeotemperatures.

ENVIRONMENTAL TECHNOLOGIES AND WASTE MANAGEMENT

For **pharmaceutical residues** our focus was on determining the pharmaceutical transformation products formed during waste treatment and in the environment. This is a novel and demanding field of research that only those groups equipped with state-of-the-art instrumentation and the necessary technical skills can tackle. For this purpose we studied the elimination of selected pharmaceuticals in an optimised (abiotic and biotic) bioreactor that mimics the treatment in a waste-water treatment plant. We also studied the possibility of coupling individual bioreactors with cavitation. Also, drinking/waste water was treated with alternative (abiotic) technologies (UV and photocatalysis), where special attention was paid to the degradation kinetics and the identification of transformation products. We succeeded in identifying a number of transformation products and degradation pathways.

Figure 3: In collaboration with the marine Biology Station in Piran and NIMD in Japan, the department organized an International workshop "Mercury in Contaminated Sites: Characterisation, impact and Remediation". Over 60 experts from all over the world participated. The results of the workshop will contribute to the preparation of the background material for the UNEP's Partnership programme on Fate and Transport as part of the new activities for the new Hg convention to be adopted in 2013. A visit to the Idrija mercury mining area was also organized and hosted by the Mayor Mr. Bojan Sever.

The potential for the re-use of electric arc furnace (EAF) black **steel slag** as substitute for the natural aggregates in asphalt layers was estimated. Long-term environmental impacts were investigated by the use of leachability tests based on diffusion.

The emission of heavy metals and persistent organic pollutants in Slovenia in 2010 were calculated based on data for BAT (Best Available Technologies) for industry and the energy sector.

The CLRTAP (Convention on Long - Rang Transboundary Air Pollution) questionnaire for NO_x, SO_x, VOC, HM and POPs was elaborated, where national legislation was taken into account. In collaboration with the Environmental Agency of Slovenia and the Chemicals Office of Slovenia, the department also participated in reporting to the European Commission, following the POPs Protocol and Stockholm Convention.

In collaboration with the University of Exeter, Great Britain, arsenic-contaminated soil samples from Cornwall were studied. A new method utilizing continuous leaching with artificial gastric juice and mathematical modelling was developed for the assessment of the bioavailability of some selected

elements. Although the distribution coefficients between soil and gastric juice were very similar for all the elements studied (B, Sr, Cd, Co, Mn and Ni), leaching was different due to the different diffusion patterns of particular elements from the soil particles. In another study the total arsenic content in arsenic-contaminated soil was compared with the arsenic content in some native Cornwall plants (bramble, gorse and heather). The main conclusion of this study was that plants take up very little arsenic, allowing them successful colonization of highly toxic waste grounds in Cornwall.

Within the frame of a bilateral co-operation with Brazil for the period 2010-2012 (BI-BR/10-12-002) we started to monitor the environmental exposure to arsenic.

In collaboration with the Department of Inorganic Chemistry and Technology (K-1) a technology for the low-cost removal of mercury in flue-gas desulhurisation equipment was further developed. In October 2010 an International workshop "Mercury in contaminated sites: characterisation, impacts and remediation" was organized.

ENVIRONMENTAL MONITORING AND BIOMONIROING

Human biomonitoring programme continued and involves our department as well as the National Chemical Bureau of the Republic of Slovenia, University Medical Centre Ljubljana and Institutes of Public Health over Slovenia. Within this research, the concentrations of toxic metals (cadmium, lead, mercury) and persistent organic pollutants (dioxins, furans, pesticides, polychlorinated biphenyls, polybrominated flame retardants) in body fluids (blood, breast milk, urine) and hair are followed. The obtained results will be the basis for a determination of reference values and an estimation of human exposure to selected environmental pollutants. In September a new EU Life+ project DEMO-COPHES started, which represents a demonstration (pilot) study of the European human biomonitoring programme COPHES. Overall, it meets the goals of the action plan of the European Environment and Health Strategy. In the pilot phase children and their mothers and men will be included in a study where endocrine disrupters (phthalates and Bisfenol A), mercury, cadmium and cotinine will be measured in biomarkers of exposure. This study compliments the Slovenian human biomonitoring, (www.biomonitoring.si) and other similar studies such as PHIME (www.phime.org).

In the framework of the EU project HYDRONET, which aims at the development of remotely operated sensitized robots for water monitoring (i.e., intelligent monitoring systems), scenarios for the coastal lagoons and coastal environments were developed, including the basis for the development of databases.

The department actively participates in the international **biomonitoring** programme coordinated by UNECE ICP-Vegetation (International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops) using mosses as the biomonitors of atmospheric heavy metal and nitrogen deposition. Temporal trends in heavy-metal accumulation in mosses in Europe showed a decline for a great majority of the investigated metals after 1990, especially in the northern and western parts of Europe, while in some eastern countries pollution is still high in comparison to others. In recent times a moderate to high correlation between cadmium and lead concentrations in mosses and modelled deposition values as obtained by the EMEP programme were found. These results are very promising and give more weight to biomonitoring methods, on the one hand, and on the other hand they can serve as a tool to modify EMEP models, especially considering the intrinsic uncertainties of EMEP models based on emissions data with high uncertainties obtained from a too sparse resolution.

In collaboration with the Environmental Agency of the Republic of Slovenia, the **monitoring of metals** and organotins in sea water and surface waters continued in 2010. Also, elemental Hg in the air and Hg in precipitation was continously measured.

We participated in the Off–Site Monitoring of **Krško Nuclear power plant** with determining strontium and tritium in environmental samples. We determined the tritium and C-14 in gas effluents from the Nuclear power plant Krško.

In Velenje Coal Mine, regular analyses of the **molecular and isotope composition of coal-bed gases** ahead of the working face and along the delivery and exit roadways are performed. These data will be used as a basis for an integrated structural-tectonic-geochemical model of the Velenje coal basin, necessary for forecasting gas outbursts.

In collaboration with the National Institute of Biology, a regular environmental quality monitoring programme was set up, where seawater is analysed and the mussel *Mytilus galloprovincialis* from Slovenian mussel farms is used as a biomonitor for temperature, salinity and changes of the nutrient sources based on $\delta^{13}C$, $\delta^{15}N$ and ^{129}I activity.

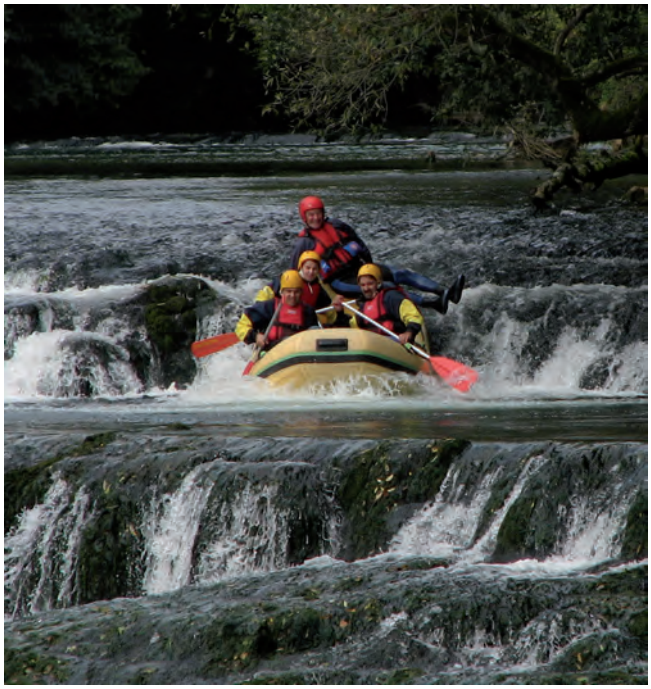

Figure 4: To estimate the uncertainty of palaeoenvironmental archives, in-situ calibration with parallel comparison of different proxies from the same time period is essential: sampling of tufa from bariers at Žužemberk, Krka river, Slovenia

The department participated in the maintenance of the **EU database** on the isotopic composition of wine, as well as the GNIP (Global Network of Isotope in Precipitation) and GNIR (Global Network of Isotopes in Rivers) databases, coordinated by the IAEA.

Ecological laboratory with a mobile unit: The department is responsible for the management of the active mobile chemical laboratory ELME (ecological laboratory with a mobile unit), which is aimed at effective action in environmental accidents with hazardous materials, determining the parameters of the field, to assess the impact of pollution on the environment and human health and consultation to neutralise the effects of pollution. The chemical mobile unit had six interventions in 2010 and also participated in the national environmental cleansing campaign "Clean Slovenia".

Risk and environmental impact assessments

Work in 2009 was primarily associated with risk evaluations for industry. We prepared safety reports for Nafta Petrochem d.o.o. and a tank farm in Ortnek (storage of gasoline and diesel), and contributed a risk assessment for a hazardous waste-storage facility managed by Snaga d.o.o. in Ljubljana and the power station TE-TOL in Ljubljana. In 2010 we started consultancy activities related to the new NPP unit in Krško; this was an environmental/spatial evaluation for the purpose of a successful licensing process. Work on the EU project "iNTeg-Risk" involves the integration of strategic, sustainable and project level environmental evaluation with spatial planning for new emerging risk technologies; a special handbook has been prepared in this context. The work on the "ArcRisk" project has been focused on the preparation of a process-evaluation plan aimed at ensuring the ultimate project results according to a "fit-for-purpose" approach. The project "CIVITAS ELAN" is aimed at improving the traffic situation in selected European cities (Brno, Gent, Ljubljana, Porto and Zagreb); our work in 2010 was a continuation of the evaluation of the impact and the success of the measures implemented in Ljubljana.

Some outstanding publications in the past year

1. Zuliani, Tea, Lespes, Gaëtane, Milačič, Radmila, Ščančar, Janez. Development of the extraction method for the simultaneous determination of butyl-, phenyl- and octyltin compounds in sewage sludge. Talanta, 2010, 80, 1945-1951.
2. Murko, Simona, Ščančar, Janez, Milačič, Radmila. Rapid fractionation of Al in human serum by the use of HiTrap desalting size exclusion column with ICP-MS detection. J. Anal. At. Spectrom., 2011, 26, 86-93.
3. Miklavčič, Ana, Stibilj, Vekoslava, Heath, Ester, Polak, Tomaž, Tratnik, Janja, Klavž, Janez, Mazej, Darja, Horvat, Milena. Mercury, selenium, PCBs and fatty acids in fresh and canned fish available on the Slovenian market. Food chem.. [Print ed.], 2010, vol. 124, issue 3, str. 711-720, doi: 10.1016/j.foodchem.2010.06.040.
4. Kosjek, Tina, Heath, Ester. Tools for evaluating selective serotonin re-uptake inhibitor residues as environmental contaminants. TrAC, Trends anal. chem. (Regul. ed.), 2010, vol. 29, issue 8, str. 832-847, doi: 10.1016/j.trac.2010.04.012.
5. Marko Štrok, Borut Smodiš: Fractionation pf natural radionuclides in soils from the vicinity of a former uranium mine Žirovski vrh, Slovenia, Journal of Environmental Radioactivity 101 (2010) 22-28.
6. Cuderman, Petra, Stibilj, Vekoslava. Stability od Se species in plant extracts rich in phenolic substances. Anal. bioanal. chem., 2010, issue 4, vol. 396, str. 1433-1439, doi: 10.1007/s00216-009-3324-5.
7. Kontić D., Gerbec M. (2010). Bridging the gap between risk assessment and land-use planning. In: Risk Management, Eds.: B. Jordao and E.Sousa, ISBN: 978-1-60876-011-4, Nova Science Publishers, Inc., pp. 89-124
8. Kocman, David, Horvat, Milena. A laboratory based experimental study of mercury emission from contaminated soils in the River Idrijca catchment. Atmos. chem. phys. (Print), 2010, vol. 10, no. 3, str. 1417-1426.
9. Šturm, Martina, Kacjan-Maršić, Nina, Zupanc, Vesna, Bračič-Železnik, Branka, Lojen, Sonja, Pintar, Marina. Effect of different fertilisation and irrigation practices on yield, nitrogen uptake anf fertiliser use efficiency of white cabbage. Sci. hortic. [Print ed.], 2010, vol. 125, str. 103-109.

Awards and appointments

1. Tina Kosjek: "Occurrence, Fate And Removal Of Pharmaceutical Residues In Water Treatment", Krka Award for doctoral thesis

Organization of conferences, congress and meetings

1. Milena Horvat: Workshop "Mercury in contaminated sites: Characterization, impacts and remediation", Piran, Slovenia, 11. 10.-15. 10. 2010

2. Ljudmila Benedik: Training courses: "Training in radiochemistry measurements for practitioners from countries eligible under the JRC Enlargement & Integration Policy", Ljubljana, Slovenia
   10. – 21. May 2010
   13. - 24. September 2010
   18. – 19. October 2010
   15. – 26. November 2010
3. Milena Horvat: PHIME Meeting, Ljubljana, Slovenia, 10. 12. 2010

INTERNATIONAL PROJECTS

1. Global Mercury Observation System
   GMOS
   7. FP, 265113
   EC; Prof. Nicola Pirrone, CNR - Consiglio Nazionale delle Ricerche, Rome; Mario Gensini, CNR - Istituto sull'Inquinamento Atmosferico Sezione di Rende, c/o Polifunzionale UNICAL, Rende, Italy
   Prof. Milena Horvat
2. Coordinating Earth and Environmental Cross-Disciplinary Projects to promote GEOSS
   EGIDA
   7. FP, 265124
   EC; Pier Francesco Moretti, CNR, Consiglio Nazionale delle Ricerche, Department of Earth and Environment, Rome, Italy
   Asst. Prof. Sonja Lojen
3. European Coordinaton Action on Human Biomonitoring
   COPHES
   7. FP, 244237
   EC; Dr. Alexandra Polcher, BiPRO GmbH, Beratungsgesellschaft für integrierte Problemlösungen, München, Germany
   Prof. Milena Horvat
4. Arctic Health Risks: Impacts on Health in the Arctic and Europe Owing to Climate-induced Changes in Contaminant Cycling
   ArcRisk
   7. FP, 226534
   EC; Arctic Monitoring and Assessment Programme, Secretariat, Norway
   Prof. Milena Horvat, Prof. Branko Kontić
5. Floating Sensorised Networked Robots for Water Monitoring
   HYDRONET
   7. FP, 212790, FP7-ENV-2007-1
   EC; Dr. Monica Vignoni, Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna, Pisa, Italy
   Prof. Milena Horvat
6. Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related Risks
   iNTeg-Risk
   7. FP, 213345, NMP2-LA-2008-213345
   EC; European Virtual Institute for Integrated Risk Management, Stuttgart, Germany
   Prof. Branko Kontić, Asst. Prof. Marko Gerbec
7. Mobilising Citizens for Vital Cities Ljubljana-Gent-Zagreb-Brno-Porto
   CIVITAS-ELAN
   7. FP, 218954, TREN/FP7TR/218954
   EC; Zdenka Šimonovič, Mestna občina Ljubljana, Ljubljana, Slovenia
   Dr. Davor Kontić, Prof. Branko Kontić, Asst. Prof. Marko Gerbec
8. Public Health Impact of Long-term, Low-level Mixed Element Exposure in Susceptible Population Strata
   PHIME
   6. FP, 016253
   EC; Ingela Byström, Prof. Staffan Skerfving, Lund University Hospital, Department of Occupational and Environmental Health, Lund, Sweden
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9. Access to Technology and Know-how in Cleaner Production in Central Europe
   ACT CLEAN
   Central Europe Programme
   EC; Jakob Gross, Horst Pohle, Federal Environment Agency, Dessau-Roßlau, Germany
   Asst. Prof. Sonja Lojen, Andrej Gyergyek, B. Sc., Dr. Andrej Stergaršek
10. The Ocean Chemistry of Bioactive Trace Elements and Paleoclimate Proxies
    COST ES0801
    EC; COST Office, Brussels, Belgium
    Asst. Prof. Nives Ogrinc
11. Stable Isotopes in Atmosphere-Biosphere-Earth System Research
    SIBAE
    COST ES0806
    EC; COST Office, Brussels, Belgium
    Asst. Prof. Sonja Lojen
12. Xenobiotics in the Urban Water Cycle
    COST 636
    EC; COST Office, Brussels, Belgium
    Asst. Prof. Ester Heath
13. Conditioning of Drinking Water with Constructed Wetlands
    WETPUR
    EUREKA
    Limnos Company for Applied Ecollogy Ltd., Great Britain
    Asst. Prof. Janez Ščančar
14. Eradication of Lung Cancer Caused by Radon Gas in Azerbaijan and Slovenia
    SCOPES
    CCR-067, 127917
    Dr. Claudio Valsangiacomo, Marcus Hoffmann, Swiss University of Applied Sciences of Southern Switzerland, Scuola Universitaria Professionale della Svizzera Italiana - SUPSI, Radon Competence Centre, Trevano, Canobbio, Switzerland; SNSF- Swiss National Science Foundation, Bern, Switzerland
    Dr. Chingiz Alyiev, Geology Institute of National Academy of Science, Baku, Azerbaijan
    Asst. Prof. Janja Vaupotič
15. Assessment of Human Milk Intake in Infants Living in Gold Mining Areas in South West Nigeria, Using Stable Isotope Techniques
    16475
    IAEA, Vienna, Austria
    Dr. Darja Mazej
16. Use of Environmental Isotopes in Investigations of Influence of Snow Melt on Stream Runoff in the Area of Julian Alps, NW Slovenia
    16199/R0
    IAEA, Vienna, Austria
    Dr. Polona Vreča
17. Stable Isotope Technique to Assess Human Milk Intake in Infants Living in Areas Contaminated with Mercury, Lead and Cadmium; Stable Isotope Technique to Assess Human Milk Intake in Infants Living in Contaminated Areas
    15825/R0
    IAEA, Vienna, Austria
    Prof. Milena Horvat
18. Assessment of Potential Association of Exposure to Vehicular Lead with Nutritional Status in Women of Child-Bearing Age in Nigeria
    15628/R0
    IAEA, Vienna, Austria
    Dr. Darja Mazej
19. Isotope Investigation of the River Sava in Slovenia: Long-term Isotopic Monitoring of Surface Water and Precipitation at Selected Sites
    14343/R0, R1, R2
    IAEA, Vienna, Austria
    Asst. Prof. Nives Ogrinc
20. Nutritional Status and Exposure to Mercury and its Compounds in Pregnant Women and Women of Childbearing Age in Former Mercury Mining Site using Nuclear and other Techniques; Exposure to Toxic and Potentially Toxic Elements in Women of Childbearing Age in Developing Countries
    13250/R1, R2
    IAEA, Vienna, Austria
    Prof. Milena Horvat, Dr. Jože Kotnik
21. IAEA - Fellowship for Mr Wassim Shames
    IAEA Fellow, SYR/09024, Pr. RAS/0/059
    IAEA, Vienna, Austria
    Dr. Radojko Jaćimović

22. IAEA - Fellowship for Mr Dennis Kpakpo Adotey
IAEA Fellow, GHA/07017, Pr. GHA/0/010
IAEA, Vienna, Austria
Prof. Vekoslava Stibilj
23. Long-term Stability Study of ERM-CC141: Aqua Regia Content of Hg in Loam Soil
IRMM.B056527
European Commission, Joint Research Center JRC, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Prof. Milena Horvat
24. Characterization of Total and Aqua Regia Leachable Content of Hg
IRMM.B056068
European Commission, Joint Research Center JRC, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Prof. Milena Horvat
25. Measurements of Br Content in ERM-EC590 and ERM-EC591 for the Stability Monitoring
IRMM.B055492
Francine Vanderveken, European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
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26. Measurements of Mercury [Concentration about 2 ng/kg] for the Stability Monitoring of Reference Material BCR-579
IRMM.B055622
European Commission, Joint Research Center JRC, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
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27. Measurements of (microg/kg and mg/kg) of Methyltin Species for Stability Monitoring of BCR-462 and ERM-CE477; Analysis of Butyltin Compounds for Stabilitiy Testing
IRMM.B054278
Francine Vanderveken, European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Asst. Prof. Janez Ščančar
28. Characterisation Study of ERM-CZ120 (As and Cd in Dust)
IRMM.B054637
Dr. Marek Piascik, European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Dr. Radojko Jaćimović
29. Training in Radiochemistry and Radioactivity Measurements for Practitioners from Countries Eligible under the JRC Enlargement & Integration Policy
54018
Ivan Celen, European Commission, Joint Research Center JRC, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Asst. Prof. Ljudmila Benedik, Asst. Prof. Borut Smodiš
30. Applications of GIS Tools on Predermined Uranium Radioisotopes in Groundwater and Surface Water of Hadzici Region
BI-BA/10-11-013
Dipl. Ing. Alfred Vidic, Institute for Public Health of FB&H, Sarajevo, Bosnia and Herzegovina
Asst. Prof. Ljudmila Benedik
31. Radilogical Investigation of Areas with Potentially Enhanced Levels of Natural Radionuclides
BI-BA/10-11-019
Bojan Štrbac, M. Sc., Institut za zaštitu zdravlja Republike Srpske, Banja, Luka, Bosnia and Herzegovina
Asst. Prof. Borut Smodiš
32. Biogeochemistry of Mercury in Contaminated Coastal Environments; Coastal Lagoons in Rio Grande do Sul, Brazil and the Gulf of Trieste, Northern Adriatic
BI-BR/10-12-001
Prof. Gilberto Fillmann, University of Rio Grande - FURG - Brazil, Rio Grande, Brazil
Prof. Milena Horvat
33. Neutron Activation Analysis on the Assessment of Arsenic Resistant
BI-BR/10-12-002
Dr. Maria Angela Menezes, Nuclear Tehnology Development Center / Brazillian Commission for Nuclear Energy, (CDTN/CNEN), Belo Horizonte, Minas Gerais, Brazil
Dr. Radojko Jaćimović
34. Presence, Mobility and Persistence of Organotin Compounds in the Terrestrial Enivornment
BI-FR/09-10-PROTEUS-009
PROTEUS
Prof. Gaëtane Lespes, Laboratoire de Chimie Analytique Bioinorganique et Enivornnement (LCABIE), UMR CNRS IPREM-UPPA, France
Asst. Prof. Janez Ščančar
35. Radiochemical Methods for Determination of Radionuclides in Water Samples
BI-HR/10-11-007
Dr. Martina Rožmarić Mačefat, Ruđer Bošković Institute, Zagreb, Croatia
Asst. Prof. Ljudmila Benedik
36. Study of Defects in Semiconductors Irradiated by Fast Neutrons
BI-HR/09-10-027
Dr. Sc. Branko Pivac, Ruđer Bošković Institute, Zagreb, Croatia
Dr. Radojko Jaćimović
37. Pollution of Croatian and Slovenian Northern Adriatic Coast with Organotin Compounds and Toxic Metals studied by Different Analytical Techniques
BI-HR/09-10-025
Dr. Nevenka Mikac, Ruđer Bošković Institute, Zagreb, Croatia
Asst. Prof. Janez Ščančar
38. Isotopic Composition of Precipitation in Croatia and Slovenia
BI-HR/09-10-032
Dr. Ines Krajcar Bronić, Ruđer Bošković Institute, Zagreb, Croatia
Dr. Polona Vreča
39. Preparation of Environmental Samples for I-129 Determination with Accelerator Mass Spectrometry
BI-JP/10-12/A-004
Dr. Suzuki Takashi, Japan Atomic Energy Agency, Aomori, Japan
Dr. Andrej Osterc
40. Where Radon (Gaseous Soil Component) is coming from?
BI-JP/10-12-002
Asst. Prof. Ryoko Fujiyoshi, Hokkaido University, Graduate School of Engineering, Division of Quantum Science and Engineering, Sapporo, Japan
Asst. Prof. Janja Vaupotič
41. Cycling of Mercury in Contaminated Environments
BI-JP/08-10/005
Prof. Takashi Tomiyasu, Kagoshima University, Department of Earth and Environmental Science, Faculty of Science, Kagoshima, Japan
Prof. Milena Horvat
42. Biomarkers of Exposure and Effects in Sensitive Population Groups Living in Contaminated Sites
BI-CN/09-11-007
Prof. Chunying Chen, Key Lab for Nuclear Analytical Techniques, Insitute of High Energy Physics (IHEP), Chinese Academy of Sciences (CAS), Beijing, China
Prof. Milena Horvat
43. Environmental Impacts and Restoration after Closure of Wanshan Mercury Mine, Guizhou Province, China and the Comparison with Idrijca Mercury Mine, Slovenia
BI-CN/09-11-025
Dr. Feng Xinbin, State Key Laboratory of Environmental Geochemisty, Institute of Geochemistry, Chinese Academy of Science, Guiyang, China
Dr. Jože Kotnik
44. Determination of Radilogical Situation at the Areas with Elevated Natural Radiation in Slovenia and in Poland
BI-PL/10-11-006
Dr. Krzysztof Kozak, Institute of Nuclear Physics, Polish Academy of Science, Kraków, Poland
Asst. Prof. Janja Vaupotič
45. Accumulation of Mercury and Methylmercury in Natural Forest Sites in Switzerland
U3-12/06
Dr. Beat Frey, Swiss Federal Research Institute WSL, Soil Sciences, Birmensdorf, Switzerland
Prof. Milena Horvat
46. Hydrogeochemistry of Carbonate Weathering Fluxes at the Terrestrial/Marine Interface of the Adriatic Sea: A Collaborative Field Study
BI-US/09-12-015
Prof. Walter Lynn M., University of Michigan, Geological Sciences, Ann Arbor, MI, USA
Asst. Prof. Nives Ogrinc
47. Exchange of Toxic Metals between Eater and Sediment in Polluted Freshwater Systems: The Idrijca River System (Slovenia) and Lake Coeur d'Alene (USA)
BI-US/08-10-015
Prof. Timothy Ginn, Department of Civil & Environmental Engineering, University of California, Davis, CA, USA
Prof. Milena Horvat

R & D GRANTS AND CONTRACTS

1. Chemical and Biological Cycling of Compounds with Endocrine Disrupting Function in Wastewater Treatment
Asst. Prof. Janez Ščančar
2. CO2 Fixation in River Carbonates: Mass Balance, Hydrological, Geochemical and Biochemical Controls
Asst. Prof. Sonja Lojen
3. Farming Possibilities in Water Protection Areas
Asst. Prof. Sonja Lojen
4. Assessment of the Risk From Metal Contaminated Soils and Aerosols to Human Health Through Advanced In Vitro Gastrointestinal and Respiratory Bioaccessibility tests
Asst. Prof. Zdenka Šlejkovec
5. Influence of Arsenic Trioxide Metabolites on Treatment of Various Cancer Types
Asst. Prof. Zdenka Šlejkovec
6. Vulnerability Assessment and Identification of Suitable Remediation Measures in a Degraded Ecosystem – a Case Study of the Idrija Mercury Mine Region
Dr. David Kocman
7. Psychoactive Pharmaceuticals and Their Transformation Products in Water Treatment Processes
Dr. Tina Kosjek
8. Sequestration of CO2 in Geological Media: Criteria and Approach for Site Selection in Response to Climate Change
Dr. Tjaša Kanduč
9. Efficiency of SEA and Health Impact Assessment in Strategic Evaluation of Plans and Programmes in Slovenia
Prof. Branko Kontić

10. Integrated Methodology for Remediation of Hg Contaminated Site
    Prof. Milena Horvat
11. Modelling Hydrodinamics, Transport of Suspended matter and Pollutants Using SPH
    Prof. Milena Horvat
12. Interaction of Organic Matter with Metals in Coastal Waters of the Gulf of Trieste
    Prof. Milena Horvat
13. Climate Change and Impacts of Anthropogenic Disturbances on Primary Production in Forest Soil
    Prof. Nives Ogrinc
14. Comparison of Two Production Forest Systems in the Light of Climate Change
    Prof. Nives Ogrinc
15. The Impact of Climate Change on the Sustainability, Stability and Biodiversity of Beech and Black Pine Stands in the Balkans
    Prof. Nives Ogrinc
16. The Impact of Environmental Changes to the Growing Response of Oak (Quercus robur L.) and Larch (Larix decidua Mill.)
    Prof. Nives Ogrinc
17. Deforested Karst Grasslands and Their Changes in Sink Activities for Carbon
    Prof. Nives Ogrinc
18. The Use of Isotope Dilution Inductively Coupled Plasma Mass Spectrometry Technique in Environmental Studies
    Prof. Radmila Milačič
19. Establishment of Ratio Between 129-I and 127-I in Marine and Terrestial Environment in Slovenia
    Prof. Vekoslava Stibilj
20. The Effect of Selenium on the Harvest and Quality of Crops
    Prof. Vekoslava Stibilj

RESEARCH PROGRAMS

1. Cycling of Substances in the Environment, Mass Balances, Modelling of Environmental Processes and Risk assessment
   Prof. Milena Horvat
2. Modelling and environmental impact assessment of processes and energy technologies
   Asst. Prof. Borut Smodiš

NEW CONTRACTS

1. Sequestration of CO_2 in geological media: criteria and approach for site selection in response to climate change
   Coal Mine Velenje - Premogovnik Velenje, d.d.
   Dr. Tjaša Kanduč
2. CLRTAP reporting and the preparation of a common base emission inventory of POPs and HMS
   Ministry of the Environment and Spatial Planning, Environmental
   Dr. Tjaša Kanduč
3. Analyses of selected metals, mercury and organotin compounds in water and cadmium and mercury in sediment and mussels.
   Ministry of the Environment and Spatial Planning, Environmental
   Asst. Prof. Janez Ščančar
4. Consultancy in the field of the environmental impacts associated to NPP Krško 2 project GEN d.o.o.
   Prof. Branko Kontić
5. Co-financing of activities of holder of national standard in 2010 - amount of substance / soil
   Ministry of Higher Education, Science and Technology
   Dr. Polona Vreča

MENTORING

Ph. D. Theses

1. Petra Cuderman, *Selenocompounds in selenium-enriched plants determined by spectrometric methods* (mentor Vekoslava Stibilj)
2. Simona Murko, *Speciation of aluminium in human serum by CIM (convective interaction media) monolithic chromatography and mass spectrometry* (mentor Janez Ščančar; co-mentor Radmila Milačič)

M. Sc. Thesis

1. Simona Golob, *Recycling of grinding slime from automotive industry* (mentor Radmila Milačič)

VISITORS FROM ABROAD

1. Wassim Shames, Atomic Energy Commission of Syria, Kafar Souseh, Damascus, Syria, 1. 2. 2010 do 28. 2. 2010
2. dr. Jorge Ricardo Ruelas Inzunza, Instituto Technológico del Mar, Apdo., Mazatlan, Mexico, 1. 2.-18. 2. 2010
3. Dennis Kpakpo Adotey, Ghana Atomic Energy Commission, Accra, Ghana, 12. 1.-14. 4. 2010
4. Roguer Edmundo Placencia Gomez, Helsinki University of Technology, Espoo, Finland, 28. 2.-30. 7. 2010
5. Llanos Lazscano Willans R., University of Castilla-La Mancha, Castilla-La Mancha, Spain, 15. 3.-15. 5. 2010
6. prof. dr. Nevenka Mikac, Martina Furtek, Rudjer Bošković Institute, Zagreb, Croatia, 8. 4. 2010
7. prof. Akihide Tada, Prof. Takuji Tomiyasu, dr. Akito Matsuyama, Asst. prof. Shin-ichirou Yano, Kohei Yano, Ryuji Fujiwara, Nagasaki University, Kyushu University, Kagoshima Univetsity, National Institute of Minamata Disease, Minamata, Japan, 6. 5.-10. 5. 2010
8. dr. Maria Angela De Barros Correia Menezes, CDTN/CNEN, Belo Horizonte, Brazil, 26. 4.-14. 5. 2010
9. dr. Uwe Wajten, IRMM, Geel, Bruselj; Dr. Abdullah DIRICAN, Ms. Simay YÜKSEK, Ms. Funda BARLAS ŞİMŞEK, Dr. Günay YÜCE, Ms. Sultan UZUN, Turkish Atomic Energy Authority, Istanbul, Ankara, Turkey; dr. Martina ROŽMARIĆ MAČEFAT, Rudjer Bošković Institute, Zagreb, Croatia, 10. 5.-21. 5. 2010
10. prof. dr. Kip Douglas Salomon, The University of Utah, Salt Lake City, USA, 31. 5.-5. 6. 2010
11. prof. dr. Brian Shutes, Middlesex University, Department: School of Health and Social Sciences, London, UK, 3. 6. 2010
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13. Alfred Vidic, Institute for Public Health of FB&H, Sarajevo, Bosnia and Herzegovina, 21. 6.-2. 7. 2010
14. Matea Rogić, Rudjer Bošković Institute, Zagreb, Croatia, 27. 6.-2. 7. 2010
15. Zorana Ilič, Institute for Public Health of FB&H, Sarajevo, Bosnia and Herzegovina, 28. 6.-2. 7. 2010
16. prof. Akihide Tada, Prof. Takashi Tomiyasu, dr. Akito Matsuyama, Asst. prof. Shin-Ichiro Yano, Nagasaki University, Kyushu University, Kagoshima Univetsity, National Institute of Minamata Disease, Minamata, Japan, 27. 8.-31. 8. 2010
17. prof. Louis Bloemen, EHSI, Netherlands, 29. 8.-31. 8. 2010
18. Rossitza Borissova Karaivanova, Iva Ivanova Peshtenska, Novi han Permanent Repository for Radioactive Waste, Sofija, Republic of Bulgaria; Matea Rogić, Rudjer Bošković Institute, Zagreb, Croatia; Ranka Žižić, Ranko Zekić, Center for Eco-Toxicological Research of Montenegro, Podgorica, Montenegro, 13. 9.-24. 9. 2010
19. prof. Ryoko Fujiyoshi, Yosuke Sakuta, Naoki Takekoshi, Faculty of Engineering, Hokkaido University, Sapporo, Japan, 27. 9.-3. 10. 2010
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24. prof. dr. Takashi Tomiyasu, Faculty of Science, Kagoshima University, Korimoto, Kagoshima, Japan; prof. Akihide Tada, Faculty of Engineering, Nagasaki University, Japan, dr. Akito Matsuyama, National Institute For Minamata Disease 15. 10.-16. 10. 2010
25. Božena Skoko, IMI, Zagreb, Croatia; Safija Islamović, Faculty of Science, University of Sarajevo, Sarajevo, Bosna In Hercegovina; Edda Prodan, Institute of Public Health "Prof. Dr. Iuliu Moldovan", Cluj-Napoca, Romania, Tsvetan Nedyalkov Piperov , Novi han Permanent Repository for Radioactive Waste, Sofia, Bulgaria, 18. 10.-29. 10. 2010
26. dr. Martina Rožmarić Mačefat, Rudjer Bošković Institute, Zagreb, Croatia, 7. 11.-12. 11. 2010
27. dr. Uwe Wajten, IRMM, Gell, Belgija; Dimitrios Xarchoulakos , Greek Atomic Energy Commission, Attiki, Greece; Ms. Snežana Dimovska, Institute of Public Health, Skopje, Republic of Macedonia; Ms. Mihaela G. Bragea Institute of Public Health, Timisoara, Romania, Ms. Andreea Grigorescu, Institute of Public Health Iaşi, Iaşi, Romania; Bojan Šešlak Institute of Nuclear Sciences "Vinča", Belgrade, Serbia, 15. 11.-26. 11. 2010
28. dr. Ines Krajcar Bronić, Rudjer Bošković Institute, Zagreb, Croatia, 8. 12.-14. 12. 2010

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26. Dr. Andrej Osterc
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34. Anže Martinčič, B. Sc.
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55. Stojan Žigon

BIBLIOGRAPHY

Original Articles

1. Indre Antanaitis-Jacobs, Mike Richard, Linas Daugnora, Rimantas Jankauskas, Nives Ogrinc, "Diet in early Lithuanian prehistory and the new stable isotope evidence", *Archaeol. Balt.*, vol. 12, pp. 12-30, 2010.
2. Maria Arribére, María C. Diéguez, Sergio Ribeiro Guevara, Claudia P. Queimaliños, Vesna Fajon, Mariana Reissing, Milena Horvat, "Mercury in an ultraoligotrophic North Patagonian Andean lake (Argentina): concentration patterns in different components of the water column", *J. Environ. Sci. (China)*, vol. 22, no. 8, pp. 1171-1178, 2010.
3. Karmen Bat, Branka Mozetič Vodopivec, Nives Ogrinc, Ines Mulič, "Metode iskanja potvorb v sadnih sokovih", *Sad (Krško)*, vol. 21, no. 9, pp. 4-5, sep. 2010.
4. Michael Philip Beeston, Andrej Pohar, Johannes Teun van Elteren, Igor Plazl, Zdenka Šlejkovec, Marjan Veber, Hylke J. Glass, "Assessment of physical leaching processes of some elements in soil upon ingestion by continuous leaching and modeling", *Environ. sci. technol.*, vol. 44, issue 16, pp. 6242-6248, 2010.
5. László Bencze, Radmila Milačič, Radojko Jaćimović, Dušan Žigon, László Mátyás, Arkadije Popović, "Knudsen effusion mass spectrometric determination of mixing thermodynamic data of liquid Al-Cu-Sn alloy", *Int. j. mass spectrom.*, vol. 289, no. 1, pp. 11-29, 2010.
6. Ljudmila Benedik, Urška Repinc, Marko Štrok, "Evaluation of procedures for determination of Ra-226 in water by [alpha]-particle spectrometry with emphasis on the recovery", In: *ICRM 2009, Proceedings*, (Applied Radiation and Isotopes, Vol. 68, Iss. 7-8), 17th International Conference on Radionuclide Metrology and its Applications, ICRM 2009, September 7-11, 2009, Bratislava, Bratislava, 2010, pp. 1221-1225.
7. Mihael Brenčič, Polona Vreča, "The use of a finite mixture distribution model in bottled water characterisation and authentication with stable hydrogen, oxygen and carbon isotopes - case study from Slovenia", *J. geochem. explor.*, vol. 107, no. 3, pp. 391-399, 2010.
8. Richard J. C. Brown, Milena Horvat, Jože Kotnik, (9 authors), "Standardisation of a European measurement method for the determination of mercury in deposition: results of the field trial campaign and determination of a measurement uncertainty and working range", *Accredit. qual. assur.*, issue 6, vol. 15, pp. 359-366, 2010.
9. Ivana Capan, B. Pivac, I.D. Hawkins, V.P. Markevich, A.R. Peaker, L. Dobaczewski, Radojko Jaćimović, "Neutron-irradiation-induced defects in germanium: a Laplace deep level transient spectroscopy study", In: *Proceedings of the 12th Joint Vacuum Conference, 10th European Vacuum Conference and 7th Annual Meeting of the German Vacuum Society (JVC-12/EVC-10/AMDVG-7), Balatonalmadi, Hungary, 22 - 26 September 2008*, (Vacuum, vol. 84, no. 1), Sándor Bohátka, ed., Béla Pécz, ed., András Berkó, ed., Oxford, New York, Pergamon Press, 2010, pp. 32-36.
10. Petra Cuderman, Ljerka Ožbolt, Ivan Kreft, Vekoslava Stibilj, "Extraction of Se species in buckwheat sprouts grown from seeds soaked in various Se solutions", *Food chem.*, vol. 123, issue 3, pp. 941-948, 2010.
11. Petra Cuderman, Vekoslava Stibilj, "How safe are anrioxidant food supplements containing selenium?", *Acta chim. slov.*, vol. 57, pp. 668-676, 2010.
12. Petra Cuderman, Vekoslava Stibilj, "Stability od Se species in plant extracts rich in phenolic substances", *Anal. bioanal. chem.*, issue 4, vol. 396, pp. 1433-1439, 2010.
13. Marko Černe, Borut Smodiš, Marko Štrok, Radojko Jaćimović, "Accumulation of [sup]226Ra, [sup]238U and [sup]230Th by wetland plants in a vicinity of U-mill tailings at Žirovski vrh (Slovenia)", In: *Proceedigs of the 16th Radiochemical Conference, RadChem 2010, 18-23rd April 2010, Marianske Lazne, Czech Republic*, (Journal of radioanalytical and nuclear chemistry, vol. 286, no. 2), Lausanne, Elsevier, Budapest, Akadémiai K, 2010, pp. 323-327.
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DEPARTMENT OF AUTOMATION, BIOCYBERNETICS AND ROBOTICS E-1

Our research brings together different fields of automatics, robotics, biocybernetics, kinesiology and environmental medicine. Most of the research topics are connected to the so-called "movement of man and machine" and its connection and interaction with the environment. The aim is to make available advanced knowledge, as well as to develop and transfer systems and technologies to our customers in industry, medicine and sport.

Head:
Asst. Prof. Leon Žlajpah

During the past year, the main research topics in the department included humanoid robotics, control of robot systems and learning strategies, studies of human physiology in extreme environments, evaluation of protective equipment, development of biomedical devices and methods, and the robotics and automation of industrial manufacturing.

In 2010, we successfully completed an EU integrated project, PACO+: "Perception, action, and cognition through learning of object-action complexes". The aim of PACO+ was to design a cognitive robot that is able to develop perceptual, behavioural and cognitive categories in a measurable way and to communicate and share these with humans and other artificial agents. For this purpose we developed (together with other project partners) a formal definition of Object-Action Complexes (OACs), which provides the basis for a symbolic representation of sensorimotor experiences and behaviours. OACs combine the properties of action formalization that have been discussed in recent decades. They are a dynamic, learnable, refinable and grounded representation that binds objects, actions, and attributes in a causal model. OACs have the ability to carry low-level (sensorimotor) as well as high-level (symbolic) information and can therefore be used to join the perception-action space of an agent with its planning-reasoning space. In addition, OACs can be combined to produce more complex behaviours and sequenced as part of a plan-generation process. We demonstrated the effectiveness of the proposed formalism by integrating complex sensorimotor behaviours such as pushing and grasping with planning.

OACs have the ability to carry low-level as well as high-level information and can therefore be used to join the perception-action space of an agent with its planning-reasoning space. In addition, OACs can be combined to produce more complex behaviours and sequenced as part of a plan-generation process.

In the frame of the ARRS project "Goal-directed action synthesis using a library of example movements" and in collaboration with ATR Computational Neuroscience Laboratories, Kyoto, Japan, we developed a new mechanism for the task-specific generalization of movements encoded by dynamic movement primitives. New actions are synthesized by the application of statistical methods, where the goal and other characteristics of an action are utilized as queries to create a suitable control policy, while taking into account the current state of the world. The proposed approach enables the generation of a wide range of policies without requiring an expert to modify the underlying representations to account for different task-specific features and perceptual feedback. We showed that the proposed methodology can be integrated with an active vision system of a humanoid robot, where 3-D vision data are used to provide query points for a statistical generalization. The approach has proven to be effective for the realization of various robotic tasks, including reaching, grasping, drumming, wiping and ball throwing.

We applied the research on methods for the control of periodic motion to different devices, e.g., to the yo-yo, the gyroscopic toy called the Powerball and the pendulum. We showed for all of the devices mentioned, that our system for movement imitation, which is based on adaptive frequency oscillators and a statistical learning method, can be effectively used for the synchronization of the motion of the robot and the actuated device. In this way we improved the previously achieved results of robotic control for the devices mentioned. We also adapted the method to allow performing movements, which cannot be attained using simple modulation, but have to be attained using a generalization between different demonstrations.

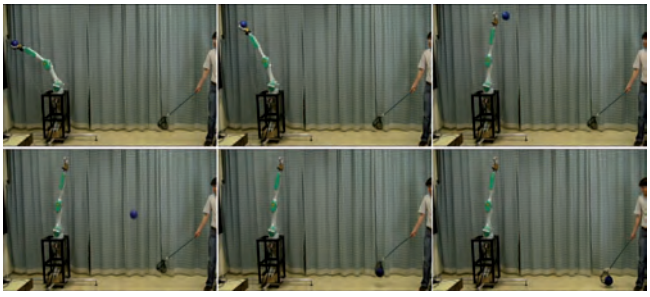

Figure 1: The trajectory-generalization algorithm works for tasks where the final position of the robot is not explicitly connected to the target, as is the case in throwing. The robot has successfully generalized from the set of recorded trajectories and has hit the target within the area bounded by the edge-demonstration trajectories. During generalization it has generated new trajectories for every throw.

Modern trends in robotics are oriented towards new types of biologically inspired actuators. It is a common belief that these actuators should have a certain amount of cognitive capabilities. In order to develop cognitive machines, we are developing new types of algorithms and control methods for

Figure 2: For the evaluation of the thermal and evaporative resistance of gloves, while holding objects in cold environments, we have developed a thermal-evaporative manikin of a human hand with movable fingers.

The results of the research suggest that the type of the feedback provided to the person affects the reaction time and the energy expenditure of controlling the robotic task.

controlling artificial, vertebral-like motor-sensory systems. These actuators will be composed of an array of binary-actuated electrical sensitive elastomers. Different artificial neural network topologies and structures are being used in order to identify an optimal control approach. A novel activation strategy was proposed for electro-sensitive elastomers, which is based on a custom electronic driver derived from the flyback transformer topology. Additionally, the actuators' mechanical design and materials are a major issue that needs to be addressed thoroughly. This research is being carried out in collaboration with the University of Bologna, Italy.

The detection and recognition of abnormal events (such as falls) or unexpected behaviours that may be related to a health problem in the elderly has been studied in the framework of the European project "Ubiquitous Care System to Support Independent Living" (CONFIDENCE). Using a motion-capture system, we measured the motion of individuals during different everyday situations and abnormal behaviour, like characteristic falls or motion influenced by typical pathologies associated with the elderly. After the motion capture and tracking of 12 markers, the trajectories of characteristic points of the human body were used as the input for analysis, modelling and recognition. This information was then used in a system with advanced functionality for the supervision of the elderly.

In the context of robot-motion synthesis that uses the human ability of visuomotor learning, we completed a series of experiments on humanoid-robot balance-control. The focus of the research was on the feedback connection between the robot and the human, specifically we analysed the visual and vestibular feedback loops. We addressed the question of whether a human can learn to generate the appropriate motor commands of the humanoid robot to maintain its posture using the human-in-the-loop paradigm. Moreover, we evaluated and compared the suitability of the visual and vestibular feedback for the control of posture with induced perturbations. The results of the research suggest that the type of the feedback provided to the person affects the reaction time and the energy expenditure of controlling the robotic task. Specifically, the results suggest that by utilization of the vestibular feedback, both the reaction time and the energy expenditure decrease significantly. The conducted research represents the basis for planned future work in the synthesis of more complex motions of the humanoid robot.

An extensive experimental study of human motion was carried out to elucidate the mechanisms in the central nervous system that are responsible for planning and executing the motion of the whole human body. We used a novel experimental approach where we induced postural perturbations to the subjects during the execution of the task motion. During the repetitions of the task motions, the subjects used their learning ability to compensate the postural perturbations. We recorded the motion of the subjects during this adaptation and analysed the obtained trajectories. Our results confirmed the hypothesis of the existence of the internal models in the human brain that are believed to be responsible for the control of the bodily motions and for the learning of novel motions. The results of the study significantly contribute to the understanding of the part of the brain that is responsible for the motor control.

Our research was focused on supervised and unsupervised learning in robotics. The aim of the supervised learning was to determine a function model from a set of training data and to predict the value of the function for any valid input object after having seen a number of training examples. The resulting model can mimic the responses of a teacher who provides two sets of observations: inputs and the corresponding desired outputs. In contrast, in unsupervised learning an agent learns from the interaction with its environment, rather than from a knowledgeable teacher that specifies the action the agent should take in any given state. The robot agent is required to learn from the data set by itself. Our approach of supervised learning is based on previously captured human demonstrated trajectories with the optical tracking system, representation of the task using the dynamic motion primitives and adaptation and generalization of the task to the specific robot. When using the dynamic motion primitives in conjunction with reinforcement learning, the problem of simultaneous learning of the goal and weight parameters

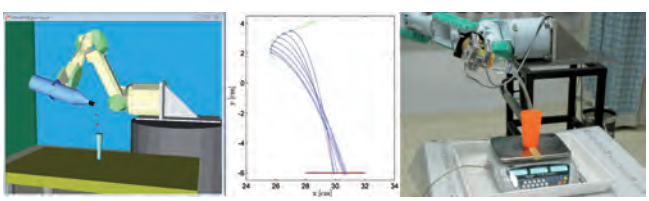

Figure 3: Reinforcement learning of pouring: Learning in a simulated environment (left), liquid trace during the learning (middle), experiment with the robot Mitsubishi PA-10.

arises. We have proposed a solution by combining two reinforcement learning techniques, one for the goal learning and one for the weights learning. The developed learning algorithms were experimentally verified on challenging robot tasks like "Kendama" and liquid pouring.

In this year we continued our cooperation with a company that develops and produces a large range of various glass products. First, we have mainly evaluated the present, predominantly manual, production operation, quantified and formalized various glass-manufacturing technologies. Then we have developed, discovered and synthesized new production procedures, which are better tailored for automatic execution. We have developed various prototypes to perform measurements, tests and experiments. In the last phase we will develop automatic components, subsystems and production cells aimed to automate the execution of glass-production tasks in the customer's production facility. To successfully complete this last step, we also have to resolve all the requirements of a 24/7 work cycle, and additional needs that arise in a specific, harsh and demanding production environment.

Figure 4: Computer-controlled shaping operation of a glass melted semi-product.

Based on the analysis of a production cell in the last year, we targeted one production phase: the shaping of glass melted semi-products. We predict this as a critical phase, for which an appropriate solution is absolutely required in order to carry out a successful automation of the whole cell. Building on the outcomes of previous tests on prototype components, we developed new, modified prototype subsystems and tested them in the final environment. Next, we started the development of an automated production device/machine that will be able to operate on a large number of different items. An important part of the development activities is represented by the software programming system that will implement the developed sensory, recognition and control algorithms. We also developed some crucial mechanotronic and electromechanical components that need to withstand round-the-clock operation.

The observation that high-altitude exposure may lead to considerable weight loss, has led to the suggestion that it might be beneficial to incorporate hypoxic training in weight-management programmes for obese individuals.

Physical performance capacity is a key factor in the quality of life. Inactivity and poor nutrition may lead to overall deconditioning, including muscle atrophy, bone osteoporosis, and a reduction in aerobic capacity. Not surprisingly, much research to date has focused on understanding the process and mechanisms of the deconditioning of physiological systems, due to ageing, illness and/or inactivity, and on measures that may prevent or minimize such deconditioning. Hypoxia is one such factor, which both limits performance, but paradoxically also causes changes, which may ultimately improve the performance in athletes. Whether such changes might help patients suffering from chronic hypoxia, or inactivity, in improving their activity and thus performance, remains speculative, and is one of the foci of our ongoing research.

Figure 5: A subject during a maximal incremental exercise test on the cycle-ergometer, while oxygen consumption and cerebral and muscle oxygenation are measured.

Chronic medical conditions (obesity, COPD, anemia, etc.) are an important focus for the development of strategies aimed at improving populations' health worldwide. A great deal of literature supports the beneficial effects of physical activity in preventing or alleviating chronic diseases and increasing physiological and psychological well-being. Particularly in obese individuals, exercise limitation can profoundly restrict daily activities and thus impair the quality of life. The observation that high-altitude exposure may lead to considerable weight loss, has led to the suggestion that it might be beneficial to incorporate hypoxic training in weight-management programmes for obese individuals. Within the framework of an ARRS project, and together with colleagues from the Royal Institute of Technology (Stockholm, Sweden) and the University of Nottingham (UK) we are investigating this possibility by monitoring the nutrition, appetite, and metabolism in normal weight and overweight subjects exposed to simulated altitudes of 3000 metres above sea level for prolonged periods.

With the support of the European Space Agency, and together with the Royal Institute of Technology, we established a Topical Team on Lunar Habitat Simulations, which met on several occasions at the Olympic Centre Planica. We also completed a pilot study to assess the logistics of conducting hypoxic bed rest studies in the Planica facility. Such an experimental design

would allow us to investigate the effect of simulated conditions within a lunar or Mars habitat. As a consequence of our efforts we hosted a site visit from representatives of NASA, who have indicated an interest in cooperating in this research endeavour.

Dehydration is considered to increase the risk of decompression sickness among divers. However, there is no evidence to support this notion. Together with colleagues from the Royal Institute of Technology and the Eye Clinic (University Medical Centre Ljubljana), we assessed the effect of deyhdration in hyperthermic and normothermic subjects on the formation of venous gas emboli. Our studies revealed that dehydration does not enhance the risk of decompression sickness.

We have previously demonstrated the contribution of individual components of the Slovenian Armed Forces desert protective clothing ensemble to heat strain during moderate activity in simulated desert conditions (45°C and 20% relative humidity) in a climatic chamber. This year, with colleagues from the Royal Institute of Technology (Stockholm, Sweden), we evaluated the effect of active cooling systems and passive cooling strategies in preventing heat strain during peace-keeping activities in desert conditions.

Together with colleagues from the University of Texas (USA), Biometerological Institute in Florence (Italy), and University of Maribor we have provided improvements to the existing algorithms in a mathematical model of human temperature regulation, thus enhancing its predictions of the thermal balance of clothed individuals exposed to hot and cold conditions. We have also demonstrated the utility of mathematical models of thermal balance in predicting the minimum required clothing insulation during activities such as hiking and guard duty. We are currently working on incorporating elements of behavioural temperature regulation into these mathematical models.

Together with CNRS (Strasbourg, France) and Royal Institute of Technology (Stockholm, Sweden) we are investigating the manner in which sweating thermal manikins can be used to evaluate active and passive cooling systems. With colleagues from the University of Maribor we are completing the construction of a new-generation immersion thermal manikin for evaluating the thermal resistance of immersion protective clothing. Combined with our work with mathematical modelling of human temperature regulation, we will be able to provide accurate predictions of the survival of humans immersed in cold water.

Some outstanding publications in the past three years

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4. Jan Babič, Lim Bokman, Damir Omrčen, Jadran Lenarčič, F. C. Park. A biarticulated robotic leg for jumping movements : theory and experiments. Journal of mechanisms and robotics, 2009, vol. 1, no. 1, str. 011013-1-011013-9.
5. Leon Žlajpah. Robot simulation for control design. V: Agustín Jimenéz (ur.), Basil M. Al Hadithi (ur.). Robot manipulators trends and development. Vukovar: In-Teh, str. 34-72.

Awards and appointments

1. Andrej Gams, Tadej Petrič, Aleš Ude, Leon Žlajpah: Best Paper Research Award, Robotics in Alpe –Adria-Danube Region – RAAD 2010, paper title: Optimizing parameters of trajectory representation for movement generalization: robotics throwing.

Organization of conferences, congress and meetings

1. 12th International Symposium on Advances in Robot Kinematics – ARK 2010, 27. 6. – 1. 7. 2010, Piran - Portorož, Slovenia.

INTERNATIONAL PROJECTS

1. International Cooperation for the Advancement of Researcher on the Undrelaying System of Human Thermoregulation
   ICARUS
   7. FP, 247631
   EC
   Prof. Igor Mekjavić
2. Ubiquitous Care System to Support Independent Living
   CONFIDENCE
   7. FP, 214986
   EC; Centro de Estudios e Investigaciones Tecnicas de Guipuzcoa, San Sebastian, Spain
   Asst. Prof. Leon Žlajpah, Prof. Matjaž Gams
3. Perception, Action & Cognition through Learning of Object-Action Complex
   PACO-PLUS
   6. FP, 027657
   EC; Universität Karlsruhe (TH), Karlsruhe, Germany
   Asst. Prof. Aleš Ude
4. Development of Protective Clothing Systems - Numerical Modelling of Textile
   BI-HR/10-11-013
   Dr. Anica Hursa, Tekstilno-tehnološki fakultet Sveučilišta u Zagrebu, Zagreb, Croatia
   Prof. Igor Mekjavić
5. Motion Capture Data for Calibration of Brain-machine Interfaces
   0114-100128001
   Dr. Mitsuo Kawato, Advanced Telecommunications Research Institute International (ATR), Computational Neuroscience Laboratories, Kyoto, Japan
   Asst. Prof. Ude Aleš
6. Human to Humanoid Robot Full Body Motion Transfer
   BI-JP/08-10/009
   Dr. Erhan Oztop, JST, ICORP Computational Brain Project/Advanced Telecommunications Research Institute International (ATR), Computational Neuroscience Laboratories, Kyoto, Japan
   Dr. Jan Babič
7. Test Device No.1
   Mark Newton, W.L.Gore & Associates GmbH, Feldkirchen /Westerham, Germany
   Asst. Prof. Leon Žlajpah
8. Co-financing of the Hypoxic and Hyperoxic Exercise
   Contract dtd. 16.4.2009
   Edwin Willemsen, b-Cat BV, MB Tiel, The Netherlands
   Prof. Igor Mekjavić
9. Co-financing the Implementation of the Project entitled Zero and Reduced Gravitiy Simulation: The Effect on the Cardiovascular and Muskuloskeletal Systems
   Contract dtd. 30.6.2010
   Royal Institute of Technology - KTH, School of Technology and Health - STH, Department of Environmental Physiology, Solna, Sweden
   Prof. Igor Mekjavić

R & D GRANTS AND CONTRACTS

1. Goal Directed Action Synthesis Using a Library of Example Movements
   Asst. Prof. Aleš Ude
2. Hypoxic and Hyperoxic Exercise
   Prof. Igor Mekjavić
3. Zero and Reduced Gravity Simulation: the Effect on the Cardiovascular and Musculoskeletal Systems
   Prof. Igor Mekjavić
4. Biologically Inspired Synthesis of Periodic Movement for a Robotic Humanoid Leg
   Dr. Andrej Gams
5. Robot Motion Synthesis Through Human Visuo-motor Learning
   Dr. Jan Babič

RESEARCH PROGRAM

1. Automation, Biocybernetics and Robotics
   Prof. Jadran Lenarčič

MENTORING

M. Sc. Thesis

1. Eva Stergaršek Kuzmič, *Detecting new objects and building models with active robot system* (mentor Aleš Leonardis; co-mentor Aleš Ude)

VISITORS FROM ABROAD

1. Prof. Michael M. Stanisic, University of Notre Dame, Indiana, USA, 4 January – 25 July 2010
2. Dr Erhan Oztop, ATR Advanced Telecommunications Institute International, Kyoto, Japan, 23 February – 12 March 2010
3. Prof. Minija Tamašiunaite, Vytautas Magnus University, Kaunas, Lithuania, 15 – 18 March 2010 and 9 – 14 April 2010
4. Prof. Vincenzo Parenti Castelli with students, University of Bologna, Italy, 20 December 2010

STAFF

Researchers
1. Dr. Jan Babič
2. Dr. Igor Kovač
3. Dr. Ladislav Lenart
4. Prof. Igor Mekjavić
5. Asst. Prof. Bojan Nemec
6. Dr. Anton Ružić
7. Asst. Prof. Aleš Ude
8. **Asst. Prof. Leon Žlajpah, Head**

Postdoctorial associates
9. Dr. Mitja Babič
10. Dr. Andrej Gams
11. *Dr. Stylianos Kounalakis, left 20.04.10*
12. Dr. Damir Omrčen
13. Dr. Martin Tomšič

Postgraduates
14. Mojca Amon*, M. Sc.
15. Tadej Debevec, B. Sc.
16. Denis Forte, B. Sc.
17. *Dr. Blaž Hajdinjak, left 01.04.10*
18. Michail Keramidas
19. Nejc Likar, B. Sc.
20. Adam Mc Donnell, B. Sc.
21. Tadej Petrič, B. Sc.
22. *Eva Stergaršek Kuzmič, M. Sc., left 01.06.10*
23. Goran Škorja, B. Sc.

Technical officers
24. *Andrej Kos, B. Sc., left 01.07.10*
25. Borut Lenart, B. Sc.
26. Bogomir Vrhovec, B. Sc.

Technical and administrative staff
27. Tanja Dragojević, B. Sc.
28. Dušan Filipič
29. Marija Kavčič, B. Sc.
30. *Jožef Opeka, retired 01.10.10*
31. Janez Zalar

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

1. Francesco Agostini, Luciano Dalla Libera, Joern Rittweger, Sara Mazzucco, Mihaela Jurdana, Igor B. Mekjavić, Rado Pišot, Luisa Gorza, Marco Narici, Gianni Biolo, "Effects of inactivity on human muscle glutathione synthesis by a double-tracer and single-biopsy approach", *J Physiol*, 2010.
2. Mitja Babič, Rocco Vertechy, G. Barselli, Jadran Lenarčič, Vincenzo Parenti-Castelli, G. Vassura, "An electronic driver for improving the open and closed loop electro-mechanical response of dielectric elastomer actuators", *Mechatronics (Oxf.)*, vol. 20, no. 2, pp. 201-212, 2010.
3. Tadej Debevec, Mojca Amon, Michail E. Keramidas, Stylianos N. Kounalakis, Rado Pišot, Igor B. Mekjavić, "Normoxic and hypoxic performance following 4 weeks of normobaric hypoxic training", *Aviat. space environ. med.*, vol. 81, no. 4, pp. 387-393, 2010.
4. Ruediger Dillmann, Tamim Asfour, Martin Do, Rainer Jäkel, Alexander Kasper, Pedram Azad, Aleš Ude, Sven R. Schmidt-Rohr, Martin Lösch, "Advances in robot programming by demonstration", *KI, Künstl. Intell. (Oldenbourg)*, vol. 24, no. 4, pp. 295-303, 2010.
5. Nickos D. Geladas, Stelios Anastassopoulos, Michail E. Keramidas, Maria D. Koskolou, "Maximal oxygen uptake may be limited by sensation of muscle oxygenation", *The open sports medicine journal*, vol. 4, pp. 9-16, 2010.
6. Michail E. Keramidas, Tadej Debevec, Mojca Amon, Stylianos N. Kounalakis, Boštjan Šimunič, Igor B. Mekjavić, "Respiratory muscle endurance training: effect on normoxic and hypoxic exercise performance", *Eur. j. appl. physiol. (Print)*, vol. 108, no. 4, pp. 759-769, 2010.
7. Michail E. Keramidas, Bojan Musizza, Stylianos N. Kounalakis, Igor B. Mekjavić, "Enhancement of the finger cold-induced vasodilation response with exercise training", *Eur. j. appl. physiol. (Print)*, vol. 109, no. 1, pp. 133-140, 2010.
8. V. Kruger, Dennis Herzog, Sanmohan Baby, Aleš Ude, Danica Kragič, "Learning actions from observations", *IEEE robot. autom. mag.*, vol. 17, no. 2, pp. 30-43, 2010.
9. Bojan Nemec, "Robot grasping using an ArToolKit library", *Elektroteh. vestn.*, vol. 77, no. 1, pp. 69-74, 2010.
10. Gerard Nobel, Arne Tribukait, Igor B. Mekjavić, Ola Eiken, "Histaminergic and cholinergic neuron systems in the impairment of human thermoregulation during motion sickness", *Brain res. bull.*, vol. 82, no. 3/4, pp. 193-200, 2010.
11. Damir Omrčen, Aleš Ude, "Redundancy control of a humanoid head for foveation and three-dimensional object tracking: a virtual mechanism approach", *Adv. robot.*, vol. 24, no. 15, pp. 2171-2197, 2010.
12. Tadej Petrič, Boris Curk, Peter Cafuta, Leon Žlajpah, "Modelling of the robotic Powerball: a nonholonomic, underactuated and variable structure-type system", *Math. comput. model. dyn. syst.*, vol. 16, no. 4, pp. 327-346, 2010.
13. Tadej Petrič, Andrej Gams, Leon Žlajpah, "Robotizirani jojo: strategija vodenja z uporabo nelinearnih dinamičnih sistemov: a control strategy based on nonlinear dynamic systems", *Elektroteh. vestn.*, vol. 77, no. 1, pp. 31-36, 2010.
14. Arne Tribukait, Gerard Nobel, Igor B. Mekjavić, Ola Eiken, "Effects of anti-histaminic and anti-cholinergic substances on human thermoregulation during cold provocation", *Brain res. bull.*, vol. 81, no. 1, pp. 100-106, 2010.
15. Aleš Ude, Andrej Gams, Tamim Asfour, Jun Morimoto, "Task-specific generalization of discrete and periodic dynamic movement primitives", *IEEE trans. robot.*, vol. 26, no. 5, pp. 800-815, 2010.
16. Daniel Yogev, Ola Eiken, Rado Pišot, Gianni Biolo, Pietro di Prampero, Marco Narici, Igor B. Mekjavić, "Effect of 21 days of horizontal bed rest on behavioural thermoregulation", *Eur. j. appl. physiol. (Print)*, vol. 108, no. 2, pp. 281-188, Jan. 2010.
17. Daniela Zavec Pavlinič, Igor B. Mekjavić, "Potrebe okolja sooblikujejo bojne oblačilne sisteme", *Slov. vojs. (Tisk. izd.)*, vol. 17, no. 16, pp. 29-31, 2010.

Review Articles and Chapters in Books

1. Aleš Ude, "Interactive object learning and recognition with multiclass support vector machines", In: *Robot vision*, Aleš Ude, ed., Vukovar, In-Tech, 2010, pp. 169-182.
2. Daniela Zavec Pavlinič, James R. House, Igor B. Mekjavić, "Protupožarni odjevni sustavi i njihovo vrednovanje", *Sigurnost*, vol. 52, no. 3, pp. 251-262, 2010.
3. Leon Žlajpah, "Robot simulation for control design", In: *Robot manipulators trends and development*, Agustín Jimenéz, ed., Basil M. Al Hadithi, ed., Vukovar, In-Teh, sDtr. 34-72.

Published Conference Papers

Regular papers

1. Jan Babič, "Robot skill synthesis through human visuo-motor learning: humanoid robot statically-stable reaching and In-place stepping", In: *ICINCO 2010: proceedings of the 7th International Conference on Informatics in Control, Automation and Robotics, [and] ANNIP, Artificial Neural Networks and Intelligent Information Processing Workshop, [and] special session IVC & ITS Intelligent Vehicle Controls & Intelligent Transportation System, Funchal, Madeira, Portugal, 15-18 June 2010*, 7th International Conference on Informatics in Control, Automation and Robotics [ALSO] ICINCO 2010 [and] ANNIP, Artificial Neural Networks and Intelligent Information Processing Workshop, [and] special session IVC & ITS Intelligent Vehicle Controls & Intelligent Transportation System, Funchal, Madeira, Portugal, 15-18 June 2010, Joaquim Filipe, ed., Juan Andrade Cetto, ed., Jean-Louis Ferrier, ed., [S. l.], SciTePress - Science and Technology Publications, 2010, pp. 212-215.
2. Jan Babič, Erhan Oztop, "Humanoid robot skill acquisition through balance interaction between human and humanoid robot", In: *Conference proceedings*, (Proceedings - IEEE International Conference on Robotics and Automation), [Piscataway], IEEE, cop. 2010, pp. 50-53.
3. Jan Babič, Erhan Oztop, Jadran Lenarčič, "Inverse kinematics of humanoid-robot reaching through human visuo-motor learning", In: *Advances in robot kinematics: motion in man and machine*, Jadran Lenarčič, ed., Michael M. Stanišić, ed., Dordrecht ... [etc.], Springer, 2010, pp. 341-358.
4. Denis Forte, Aleš Ude, "Uporaba Gaussove regresije pri strojnem učenju primerjanja", In: *Zbornik 13. mednarodne multikonference Informacijska družba - IS 2010, 11.-15. oktober 2010: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 337-340.
5. Denis Forte, Aleš Ude, Andrej Kos, "Robot learning by Gaussian process regression", In: *RAAD 2010: [proceedings]*, 19th International Workshop on Robotics in Alpe-Adria-Danube Region, June 23-27, 2010, Budapest [and] Balatonfüred, [Piscataway], IEEE, cop. 2010, pp. 303-308.
6. Denis Forte, Aleš Ude, Andrej Kos, "Uporaba Gaussove regresije pri učenju robotov", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniske konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, zv. B, pp. 203-206.
7. Andrej Gams, Martin Do, Aleš Ude, Tamim Asfour, Ruediger Dillmann, "On-line periodic movement and force-profile learning for adaptation to new surface", In: *Proceedings*, 10th IEEE-RAS International Conference on Humanoid Robots, December 6-8, 2010 Nashville, Tennessee, U.S.A., [S. l.], IEEE, 2010, pp. 560-565.
8. Andrej Gams, Tadej Petrič, Leon Žlajpah, Aleš Ude, "Optimizing parameters of trajectory representation for movement generalization: robotic throwing", In: *RAAD 2010: [proceedings]*, 19th International Workshop on Robotics in Alpe-Adria-Danube Region, June 23-27, 2010, Budapest [and] Balatonfüred, [Piscataway], IEEE, cop. 2010, pp. 161-166.
9. Andrej Gams, Tadej Petrič, Leon Žlajpah, Aleš Ude, "Posploševanje robotskega gibanja - met", In: *Zbornik 13. mednarodne multikonference Informacijska družba - IS 2010, 11.-15. oktober 2010: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej

Gams, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 341-344.
10. Andrej Gams, Aleš Ude, "Prilagajanje periodičnega gibanja novim oblikam površine: robotsko brisanje mize v vsakdanjem človeškem okolju: robotic table wiping in everyday human environment", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniske konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, zv. B, pp. 187-190.
11. Andrej Kos, Jan Babič, "Programming and control of hymanoid robot football playig tasks", In: *RAAD 2010: [proceedings]*, 19th International Workshop on Robotics in Alpe-Adria-Danube Region, June 23-27, 2010, Budapest [and] Balatonfüred, [Piscataway], IEEE, cop. 2010, pp. 115-118.
12. Ladislav Lenart, Jan Babič, "Linearna analiza na grupah za rešitev nekaterih nalog v kinematiki in dinamiki robotov", In: *Uravnotežite naložbe, tveganja in razvoj za uspeh: zbornik prispevkov*, Dnevi slovenske informatike 2010 - DSI, Portorož, Slovenija, 14.-16. april 2010, Ljubljana, Slovensko društvo Informatika, 2010, 8 pp.
13. Bojan Nemec, Matej Zorko, Leon Žlajpah, "Learning of a ball-in-a-cup playing robot", In: *RAAD 2010: [proceedings]*, 19th International Workshop on Robotics in Alpe-Adria-Danube Region, June 23-27, 2010, Budapest [and] Balatonfüred, [Piscataway], IEEE, cop. 2010, pp. 297-301.
14. Bojan Nemec, Leon Žlajpah, "Modeling of robot learning in MATLAB/SIMULINK environment", In: *EUROSIM 2010: proceedings of the 7th EUROSIM Congress on Modelling and Simulation, September 6-10, 2010, Prague, Czech Republic. Vol. 2, Full papers (CD)*, Miroslav Šnorek, ed., Prague, Czech Technical University in Prague, 2010, 7 pp.
15. Damir Omrčen, Aleš Ude, "Redundant control of a humanoid robot head with foveated vision for object tracking", In: *Conference proceedings*, (Proceedings - IEEE International Conference on Robotics and Automation), [Piscataway], IEEE, cop. 2010, pp. 4151-4156.
16. Damir Omrčen, Aleš Ude, "A virtual mechanism enhanced approach for object tracking with humanoid robot head", In: *Advances in robot kinematics: motion in man and machine*, Jadran Lenarčič, ed., Michael M. Stanišić, ed., Dordrecht ... [etc.], Springer, 2010, pp. 241-250.
17. Tadej Petrič, Andrej Gams, Martin Tomšič, Leon Žlajpah, "Ritmično vodenje robota z uporabo nelinearnih oscilatorjev in človeške mišične aktivnosti", In: *Zbornik 13. mednarodne multikonference Informacijska družba - IS 2010, 11.-15. oktober 2010: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 349-352.
18. Tadej Petrič, Andrej Gams, Aleš Ude, Leon Žlajpah, "Real-time 3D marker tracking with a WIIMOTE stereo vision: application to robotic throwing", In: *RAAD 2010: [proceedings]*, 19th International Workshop on Robotics in Alpe-Adria-Danube Region, June 23-27, 2010, Budapest [and] Balatonfüred, [Piscataway], IEEE, cop. 2010, pp. 357-362.
19. Tadej Petrič, Andrej Gams, Leon Žlajpah, "Frequency extraction based on adaptive fourier series: application to robotic yo-yo", In: *ICINCO 2010: proceedings of the 7th International Conference on Informatics in Control, Automation and Robotics, [and] ANNIP, Artificial Neural Networks and Intelligent Information Processing Workshop, [and] special session IVC & ITS Intelligent Vehicle Controls & Intelligent Transportation System, Funchal, Madeira, Portugal, 15-18 June 2010*, 7th International Conference on Informatics in Control, Automation and Robotics [ALSO] ICINCO 2010 [and] ANNIP, Artificial Neural Networks and Intelligent Information Processing Workshop, [and] special session IVC & ITS Intelligent Vehicle Controls & Intelligent Transportation System, Funchal, Madeira, Portugal, 15-18 June 2010, Joaquim Filipe, ed., Juan Andrade Cetto, ed., Jean-Louis Ferrier, ed., [S. l.], SciTePress - Science and Technology Publications, 2010, pp. 32-38.
20. Tadej Petrič, Leon Žlajpah, "Application of neural networks for dynamic modeling of robotic mechanisms", In: *EUROSIM 2010: proceedings of the 7th EUROSIM Congress on Modelling and Simulation, September 6-10, 2010, Prague, Czech Republic. Vol. 2, Full papers (CD)*, Miroslav Šnorek, ed., Prague, Czech Technical University in Prague, 2010, 8 pp.
21. Tadej Petrič, Leon Žlajpah, "Uporaba nevronskih mrež za kompenzacijo nelinearnosti v robotskem mehanizmu", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniske konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, zv. B, pp. 191-194.
22. Eva Stergaršek Kuzmič, Aleš Ude, "Object segmentation and learning through feature grouping and manipulation", In: *Proceedings*, 10th IEEE-RAS International Conference on Humanoid Robots, December 6-8, 2010 Nashville, Tennessee, U.S.A., [S. l.], IEEE, 2010, pp. 371-378.
23. Goran Škorja, Jan Babič, "Implementation of the three degrees-of-freedom parallel platform in human posture analysis", In: *RAAD 2010: [proceedings]*, 19th International Workshop on Robotics in Alpe-Adria-Danube Region, June 23-27, 2010, Budapest [and] Balatonfüred, [Piscataway], IEEE, cop. 2010, pp. 321-326.
24. Goran Škorja, Jan Babič, "Postural control analysis during angular perturbations of the support surface", In: *6th World Congress of Biomechanics, (WCB 2010) in conjunction with 14th International Conference on Biomedical Engineering (ICBME) and 5th Asia Pacific Conference on Biomechanics (APBiomech), 1-6 August 2010, Singapore*, (IFMBE proceedings, vol. 31), Chwee Teck Lim, ed., James Cho Hong Goh, ed., Heidelberg, Springer, 2010, pp. 969-972.
25. Goran Škorja, Jan Babič, "Robotski paralelni mehanizem za analizo človekovega ravnotežja", In: *Zbornik 13. mednarodne multikonference Informacijska družba - IS 2010, 11.-15. oktober 2010: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 345-348.
26. Daniela Zavec Pavlinič, Igor B. Mekjavić, "Extreme environmental conditions require optimal military clothing ensembles", In: *Magic world of textiles: book of proceedings*, 5th International Textile, Clothing & Design Conference [also] ITC&DC, October 3rd to October 6th, 2010, Dubrovnik, Croatia, Zvonko Dragčević, ed., Zagreb, Faculty of Textile Technology, University of Zagreb, 2010, pp. 535-539.
27. Daniela Zavec Pavlinič, Igor B. Mekjavić, "The process of development of functional clothing ensembles for industrial application", In: *Symposium proceedings*, 41st International Symposium on Novelties in Textiles and 5th International Symposium on Novelties in Graphics and 45th International Congress IFKT, Ljubljana, Slovenia, 27-29 May 2010, Barbara Simončič, ed., Aleš Hladnik, ed., Alenka Pavko-Čuden, ed., Jure Ahtik, ed., Barbara Luštek Preskar, ed., Andrej Demšar, ed., Raša Urbas, ed., Ljubljana, Faculty of Natural Sciences and Engineering, Department of Textiles, 2010, pp. 157-163.

Textbooks and Lecture Notes

1. Roman Kamnik, Janez Podobnik, Jan Babič, Tomaž Koritnik, *Osnove robotike: priročnik in navodila za laboratorijske vaje*, 1. izd., Ljubljana, Založba FE in FRI, 2010.
2. Drago Matko, Peter Omersel, Anton Ružić, Marjan Mihelin, Vinko Kunc, *Računalniško podprto načrtovanje*, Ljubljana, Fakulteta za elektrotehniko in računalništvo, 1988-.
3. Igor B. Mekjavić, Ola Eiken, *Lunar habitat simulation: [workshop on Bedrest in Hypoxic Environments, June 12 & 13, 2010, Planica, Slovenia]*, 1. izd., Ljubljana, Biomed, 2010.

Theses

Ph. D. Thesis

1. Mitja Babič, *The control of electroelastic polymer actuators: doctoral dissertation*, Ljubljana, [M. Babič], 2010.

M. Sc. Theses

1. Blaž Hajdinjak, *Closed loop control of humanoid robot through learning by imitation: master's thesis*, Ljubljana, [B. Hajdinjak], 2010.
2. Eva Stergaršek Kuzmič, *Detecting new objects and building models with active robot system: master's thesis*, Ljubljana, [E. Stergaršek Kuzmič], 2010.

Patent

1. Aleš Jurca, Damir Omrčen, *Postopek za merjenje notranjih dimenzij obuvala: SI22848 (A)*, Ljubljana, Urad RS za intelektualno lastnino, 26. feb. 2010.

DEPARTMENT OF SYSTEMS AND CONTROL

E-2

The department is engaged in the analysis, control and optimization of systems and processes. The activities of the department are focused on the research of new methods and algorithms for automatic control, the development of procedures and tools to support the design and construction of control systems, the development of specific measurement and control modules, and the development and construction of complete systems for the control and supervision of machines, devices and industrial processes.

Head:
Prof. Stanislav Strmčnik

Basic and applied research

The basic and applied research in 2010 was devoted to three sub-areas: methodologies for analysis and control systems design; tools and building blocks for implementation; and applied research in the priority problem domains.

The sub-area **methodologies for analysis and control systems design** included three topics. The first topic addressed the **modelling and identification of nonlinear and complex dynamical systems**. The research in the dynamic systems modelling of Gaussian process models was directed towards the acceleration of dynamic systems identification with hardware, the modelling of multiple-input, multiple-output systems, and the application of modelling with Gaussian process models of environmental and traffic dynamic systems as well as biological systems (Fig. 2). The other part of this topic was related to the identification of stochastic nonlinear dynamical systems. A numerically efficient algorithm based on the optimisation of the likelihood function by means of the EM (expectation-maximization) approach has been developed. The UT (Unscented Transform) has been adopted to approximate the underlying probability density functions and its efficiency was compared with the Particle Filtering approach.

The second topic was **(advanced) control**. Within the research and development of explicit predictive controllers based on linear and hybrid models, the emphasis was on the problem of the reliable computation of parametric-controller partitions for numerically problematic cases and degeneracies, using methods of parametric quadratic programming and parametric linear complementarity. The other part of this topic was related to PID control. Research was focused on the implementation of the Magnitude Optimum (MO) method to unstable processes and integrating processes. For multivariable processes, the MO method was extended to controllers based on inverse decouplers.

The third topic of interest was **condition monitoring and fault diagnosis**. In this area the problem of fault detection in mechanical drives under weakly non-stationary operating conditions has been addressed. Under the assumption that neither speed nor load measurements are available, a novel feature has been proposed based on a wavelet analysis and an entropy measure has been developed. A validation on the experimental test bed clearly indicates a high diagnostic accuracy and an insensitivity to speed/load fluctuations.

New results have been obtained in the challenging area of estimating the remaining useful life of machines. A novel approach based on the on-line identification of wear processes and the prediction of fault progression has been proposed (Fig. 3).

A part of the work, which is also related to condition monitoring, dealt with the problem of monitoring the depth of anaesthesia (DOA). Our recent studies have shown that by studying the couplings between EEG frequency bands it is possible to discriminate between different states of anaesthesia in rats. Our latest work includes new measurements on humans during general anaesthesia, where the state of the anaesthesia was continuously assessed by anaesthetists. These new measurements will, first, allow us to correctly

At the Industrial forum IRT 2010 (Innovation, Development and Technology) the award "TARAS statuette" promoting innovation, development and technological excellence was granted to the program group Systems and Control of our department and to the company Domel, d.d. for successful cooperation in the development of the System for the Automatic End-Quality Assessment of Vacuum-Cleaner motors (Fig. 1).

Figure 1: Photo from the "TARAS statuette" award ceremony (from left to right: Andrej Bičeк, univ. dipl. ing., development engineer in the DOMEL company, dr. Jožica Rejec, president of the DOMEL management board, dr. Janko Petrovčič, leader of the project team at our department, and prof.dr. Đani Juričić, leader of our research program)

At the third international Technology Transfer Conference, which was held in Ljubljana and Maribor, the committee of six foreign experts has awarded a group of researchers from our Department with the 2nd award . The award was granted for the Diagnostic and Prognostic Platform for Automated Condition Monitoring of Process Equipment. The recipients of the award were Đani Juričić, Petrovčič Janko, Bojan Musizza, Aleš Svetek, Pavle Boškoski, Matej Gašperin and Stanislav Černe.

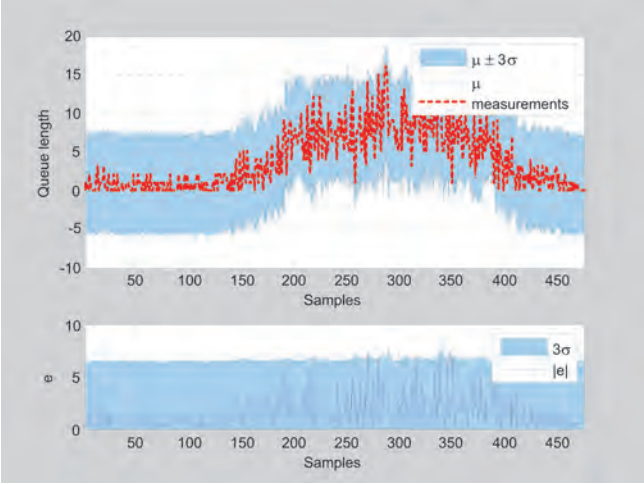

Figure 2: One-step-ahead predictions on data used for estimation (upper figure) and residuals of predictions with 3σ band (lower figure)

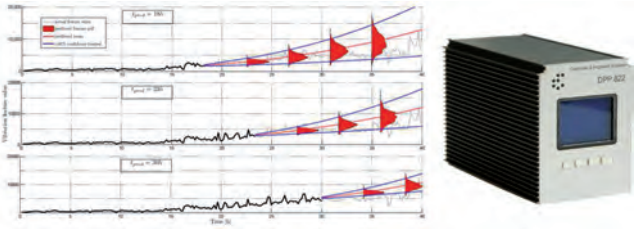

Figure 3: Prognosis of the remaining useful life of a machine; predicted distributions (left), a prototype system for automated condition monitoring and prognosis (right)

Among the seven selected applications of a public tender for the development of competence centres, published by the Ministry of Higher Education, Science and Technology, is also the Competence Centre for Advanced Control Technologies (CCACT) in which our Department plays a crucial role. The competence centre includes 7 R&D projects with 17 partners.

map different states of anaesthesia to the value of EEG coupling index, and second, enable us to improve the robustness of the DOA prediction in humans.

The sub-area **tools and building blocks for implementation** also included three parts. The first part of our work was devoted to a further development of the **program package for the rapid prototyping of advanced control algorithms**. In the past year new algorithms for tuning integrating processes and for the robust identification of process parameters have been tested.

The second part included activities related to the development of **tools and methods for control SW design**. In this area an approach based on the model-driven engineering paradigm (MDE) for the development of industrial process control software (for controllers) was elaborated. This approach is defined through a sequence of development activities, a formalized ProcGraph modeling language, and a new version of the integrated development environment prototype.

In the third part, the HW platform for the first prototype of the diagnostic system DPP822 has been developed. The system is aimed at on-line condition monitoring and prognosis of the remaining useful life of mechanical drives (Fig.3). The system received the 2nd award for innovative solutions at the International Conference of Technology Transfer.

Applied research in the priority problem domains was the third subarea of our interest.

In this frame a substantial part of our activities was devoted to the development of **specific control systems** described below.

In the past year we continued with the work related to the **automatic landing of aircraft**, based on onboard-camera-generated images. The research was focused on the completion of some control algorithms, the evaluation of their performance, and analyzing the conformity of the obtained landing trajectories with the prescribed standard requirements.

Within **polymerization process control** the real plant experiments were performed that confirmed the possibility of achieving a much more stable reactor temperature during the batch by applying the proposed on-line reactant-dosing control algorithm.

A novel approach to **on-line sensor validation in cold rolling mills** based on extended Kalman filtering has been developed. Of essential importance is the grey process model identified from the operating data. Statistical hypothesis tests are employed to detect sensor faults on the basis of a discrepancy between the measured value and the value predicted by the model. The work has been carried out in the frame of the international project PROBASENSOR as a part of the EUROSTARS project supporting initiative.

Control of wastewater treatment plants is our traditional research area. Within an applied research project in this area the ADM1-based simulation model of the sludge-treatment process in Domžale-Kamnik WWTP was designed and used to analyze the possibilities for increasing the biogas production by operating the anaerobic digesters at higher temperature and reduced volume.

Production control is also an important domain of our research work. The major problems in manufacturing today still relate to unexpected breakdowns and the degradation of product quality with no obvious reasons. Through the cooperation with the Kolektor Sinabit company a new system has been developed for acquiring process data from operating machines in a plastic extruding line. The preliminary sensitivity analysis of the product quality with respect to the process parameters has been performed by means of statistical tests. We have also proceeded with the evaluation of a hierarchical concept of model-based production control developed in previous years. The main focus in 2010 was on building the model from the operational data using neural networks.

In recent years, a part of our work was focused on the area of **fuel cells**. In 2010 the commercial system HyPM HD-200 was upgraded in order to measure various energy and material flows. The measurements performed have enabled

a calculation of the actual efficiency of a fuel-cells-based system and are the basis for designing advanced control algorithms for fuel-cell-based systems.

R&D projects for industry and other users

A significant part of the development activities of our department is oriented towards the implementation of fuel cells in various applications and to the development of special-purpose modules for fuel-cells-based generator sets. In 2010 the three-year project related to the development of a mobile experimental laboratory for hydrogen technologies research, referred to as TESTLAB, was completed. The laboratory consists of various interconnected subsystems including units for hydrogen production and storage, PEM fuel cells, electric and heat energy storages, electrical converters, etc., and is upgraded by a monitoring and computer control system (Fig. 4). The development related to fuel-cells-based systems applications has also been performed within the Centre of Excellence Low-carbon Technologies. Note that our group is leading this part of the activities within the centre.

Figure 4: TESTLAB subunits: electrolyser, methanol reformer, fuel cells (left); Presentation of the mobile experimental laboratory TESTLAB at the event SOBRA 2010, G. Radgona, Slovenia (right)

At the 5th International Fair of Defence, Security, Protection and Rescue, SOBRA, which was held in Gornja Radgona, a mobile laboratory for hydrogen technologies was presented, which was jointly developed by our Department and the companies INEA d.o.o. and Domel d.d. (Fig.4)

The multidisciplinary project Kerapro, finished in the past year, was also related to fuel cells. Within this project prototypes of critical components of the miniature size fuel reformer were developed, which will serve as a source of hydrogen for miniature fuel cells. The project was financed by the Ministry of Defense of the Republic of Slovenia and carried out by four partners: Jožef Stefan Institute (Dept. of Electronic Ceramics and Dept. of Systems and Control), National Institute of Chemistry Slovenia (Laboratory of Catalysis and Chemical Reaction Engineering) and Hipot RR company.

As described below, an important part of our activities is also devoted to direct cooperation with various companies.

Based on the contract with the Domel company, Železniki, a diagnostic system for end-quality control of electrical motors of type 462 was developed. The system is characterized by a new set of manipulators, which enable a suitable acoustical and vibrational isolation of motors during measurements on the production line. The new system is the fifth in a row of similar, very successful diagnostic systems developed for Domel. Up till now, the implemented systems have been used to test more than 10 million motors.

An important part of the activities was, in the past year, performed in close cooperation with the INEA company. One of the activities to mention was the development of a new version of the batch-control tool. By the use of object solutions, the reuse of recipes has been increased and the user interface has been improved. Through the user-configurable used sequences, the flexibility of the phase behaviour model has been achieved. The transfer to a new powerful multiple CPU PLC platform was carried out, which also enabled the physical separation of the system and application software. The new version of the tool is marketed by Mitsubishi under the brand name Cbatch.

Another activity for the company INEA was related to the advanced demand response software solution for Smart Grids with the brand name KIBERnet. Based on the functional requirements, we implemented a program module for the calculation of user reliability. The module reads the adaptation data from the database and writes the calculated reliability factor into the database.

For the Brinox company we have carried out a research study on possible new approaches for a supervision system for a fluidized-bed machine used for agglomeration, coating and drying. The goal was to monitor the process via non-invasive measurements (analysis of pressure fluctuations and sound), which do not require any complex installations within the process equipment (Fig.5).

For the Plasmabull company we have been developing a control system for a new type of production machine using plasma for metal-plates processing. The machine will operate in batch mode; a great part of effort is being dedicated to the control of power distribution over the plate surface to achieve uniform processing.

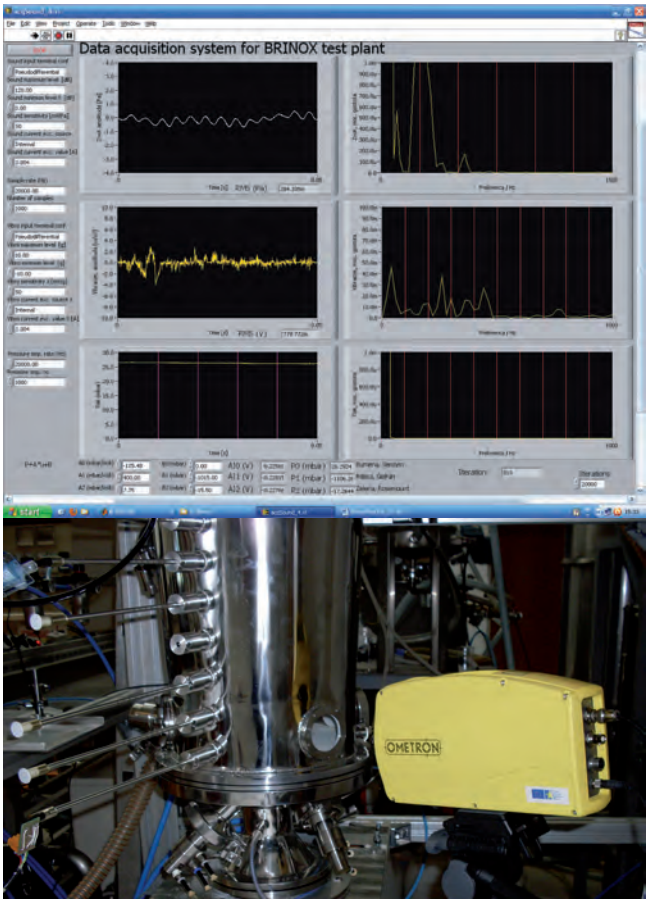

Figure 5: Supervision system for a fluidized bed process

"The Department of Systems and Control, Jožef Stefan Institute, is an excellent entity for applied research on control systems, covering nonlinear dynamics, fault-detection systems up to the implementation of control systems for industry." This assessment has been given to our Department by international experts evaluating the level of knowledge and competencies usable in the area of space research.

In the past year we established a cooperation with the municipal company VO-KA in Ljubljana. A project considering the modelling of the Ljubljana Waste-Water Treatment Plant was started with the purpose to verify and optimise the conceptual design for the third stage of the plant construction, targeted to the desired elimination of nitrogen in waste water.

Other projects

In 2010 the activities on the project "Promoting Innovation in the Industrial Informatics and Embedded Systems Sector through Networking - I3E" funded by the "South East Europe-Transnational Cooperation Programme" have been continued. Its basic objectives are the promotion of innovation and entrepreneurship in the area of Southeast Europe with an emphasis on the development of advanced products and services in the sectors of industrial informatics and embedded systems. Our group participated at the definition of the Strategic Research Agenda, which is one of the essential results of the project. In October 2010 we also organised the national workshop where the aims, scope and the current results of the I3E project were presented to more than 100 participants.

Education and training activities

Some members of the department are giving lectures and practical courses at different faculties and universities: the Faculty of Electrical Engineering, University of Ljubljana, the Faculty of Logistics, University of Maribor, the University of Nova Gorica and the "Jožef Stefan" International Postgraduate School. They also act as supervisors of M.Sc. and Ph.D. students. Special care was given to post-qualification training for engineers from industry. In 2010, three one-week courses were organized. These courses were organized in close co-operation with the Faculty of Electrical Engineering, University of Ljubljana and the Information Technologies Knowledge Transfer Centre at the Jožef Stefan Institute.

Some outstanding publications in the past year

1. Matej Gašperin, Đani Juričić, Pavle Boškoski, Jože Vižintin. Model-based prognostics of gear health using stochastic dynamical models. Mech. syst. signal process., [in press] 2010, 7 str., doi: 10.1016/j.ymssp.2010.07.003.
2. Pavle Boškoski, Janko Petrovčič, Bojan Musizza, Đani Juričić. Detection of lubrication starved bearings in electrical motors by means of vibration analysis. Tribol. int.. [Print ed.], 2010, vol. 43, no. 9, str. 1683-1692, doi: 10.1016/j.triboint.2010.03.018.
3. Boštjan Pregelj, Samo Gerkšič. Hybrid explicit model predictive control of a nonlinear process approximated with a piecewise affine model. J. process control. [Print ed.], [in press] 2010, 8 str., doi: 10.1016/j.jprocont.2010.05.002
4. Vladimir Jovan, Matija Perne, Janko Petrovčič. An assessment of the energetic flows in a commercial PEM fuel cell system. Energy convers. manage.. [Print ed.], 2010, vol. 51, no. 12, str. 2467-2472, doi: 10.1016/j.enconman.2010.04.014.

The most important technological achievement in the past year

1. TESTLAB - a mobile experimental laboratory for hydrogen technologies research, 2010, (in cooperation with companies INEA and DOMEL), (Vladimir Jovan, Janko Petrovčič, Aleš Svetek, Stane Černe, Primož Fajdiga, Miroslav Štrubelj)

Awards and appointments

1. Prof. Đani Juričić, Dr Janko Petrovčič, Dr Bojan Musizza, Aleš Svetek, Pavle Boškoski, Matej Gašperin and Stanislav Černe received the second award among the five awards for the innovation in the economy granted by six foreign experts at the third Technology Transfer Conference, held on 7-8 October 2010 in Ljubljana and Maribor. The award was granted for the development of Diagnostic and prognostic platform for automated condition monitoring of process equipment.
2. Domel, d.d. company and Systems and Control programme group at Jožef Stefan Institute were granted the TARAS statuette for successful cooperation in the development of a System for the automatic end-quality assessment of vacuum-cleaner motors. This award, recognizing the most successful cooperation between research teams and organisations on the one hand and development teams in industry and the economy on the other hand, as well as promoting innovation, development and technological excellence, was granted at the Industrial forum IRT 2010 (Innovation, development and technology), held in Portorož.

Organization of conferences, congress and meetings

1. Modelling and simulation of control systems: continuing education (specialisation) course in Control Technology, Ljubljana, 1–5 February 2010
2. Industrial regulation systems: continuing education (specialisation) course in Control Technology, Ljubljana, 12–16 April 2010
3. Advanced control methods: continuing education (specialisation) course in Control Technology, Ljubljana, 7–11 June 2010

INTERNATIONAL PROJECTS

1. Probalistic Bayesian Soft Sensor - A Tool for On-line Estimation of the Key Process Variable in Cold Rolling Mills
   ProBaSensor
   EUROSTARS
   COMPUREG Plzen, s.r.o., Czech Republic
   Prof. Đani Juričič
2. Promoting Innovation in the Industrial Informatics and Embedded Systems Sectors through Networking
   I3E
   South East Europe Programme
   SEE/A/219/1.1/X
   Dr. Athanasios Kalogeras, Industrial Systems Institute / Research Centre ATHENA, Patras, Greece
   Dr. Vladimir Jovan
3. Combining Soft Computing Techniques and Statistical Methods to Improve Data Analysis Solutions
   SOFTSTAT
   COST IC0702
   EC; Cost Office, Brussels, Belgium
   Prof. Juš Kocijan
4. Specification of the Automation System for the Metal Plate Treatment Machine Using Plasma
   B0-10-0009
   Primož Eiselt, PlasmaBull Engineering GmbH, Lebring, Austria
   Dr. Gregor Dolanc
5. Application of Gaussian Processes to the Modelling and Control of Complex Stochastic Systems
   BI-BG/09-10-005
   Dr. Alexandra Grancharova, Institute of Control and System Research, Bulgarian Academy of Sciences (ICSR-BAS), Sofia, Bulgaria
   Prof. Juš Kocijan
6. System Identification Based on Gaussian Process Model for Traffic Control Applications
   BI-CZ/10-11-014
   Dr. Jan Prikryl, Institute of Information Theory and Automation, Czech Academy of Science, Prague, Czech Republic
   Prof. Juš Kocijan

R & D GRANTS AND CONTRACTS

1. Identification and Model Analysis for Dynamic Systems Control Design with Gaussian Process Priors
   Prof. Juš Kocijan
2. Integrated Diagnostic System for Drive Assemblies
   Prof. Đani Juričić
3. Modelling and Control of Wastewater Treatment Plants for Improving the Effluent Quality and Energy Effective Operation
   Dr. Darko Vrečko
4. Advanced Model-based Procedures for Product Quality Control and Management in Complex Production Processes
   Prof. Đani Juričić
5. Simplified Explicit Predictive Controller
   Prof. Stanislav Strmčnik

RESEARCH PROGRAM

1. Program Systems and Control
   Prof. Đani Juričić

NEW CONTRACTS

1. Freezing protection heaters for fuel cell power modules
   INEA d.o.o.
   Dr. Vladimir Jovan
2. Feasibility study of the supervision system of the fluidized bed agglomeration and deposition process
   BRINOX INŽENIRING d.o.o.
   Dr. Gregor Dolanc
3. Improvement of industrial diagnostic systems for Domel
   DOMEL, d.o.o.
   Dr. Janko Petrovčič
4. Review of preliminary design of the Ljubljana Waste Water Treatment Plant - Phase III construction
   JP Vodovod-Kanalizacija d.o.o.
   Dr. Nadja Hvala
5. Batch client specification
   INEA d.o.o.
   Giovanni Godena, M. Sc.
6. Operater panel interface specification
   INEA d.o.o.
   Giovanni Godena, M. Sc.
7. A diagnostic system for vacuum cleaner motors on the production line ML7
   DOMEL, d.o.o.
   Dr. Janko Petrovčič

VISITORS FROM ABROAD

1. Dr. Kosta Boshnakov, University of Chemical Technology and Metallurgy, Sofia, Bulgaria, 28 May 2010
2. Pavle Boškoski, Elektrotehnički fakultet, Univerzitet Sv. Kiril i Metodij, Skopje, R. Macedonia, 1 January to 31 December 2010
3. dr. Jan Přikryl, Institute of Information Theory and Automation, Czech Academy of Sciences, Prague, Czech Republic, 17 October to 14 November 2010
4. Jan Šindlář, Institute of Information Theory and Automation, Czech Academy of Sciences, Prague, Czech Republic, 31 October to 7 November 2010
5. Kateřina Zemánková, Institute of Information Theory and Automation, Czech Academy of Sciences, Prague, Czech Republic, 31 October to 7 November 2010
6. Hristina Hristova, Institute of Control and System Research, Bulgarian Academy of Sciences, Sofia, Bulgaria, olgarija, 8–17 November 2010
7. Aleksander Krastov, Institute of Control and System Research, Bulgarian Academy of Sciences, Sofia, Bulgaria, 8–17 November 2010
8. Prof. Stefan Jakubek, Technische universität Wien, Vienna, Austria, 7 December 2010

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5. Dr. Nadja Hvala
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Technical and administrative staff
27. Maja Janežič, B. Sc.
28. Miroslav Štrubelj

Note:
* part-time JSI member

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Original Articles

1. Pavle Boškoski, Janko Petrovčič, Bojan Musizza, Đani Juričić, "Detection of lubrication starved bearings in electrical motors by means of vibration analysis", *Tribol. int.*, vol. 43, no. 9, pp. 1683-1692, 2010.
2. Gregor Dolanc, Satja Lumbar, Stanko Strmčnik, Darko Vrečko, Drago Matko, "Sistem za vodenje letala na osnovi prediktivne regulacije in kratkoročnih trajektorij", *Ventil (Ljubl.)*, vol. 16, no. 1, pp. 56-61, 2010.
3. Giovanni Godena, Janez Tancek, Igor Steiner, "Ein Kochbuch für Chargenprozesse", *IEE (Heidelb.)*, no. 11, pp. 144-147, 2010.
4. Dejan Gradišar, Antonio Espuña, Luis Puigjaner, "Komunikacijska shema za celovito vodenje šaržnih procesov", *Ventil (Ljubl.)*, vol. 16, no. 2, pp. 152-155, 2010.
5. Jurij Jaklič, Aleš Popovič, Tomaž Lukman, "Zrelost poslovne inteligence v slovenskih organizacijah", *Uporab. inform. (Ljubl.)*, vol. 18, no. 1, pp. 16-31, jan./feb./mar. 2010.
6. Matej Jerala, Vladimir Jovan, Jure Vindišar, Peter Nemček, "Vodik - energent prihodnosti?", *EGES, Energ. gospod. ekol. Slov.*, vol. 14, no. 1, pp. 82-85, 2010.
7. Vladimir Jovan, Matija Perne, Janko Petrovčič, "An assessment of the energetic flows in a commercial PEM fuelcell system", *Energy convers. manage.*, vol. 51, no. 12, pp. 2467-2472, 2010.
8. Gregor Kandare, Antonio Nevado Reviriego, "Adaptivno prediktivno vodenje raztopljenega kisika v bioloških reaktorjih čistilnih naprav", *Ventil (Ljubl.)*, vol. 16, no. 6, pp. 540-546, 2010.
9. Gregor Kandare, Stanko Strmčnik, Giovanni Godena, "Domain specific model-based development of software for programmable logic controllers", *Comput. ind.*, vol. 61, no. 5, pp. 419-431, 2010.
10. Michail E. Keramidas, Bojan Musizza, Stylianos N. Kounalakis, Igor B. Mekjavić, "Enhancement of the finger cold-induced vasodilation response with exercise training", *Eur. j. appl. physiol. (Print)*, vol. 109, no. 1, pp. 133-140, 2010.
11. Juš Kocijan, Alexandra Grancharova, "Gaussian process modelling case study with multiple outputs", *Dokl. B''lg. akad. nauk.*, vol. 63, no. 4, pp. 601-607, 2010.
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14. Simon Štampar, Saša Sokolić, Gorazd Karer, Alenka Žnidaršič, Igor Škrjanc, "Theoretical and fuzzy modelling of a pharmaceutical batch reactor", *Math. comput. model.*, vol., no., pp. 1-9, 2010.
15. Damir Vrančić, Stanko Strmčnik, Juš Kocijan, P. B. de Moura Oliveira, "Improving disturbance rejection of PID controllers by means of the magnitude optimum method", *ISA trans.*, vol. 49, no. 1, pp. 47-56, 2010.
16. Darko Vrečko, Anton Ložar, Vladimir Vrečko, Vladimir Jovan, "Programsko orodje za razvrščanje šarž v pripravi surovin v Cinkarni Celje", *Ventil (Ljubl.)*, vol. 16, no. 3, pp. 260-265, 2010.

Review Articles and Chapters in Books

1. Bojan Musizza, Samo Ribarič, "Monitoring the depth of anaesthesia", *Sensors*, vol. 10, no.12, pp. 10896-10935, 2010.

Published Conference Papers

Regular papers

1. Andrej Biček, Janko Petrovčič, Bojan Musizza, Gregor Dolanc, Janez Koblar, Dejan Petelin, Đani Juričić, "Sistem za avtomatsko končno kontrolo elektromotorjev", In: *Vir znanja in izkušenj za stroko: zbornik foruma*, Industrijski forum IRT, Portorož, 7.-8. junij 2010, Tomaž Perme, ed., Darko Švetak, ed., Jože Balič, ed., Škofljica, Profidtp, 2010, pp. 41-46.
2. Pavle Boškoski, Đani Juričić, Mile J. Stankovski, Jože Vižintin, "Wavelet based information cost functions for condition monitoring", In: *Zbornik predavanj Posvetovanja o tribologiji, mazivih in alternativnih gorivih*, Jože Vižintin, ed., Igor Velkavrh, ed., Bojan Podgornik, ed., Ljubljana, Slovensko društvo za tribologijo, = Slovenian Society for Tribology, 2010, pp. 241-254.
3. Pavle Boškoski, Janko Petrovčič, Bojan Musizza, Đani Juričić, "Final quality assessment system of electronically commutated motors", In: *CM 2010/MFPT 2010*, The 7th International Conference on Condition Monitoring and Machinery Failure Prevention Technologies, 22-24 June 2010, Ettington Chase, Stratford-upon-Avon, England, Northampton, The British Institute of NT, 2010, 12 pp.
4. Stanislav Černe, Janko Petrovčič, Aleš Belič, "Merilni sistem za določanje karakteristik hladilnih naprav za sisteme z gorivnimi celicami", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniške konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, zv. A, pp. 307-310.
5. Matej Gašperin, Đani Juričić, "Model-based prognostics of mechanical drives: the maximum-likelihood approach", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniške konference ERK ...), Baldomir Zajc, ed., Andrej Trost,

ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, zv. A, pp. 405-408.
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2. Gašper Mušič, Borut Zupančič, Jurij Čretnik, Gregor Dolanc, Damjan Janežič, Gregor Klančar, Dejan Gradišar, Borut Zupančič, ed., *Industrijski krmilni in regulacijski sistemi: [študijsko gradivo za tečaj dopolnilnega izobraževanja in specializacije "Tehnologija vodenja industrijskih procesov"]: Ljubljana, 12. do 16. april 2010*, Ljubljana, Inštitut Jožef Stefan, Fakulteta za elektrotehniko, 2010.

Theses

M. Sc. Thesis

1. Stanislav Černe, *Measurement system for measuring fuel cell cooling systems characteristics: specialist thesis*, Ljubljana, [S. Černe], 2010.

B. Sc. Thesis

1. Miha Glavan, *Neural network based modelling of production process performance: undergraduate thesis*, Ljubljana, [M. Glavan], 2010.

LABORATORY FOR OPEN SYSTEMS AND NETWORKS E-5

The main activities of the laboratory are the R&D of next-generation networks, telecommunications technologies, components and integrated systems and information-society services and applications, especially those that ensure an efficient and pervasive life-long learning concept.

Head:
Prof. Borka Jerman Blažič

In 2010, the research group implemented the research program "Future Internet Technologies: concepts, architectures, services and socio-economic issues". Research was also carried out in the EU 7FP projects "P2P-Next", "Eiffel"," GLOBAL" and "UNITE", the eContentplus "ICOPER" and "OpenScout" projects, the "e^{4}VET" project from the Leonardo da Vinci programme, the "Twin Tide" project from the COST programme, and in a few national projects. The main fields of work were technologies and services in advanced next-generation, security and privacy in information systems networks, and technology-enhanced learning. Members of the laboratory are also teaching at the undergraduate and graduate levels at the University of Ljubljana, the University of Maribor, and the Jožef Stefan International Postgraduate School.

Concepts, architectures, technologies and services in the future internet

The group was a partner in the EU 7FP project "Evolving Future Internet for European Leadership (**EIFFEL**)" that aimed at identifying and developing the major concepts and design architecture of the Future Internet. This area of research was carried out within the "think tank" group of European and worldwide scientists and experts coming from the most famous universities in the world, such as MIT, Stanford, Berkley, Oxford, Cambridge, Aachen, Tokyo and others. The main topic of research carried out in 2010 in the project by the members of the laboratory was related to the privacy issues in the Future Internet. The results were presented at the project workshop in March 2010 and at the IEEE IARIA Digital Society conference in St. Maarten. The presented paper was declared as the best paper at the conference and was invited for publication in the International Journal On Advances in Internet Technology. Within the EIFFEL project, in cooperation with the EU Commission and the Internet Society, we also organized a workshop at Brdo pri Kranju on June 11th with the topic "Future Internet Public Private Partnership". At the workshop, Prof. Borka Jerman Blažič gave a presentation about the research achievements of the Slovenian organizations within the FP7 topic Future Internet. The workshop triggered the Slovenian initiative on the Future Internet with the participation of industry and academic institutions. The EIFFEL project and its research results were presented, as well as an invited lecture at the Berlin Symposium on the Future Internet in September 2010.

Another project in the area of the Future Internet is the "Upgrading ICT excellence by strengthening cooperation between research teams in an enlarged Europe (**UNITE**)" project. The main goals of the project are the organization of researchers and PhD students exchange between EU research, academic and industrial organizations, the organization of targeted workshops, such as doctoral symposiums, across an enlarged Europe to build-up synergies and support networking and collaboration, and the creation of virtual communities for the institutions involved in the research of the Future Internet.

The research and development of an open-source, efficient, trusted, personalized, user-centric and participatory television and media delivery system with social and collaborative connotation using the emerging Peer-to-Peer (P2P) paradigm is part of the "Next Generation Peer-to-Peer Content Delivery Platform (**P2P-Next**)" project. The research takes into account the existing EU legal framework and is oriented towards the development of a next-generation P2P content-delivery platform by taking into account the heterogeneous and demanding environments and the demands for the low-cost delivery of professional and user-created content. In 2010 the laboratory's contribution to the project was focused on the provision of security and trust building services of the platform and the setting up of a Living Lab. For the lab test users and RTV Slovenia we have provided the distribution of a full DVB-T signal using P2P technology.

Figure 1: Workshop on Future Internet

An important project in the field of research e-infrastructures is the "Global Linkage Over BroadbAnd Links (**GLOBAL**)" project. The project has built a virtual conference centre using advanced communication technologies and concepts in support of an efficient and world-wide accessible e-infrastructure.

Figure 2: EduCenter portal

With the ISABEL videoconference tool, which is part of the open-source site known as the Global Plaza (www.globalplaza.org) virtual conference centre, we organized 15 events in 2010 and in this way connected infrastructures in South America, India and Africa, and provided, in addition to the e-infrastructure services, the necessary spread up and transfer of knowledge. In the organized events, 104 remote sites participated with 12 speakers (8 of which were located in 3rd countries) and 310 participants (76 of which are located in 3rd countries). Also, approximately 1400 local attendees participated at the events.

Under the Infrastructure program in research organizations we have upgraded in 2010 a **video-conferencing centre**. The main objective of the video-conferencing centre is to provide the Jozef Stefan Institute with some support services that allow better communications between the members of the research programs, especially in the programmes that are multi-disciplinary and the merging of multiple geographically distributed institutions. The video-conferencing centre provides support for the Simple online communications and Advanced online communications services, which allow participants a direct view and cooperation in the distance across Europe and around the world, but their use depends on the purpose and complexity of the event.

Technology-enhanced learning

Learning outcomes, achievements and competencies are the main research theme of the "Interoperable Content for Performance in a Competency-driven Society (**ICOPER**)" project from the European eContentplus programme. Here, the members of the Laboratory explore and look for solutions to problems that appear in outcome-based learning, such as the specification and formal description of learning outcomes, the preparation and search of learning designs in line with expected learning outcomes, searching for the most useful courses according to the expected learning outcomes, the evaluation of obtained skills and competencies, and the collection of learner achievements over longer periods of time. The project is evaluating the technology-enhanced learning standards, such as IEEE RCD, IMS LD or IMS QTI, and is developing good practice approaches in using these standards. In 2010 we revised together with other project partners a PALO specification for the description, storage and sharing of personally achieved learning outcomes, and prepared the first version of the ICOPER Reference Model. The results were published in a scientific journal and at several conferences, while the standardisation process of the PALO specification is expected to start in 2011 within CEN WS/LT (CEN Workshop on "Learning Technologies"). The reference model defines on three levels (data, services, processes) the basic concepts and their relations, the technical services and processes in learning-outcome-based learning. Part of the eContentplus programme is also the "Skill based scouting of open user-generated and community-improved content for management education and training (**OpenScout**)" project that enables users to easily find, access, use and exchange open content for management education and training.

Another European e-learning project that was coordinated by the Laboratory was the "**e^4 VET**" project. This project was primarily aimed at the promotion of the attractiveness of the VET (Vocational Education and Training) schools by establishing an **EduCenter** (http://www.educenter.eu) by building a network of different open-source educational systems and tools. The project helps the teachers of general and vocational subjects, and teachers specializing in adult education and training, to learn about the innovative and easy-to-use tools for developing e-learning materials and access to a broad variety of e-learning materials. In 2010, we trained about 100 teachers for working with modern tools for learning and teaching. The main objective of the COST project "Towards the Integration of Transectorial IT Design and Evaluation (**TwinTide**)" is to harmonize and integrate research findings and achievements with practice durint the process of designing and evaluatinf information technologies across various sectors and disciplines.

Figure 3: Teache's education and training

Security, dependability and privacy in information systems

The provision of security and privacy services is crucial for the modern information society. In 2010 our activities in this field were focused on R&D in security mechanisms and services for advanced systems and networks, such as pervasive systems, P2P networks, next-generation internet systems and networks, etc., as well as on secure applications, e.g., secure long-term archiving systems. The problems were approached in a multidisciplinary way. The first area of research was trust and reputation management in P2P networks and social software systems. We have analyzed existing trust and reputation

systems, such as BarterCast, a fully distributed reputation mechanism based on the BitTorrent protocol, and suggested potential improvements.

The second area of research was related to authorization and access control in P2P networks and next generation internet systems. Within the previously mentioned "**P2P-Next**" project we created a content delivery system based on the BitTorrent protocol named Closed Swarms. Closed Swarms allows us to differentiate between authorized and non-authorized nodes (peers) within an overlay network. We also demonstrated how this access control mechanism may be used to create a high quality content delivery service which provides legitimate users with an improved service over non-authorised users. Later, we extended the Closed Swarms protocol for distributed access control in P2P networks with credentials and policies. The extension provides more flexible access control and enables new scenarios and business models of video content distribution in P2P networks. The results were published at scientific conferences.

The Provision of a secure long-term electronic document archiving service is an important step in transforming business environments into paperless business environments. The main goal of our research was to analyze electronic records preservation for business organizations from an organizational perspective and identify factors that organizations need to take into consideration when selecting and introducing a secure long-term electronic record preservation solution. The results were published as a book chapter.

Figure 4: Eye Tracker-based usability evaluation of a web application

Some outstanding publications in the past three years

1. Tomaž Turk, Borka Jerman-Blažič, Peter Trkman,. Factors and sustainable strategies fostering the adoption of broadband communications in an enlarged European Union. Technol. forecast. soc. change. [Print ed.], 2008, vol. 75, no. 7, pp. 933-951.
2. Peter Dolog, Bernd Simon, Wolfgang Nejdl, Tomaž Klobučar. Personalizing access to learning networks. ACM trans. Internet technol., 2008, vol. 8, no. 2, pp. 8-1-8-21.
3. Borka Jerman-Blažič. Web-hosting market development status and its value as an indicator of a country's e-readiness. Telecommun. policy. [Print ed.], 2008, vol. 32, no. 6, pp. 422-435.

Organization of conferences, congress and meetings

1. Co-organisation of the Future Internet Public Private Partnership event, Brdo pri Kranju, Slovenia, 11. June 2010.
2. Distributed event GLOBAL Plaza 13. September 2010.

INTERNATIONAL PROJECTS

1. Upgrading ICT Excellence by Strengthening Cooperation between Research Teams in an Enlarged Europe
   UNITE
   7. FP, 248583
   EC; Ricardo Goncalves, UNINOVA - Instituto de Desenvolvimento de Novas Technologias, Monte Caparica, Portugal
   Prof. Borka Jerman Blažič
2. Next Generation Peer-to-Peer Content Delivery Platform
   P2P-Next
   7. FP, 216217
   EC; Jari Ahola, VTT - Valtion Teknillinen Tutkimuskeskus, Espoo, Finland
   Dr. Dušan Gabrijelčič
3. Global Linkage Over BroadbAnd Links
   GLOBAL
   7. FP, 223120
   EC; Zentrum für Soziale Innovation, Vienna, Austria
   Prof. Borka Jerman Blažič
4. Evolved Internet Future for European Leadership
   EIFFEL
   7. FP, 216068
   EC; Rheinisch-Westfälische Technische Hochschule Aachen (Rwth – Aachen), Lehrstuhl für Mobilfunknetze, Aachen, Germany
   Prof. Borka Jerman Blažič
5. Towards the Integration of Trans-sectorial IT Design and Evaluation
   COST IC0904
   EC
   Matija Pipan, M. Sc.
6. Enhancing, Empowering and Emphasizing E-learning in Vocational Education and Training
   e4 VET Community Portal
   Leonardo da Vinci Programme
   2008-5772-LdV-TOI, LLP-LDV-TOI-2008-SI-2
   Center Republike Slovenije za mobilnost in evropske programe izobraževanja in usposabljanja - CMEPIUS, Ljubljana, Slovenia
   Tanja Arh, M. Sc.
7. Skill based Scouting of Open User-generated and Community-improved Content for Management Education and Training
   OpenScout, eContentplus
   ECP-2008-EDU-428016
   EC; Jyväskylän Yliopisto, University of Jyväskylän, Jyväskylä, Finland
   Asst. Prof. Tomaž Klobučar

8. Interoperable Content for Performance in a Competency-driven Society
   ICOPER
   eContentplus
   ECP-2007-EDU-417007
   EC; Dr. Bernd Simon, Wirtschaftsuniversität Wien, Institut für Wirtschaftsinformatik und Neue Medien, Vienna, Austria
   Asst. Prof. Tomaž Klobučar
9. Quality and Usability Evaluation of Online Courses and Web 2.0 Tools in E-learning
   BI-HR/09-10-005
   Dr. Goran Bubač, University of Zagreb, Faculty of Organization and Informatics Varaždin, Varaždin, Croatia
   Prof. Borka Jerman Blažič

R & D GRANTS AND CONTRACTS

1. Security and Trust in the New Generation of P2P Networks
   Prof. Borka Džonova Jerman Blažič
2. Security, Dependability and Privacy in Pervasive Systems
   Prof. Borka Džonova Jerman Blažič

RESEARCH PROGRAM

1. Future Internet Technologies: Concepts, Architectures, Services and Socio-Economic Issues
   Prof. Borka Džonova Jerman Blažič

MENTORING

Ph. D. Thesis

1. Tanja Arh, *Vpliv tehnološko podprtega organizacijskega učenja na uspešnost poslovanja podjetij* (mentor Vlado Dimovski; co-mentor Borka Jerman Blažič)

M. Sc. Theses

1. Tomaž Klančnik, *Identity management in cloud computing* (mentor Borka Jerman Blažič)
2. Maja Končar, *Študija prehoda na protokol IPv6 pri večjem internetnem operaterju in ocena potrebnih finančnih vlaganj* (mentor Borka Jerman Blažič)

VISITORS FROM ABROAD

1. Prof. Vladislav V. Fomin, Faculty for informatics, University Vytautas Magnus, Kaunas, Lithuania, 17. September 2010.
2. Mag. Martin Mihajlov, Faculty of economics, Cyril and Methodius University in Skopje, Skopje, Macedonia, 22. – 23. September 2010.
3. Mag. Igor Balaban, Tihomir Orehovački, Miran Zlatović, Tonimir Kišasondi, Faculty of organization and informatics, University of Zagreb, Varaždin, Croatia, 28. – 29. October 2010.

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4. Jad Najjar, Michael Derntl, Tomaž Klobučar, Simon Bernd, Michael Totschnig, Simon Grant, Jan M. Pawlowski, "A data model for describing and exchanging Personal Achieved Learning Outcomes (PALO)", *International journal of IT standards & standardization research*, vol. 8, no. 2, pp. 87-104, 2010.

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1. Tanja Arh, "E-izobraževanje", In: *Kako pripraviti in popestriti izobraževanje z interaktivnimi učnimi gradivi: vzpodbujanje in krepitev e-izobraževanja v poklicnem izobraževanju in usposabljanju: priročnik*, Tanja Arh, ed., Matija Pipan, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 9-14.
2. Tanja Arh, Matija Pipan, "Spletni portal EduCenter", In: *Kako pripraviti in popestriti izobraževanje z interaktivnimi učnimi gradivi: vzpodbujanje in krepitev e-izobraževanja v poklicnem izobraževanju in usposabljanju: priročnik*, Tanja Arh, ed., Matija Pipan, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 57-68.
3. Dejan Dinevski, Andrea Poli, Ivan Krajnc, Olga Šušteršič, Tanja Arh, "E-health integration and interoperability based on open-source information technology", *Wien. klin. Wochenschr., Suppl.*, vol. 122, suppl. 2, pp. 3-10, 2010.
4. Helena Halas, Tomaž Klobučar, "Importance of electronic record preservation in E-busines", In: *Encyclopedia of e-business development and management in the global economy*, In Lee, ed., Hershey, Business Science Reference, cop. 2010, pp. 1076-1085.
5. Rok Kokalj, Urška Mekiš, Matija Pipan, Tanja Arh, "Kako pripraviti kakovostno e-učno gradivo", In: *Kako pripraviti in popestriti izobraževanje z interaktivnimi učnimi gradivi: vzpodbujanje in krepitev e-izobraževanja v poklicnem izobraževanju in usposabljanju: priročnik*, Tanja Arh, ed., Matija Pipan, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 15-56.
6. Matija Pipan, Tanja Arh, Borka Jerman-Blažič, "The evaluation cycle management - method applied to the evaluation of learning management systems", In: *Integrating usability engineering for designing the web experience: methodologies and principles*, Tasos Spiliotopoulos, ed., Hershey, Information Science Reference, 2010, pp. 58-80.

Published Conference Papers

Regular papers

1. Tanja Arh, Borka Jerman-Blažič, "E-learning and web 2.0 technologies in vocational education and training: the development of an EduCenter", In: *Človek in organizacija: zbornik 29. mednarodne konference o razvoju organizacijskih znanosti: proceedings of the 29th International Conference on Organizational Science Development*, 29. mednarodna konferenca o razvoju organizacijskih znanosti, 24.-26. marec 2010, Portorož, Slovenija = 29th International Conference on Organizational Science Development, 24-26 March 2010, Portorož, Slovenia, Tomaž Kern, ed., Vladislav Rajkovič, ed., Björn Paape, ed., Marko Ferjan, ed., Kranj, Moderna organizacija, 2010, pp. 65-75.
2. Tanja Arh, Matija Pipan, Borka Jerman-Blažič, "The contribution of Web 2.0 technologies and eduCenter community portal to the raising the quality of vocational educational and training", In: *ED-MEDIA 2010: world conference on educational multimedia, hypermedia & telecommunications June 29 - July 2, 2010, Toronto, Canada*, Chesapeake, AACE, 2010, pp. 3255-3263.
3. Tanja Arh, Matija Pipan, Marija Mojca Peternel, "Educational community and e-content repository portal EduCenter", In: *Elektronsko učenje na putu ka društvu znanja: Zbornik radova sa nacionalne konferencije, 7. oktobar, 2010, Beograd*, Miroslav Trajanović, ed., Beograd, Metropolitan Univerzitet, 2010, pp. 78-83.
4. Tanja Ažderska, Dušan Gabrijelčič, Borka Jerman-Blažič, "Providing trust and reputation in P2P network", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniske konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, zv. B, pp. 139-142.
5. Njaal Borch, Keith Mitchell, Dušan Gabrijelčič, "Access control to Bit Torrent swarms using closed swarms", In: *AVSTP2P '10: proceedings of the 2010 ACM Workshop on Advanced Video Streaming Techniques for Peer-to-Peer Networks and Social Networking, co-located with ACM Multimedia 2010, October 29, 2010, Firenze Italy*, New York, N.Y., ACM, = Association for Computing Machinery, cop. 2010, pp. 25-30.
6. Borka Jerman-Blažič, "The future of the internet: tussles and challenges in the evolution path as identified by EIFFEL think tank", In: *ICDS 2010*, The Fourth International Conference on Digital Society includes CYBERLAWS 2010, The First International Conference on Technical and Legal Aspects of thee-Society, 10-16 February 2010 St. Maarten, Netherlands Antilles, Lasse Berntzen, ed., [S. l.], IEEE Computer Society, = Institute of Electrical and Electronics Engineers, 2010, pp. 25-30.
7. Vladimir Jovanovikj, Dušan Gabrijelčič, Tomaž Klobučar, "Security issues of the future internet with focus on access control in the content delivery platforms", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniske konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, zv. B, pp. 151-154.
8. Tomaž Klobučar, "Tehnološko podprta uporaba koncepta učnih izidov v e-izobraževanju", In: *Vzgoja in izobraževanje v informacijski družbi: zbornik konfrence: conference proceedings*, Vladislav Rajkovič, ed., Mojca Bernik, ed., Tanja Urbančič, ed., Ljubljana, Ministrstvo Republike slovenije za šolstvo in šport, Institut Jožef Stefan, Zavod Republike Slovenije za šolstvo, Kranj, Fakulteta za organizacijske vede, 2010, 9 pp.
9. Tomaž Klobučar, "Učni izidi in tehnološko podprto učno okolje", In: *Človek in organizacija: zbornik 29. mednarodne konference o razvoju organizacijskih znanosti: proceedings of the 29th International Conference on Organizational Science Development*, 29. mednarodna konferenca o razvoju organizacijskih znanosti, 24.-26. marec 2010, Portorož, Slovenija = 29th International Conference on Organizational Science Development, 24-26 March 2010, Portorož, Slovenia, Tomaž Kern, ed., Vladislav Rajkovič, ed., Björn Paape, ed., Marko Ferjan, ed., Kranj, Moderna organizacija, 2010, pp. 646-652.
10. Tomaž Klobučar, Jad Najjar, "Learning outcome-driven technology enhanced learning in higher education", In: *eChallenges 2010: conference and exhibition 27-29 October, Warsaw, Poland*, Paul Cunningham, ed., Miriam Cunningham, ed., Dublin, IIMC, = International Information Management Corporation, 2010, 8 pp.
11. Matija Pipan, "Uporaba tehnologije sledenja oči pri ocenjevanju uporabnosti e-učnega okolja", In: *Človek in organizacija: zbornik 29. mednarodne konference o razvoju organizacijskih znanosti: proceedings of the 29th International Conference on Organizational Science Development*, 29. mednarodna konferenca o razvoju organizacijskih znanosti, 24.-26. marec 2010, Portorož, Slovenija = 29th International Conference on Organizational Science Development, 24-26 March 2010, Portorož, Slovenia, Tomaž Kern, ed., Vladislav Rajkovič, ed., Björn Paape, ed., Marko Ferjan, ed., Kranj, Moderna organizacija, 2010, pp. 1119-1127.
12. Matija Pipan, Effie Lai-Chong Law, Borka Jerman-Blažič, "Use of eye tracking in the usability evaluation of the eLearning environment", In: *ED-MEDIA 2010: world conference on educational multimedia, hypermedia & telecommunications June 29 - July 2, 2010, Toronto, Canada*, Chesapeake, AACE, 2010, pp. 832-839.

Theses

Ph. D. Thesis

1. Tanja Arh*, Vpliv tehnološko podprtega organizacijskega učenja na uspešnost poslovanja podjetij: doctoral dissertation*, Ljubljana, [T. Arh], 2010.

M. Sc. Thesis

1. Tomaž Klančnik*, Identity management in cloud computing: master thesis*, Ljubljana, [T. Klančnik], 2010.

DEPARTMENT OF COMMUNICATION SYSTEMS E-6

The Department of Communication Systems is concerned mainly with the research, development and design of next-generation telecommunication networks, wireless-communication and sensor networks and new algorithms for parallel and distributed computing in computer simulations. Other research activities include the development of methods and software tools for the modelling, simulation, analysis and synthesis of communication systems, security services in communication networks, advanced bio-signal processing, the education of young researchers, and the transfer of knowledge and new technologies to industry.

Head:
Asst. prof. Mihael Mohorčič

Research and development activities at the department are carried out in two groups: one specialising in telecommunication systems and the other in parallel and distributed systems. With the convergence of telecommunications and information systems, the work in both groups is becoming increasingly interconnected, bringing about synergy effects, particularly in applied projects.

Telecommunication Systems

Most of our research activities in 2010 related to telecommunications systems were concentrated on the areas of cognitive communications, wireless sensor networks and also on different access-segment technologies enabling the end-user to access new multimedia services and applications. The research emphasis was in the areas of: radio transmission; multiple-input multiple-output (MIMO) antenna systems; access architectures for heterogeneous wireless networks; management of radio and network resources; and mobile, personal and emergency communications. We continued the work on cross-layer design and the optimisation of communication protocols in wireless communication systems, whose aim is to improve the utilization efficiency of scarce radio resources and to support the provision of quality of service. We were developing advanced and innovative concepts and technologies enabling interworking, the convergence of networks and the mobility of terminals and networks with a special emphasis on the solutions providing network robustness, security and quality of services. We also rounded more than 10 years of research in the area of stratospheric communications by publishing a book "Broadband Communications via High-Altitude Platforms" with the renowned publisher Wiley.

- **We developed a method and built a proof-of-concept quantum-key distribution device in the energy range of gamma photons.**
- **We developed software modules for radiowave-propagation modelling in mobile communication systems, which can be integrated into an existing open-source geographic information systems (GIS).**

The investigation of radio-signal propagation was focusing on two main topics. The first topic concerns research of radio propagation in special environments, such as long road and railway tunnels, for emergency situations, which includes voice communications systems at 400 MHz, high-speed data communication systems at 3.5 GHz and low-data-rate wireless-sensor networks at 868 MHz and 2.4 GHz. The second topic, carried out in cooperation with the Slovenian national mobile operator Mobitel, d.d., concerns the development, implementation and testing of software modules for radiowave propagation modelling in mobile communications systems for rural and urban environments, including statistical channel models as well channel models based on ray tracing and its integration into the existing open-source geographic information system (GIS).

We continued the research of the utilization of wireless communication technologies in mesh networks. We were focusing our research on the self-organizing networks, especially the problems and solutions of the node localization. The procedure and the algorithm for the node location using received signal strength and time difference of arrival has been invented. The procedure has been submitted as an international patent application to the United States Patent and Trademark office. Within the national development project RIP we also contributed to the design of algorithms and protocols for a WiMAX pico base-station with mesh-router functionality.

We continued our research in the area of cognitive communications in the radio and access segments and thus contributed to the projects WUN-CogCom and COST IC0902. In the access segment we focused on the utilisation of advanced access architecture SmartA for the autonomous selection of the access network and vertical handover in heterogeneous wireless networks. In the radio segment we developed a simple frequency-spectrum sniffer for the Industrial, Scientific and Medical (ISM) bands based on energy detection. It can be used for spectrum sensing in a cognitive radio terminal or for space-time frequency spectrum utilisation database.

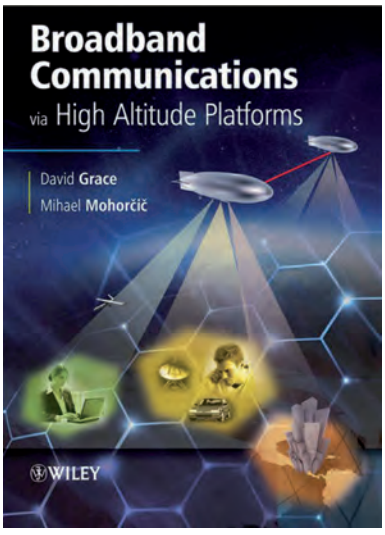

Figure 1: A book has been published on Broadband Communications via High-Altitude Platforms at Wiley (authors David Grace and Mihael Mohorčič, contributions also from Tomaž Javornik and Roman Novak).

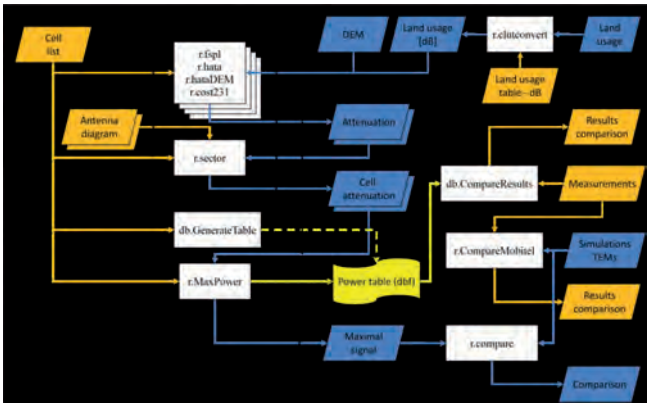

Figure 2: An open-source radio planning tool GRASS-RaPlaT has been designed and implemented.

- **We developed a Versatile Sensor Node (VSN) which represents a modular and fully flexible platform for the research and implementation of wireless semantic sensor networks.**
- **We developed a simple ISM band frequency spectrum sniffer based on energy detection.**
- **We have estimated the asymptotic calculation complexity of meshless numerical methods for the solution of differential equations.**

On the network layer we continued with the investigations of fixed-mobile convergence and with simulations of telecommunications networks. The emphasis in fixed-mobile convergence was on mobility management in convergent networks, in particular on the seamless vertical handover between networks based on different access technologies. We were focusing on the provision of the requested quality of user experience in the target network. We proposed an adaptive mechanism based on SIP communication protocol, which detects the congestion level in the target network, with minimal influence on the device's load in the operator's network. In the area of simulations of telecommunications networks we were focusing in collaboration with Telekom Slovenije, d.d. on the analysis of the introduction of new IP Tv services in the network such as Fast Channel Changing. In particular, we were evaluating the impact of new services on the performance of the access network using a purpose-built simulation model.

In the collaboration of the interdepartmental (E6, E8, CT3) Laboratory for Wireless Sensor Networks (SensorLab) and the company Isotel d.o.o. we developed a Versatile Sensor Node (VSN) platform. VSN is a modular and fully flexible platform which can be used for research work or as a baseline for the actual deployment of wireless-sensor networks. With respect to the research work the emphasis is on the vertical integration of different wireless sensor network technologies with semantic technologies in support of autonomous search for and composition of sensors and sensor data, as well as on the development of new applications using various machine-learning and decision-making algorithms. With these activities we also actively contribute to the FP7 Network of Excellence PlanetData.

In the areas of wireless-sensor networks we also participated in the FP7 projects AgroSense and BalkanGEONet. We designed the remotely controlled airplane model and developed software and hardware equipment for the remote collection, transmission and processing of sensor data and images.

In the framework of the COST IC0802 project and in cooperation with the French Aerospace Lab ONERA we developed new methods to process satellite-beacon data received from EUTELSAT HotBird 6. Related to this activity we won the ESA PECS project "Ka/Q-band Propagation Measurements and Modelling for the Design of Prediction and Impairment Mitigation Techniques" (SatProSi).

In cooperation with TU Graz we participated in the design of new algorithms for hybrid FSO/RF broadband networks and analysed their performance under different weather conditions. The aim of the research was to achieve the maximum throughput while maintaining the required network availability.

We investigated specific non-radiofrequency communication channels within the interdepartmental (E6 and F2) Laboratory for Mathematical Methods in Nuclear Instrumentation. The properties of a quantum channel in a significantly higher energy range of gamma photons were used for the short-range quantum key distribution, which extends classical cryptographic schemes with the possibility to exchange a shared secret key between the two parties using the quantum effects in a way that guarantees unconditional security, i.e., in order to break the scheme one should have to change the fundamental principles of quantum physics. Our approach is an original contribution to the field in which technology based on light quanta currently prevails. The research activities within the laboratory focused on the high-data-rate acquisition in the detector systems and on the measurements of entangled quantum states. The signal-processing algorithms and their efficient mapping on the computation resources were also investigated.

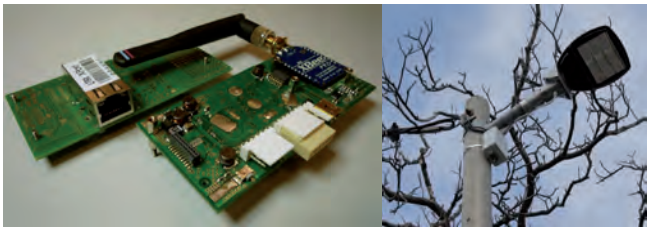

Figure 3: Versatile sensor node (VSN) for the research and development of semantic sensor networks (left) and its deployment in a street-lighting testbed (right)

In 2010 we actively joined the Centre of Excellence for Biosensors, Instrumentation and Process Control (CE BIC) and the Centre of Excellence for Space, Sciences and Technologies (CE SPACE-SI).

Parallel and Distributed Systemst

In 2010 we continued our successful cooperation with two research groups from the University of Ljubljana, the Laboratory for Machine Vision from the Faculty for Electrical Engineering and the Laboratory for Algorithms and Data Structures from the Faculty for Computing and Informatics. We cooperated on a substantial number of research topics in the scope of the

program group Parallel and Distributed Computing. Our cooperating researchers come also from the industry (Turboinstitut, d.d. and Xlab d.o.o.) and from medicine (Clinical Center Ljubljana).

Computer algorithms for efficient and secure implementation on parallel and distributed computers were investigated. Software tools for cluster computing were tested on a 32-processor cluster computer, which runs at our department, and on a grid recently installed in cooperation with the Faculty of Computer and Information Science of the University of Ljubljana and a hi-tech company Turboinstitut, d.d. A computer simulation for medical applications was investigated and applied to several practical examples. We have developed new numerical methods which, unlike, e.g., the finite-elements method, are based on meshless computing. We investigated the computational complexity of mesh-free methods and the possibilities for their parallelization.

We successfully finished the FP7 project ProSense (Promote, mobilize, reinforce and integrate wireless sensor networking research and researchers: Towards pervasive networking of WBC and the EU). Thereby, we entered into a new research area, wireless-sensor networks, founded in the theory of parallel and distributed computing and communication. We edited and contributed to a book from the area: "Application and multidisciplinary aspects of wireless-sensor networks: concepts, integration, and case studies", published by Springer.

- **We were the first in the world to measure the temperatures in the central part of the knee.**
- **We have developed a prototype wireless electrode of biopotentials from the body surface.**
- **To the best of our knowledge we were the first in the world to synthesise a standard 12-channel ECG from just three bipolar wireless electrodes.**

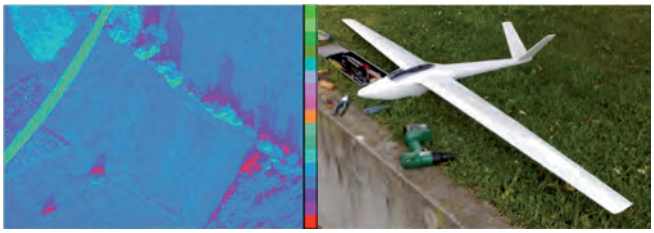

Figure 4: Remotely controlled airplane model for the collection of sensor data and multispectral imagery

In the field of medical research, the spatial model of a human knee with a resolution of 1 mm was finalized in cooperation with colleagues from the Clinical Centre Ljubljana (CCL). We improved the simulation of the heat transfer in biological tissues, including heat transfer in the surrounding fluids. In the model, we also included heat transfer over capillaries and the metabolic heat source. A parallel simulation program was finalized using advanced numerical methods (multigrid and meshless). Parallel programs for the simulation of human-knee cooling were developed and employed for comparing the results of various post-operative knee-cooling methods, which were selected by the CCL team members. After publishing the research results in a journal paper in Computers in Biology and Medicine the representative of the Belgian medical company Weagener, which develops and produces cooling equipment for human body parts contacted us. We signed an industrial contract for the measurements of the inner-knee temperatures during arthroscopic surgery.

We investigated possible options for the detection of respiratory sinus arrhythmia (RSA) in the ST interval. A new investigation method for the variability of the ST interval was investigated that enables a sub-millisecond resolution. We further developed and upgraded the NeuroECG device and measurements, in cooperation with neurologists from Cinical Center Ljubljana.

In the field of formal methods for discrete-systems modelling and development, we adapted our generic test-generation method for deterministic finite-state machines to support segment-based test synthesis. As its specialization, we then developed a method which generalizes a large family of established methods for checking the sequence construction and facilitates the synthesis of cheaper tests also for distributed testing with no coordination between the testers.

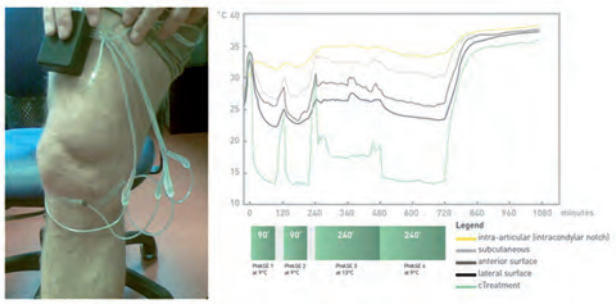

Figure 5: System for a temperature measurement in the central parts of the knee after surgery (left) and the measured average temperatures on the skin and in the inner knee after sixteen hours of cooling (right)

Some outstanding publications in the past year

1. David Grace, Mihael Mohorčič. Broadband Communications via High-Altitude Platforms. Chichester: Wiley, October 2010. 398 pp. ISBN: 978-0-470-69445-9.
2. Rok Libnik, Aleš Švigelj, Gorazd Kandus. A novel SIP based procedure for congestion aware handover in heterogeneous networks. Computer communications. [Print ed.], 2010, vol. 33, no. 18, pp. 2176-2184.
3. Andrej Vilhar, Roman Novak, Gorazd Kandus. The impact of network topology on the performance of MAP selection algorithms. Comput. networks, 2010, vol. 54, no. 7, pp. 1197-1209.
4. Andrej Hrovat, Gorazd Kandus, Tomaž Javornik. Four-slope channel model for path loss prediction in tunnels at 400 MHz. IET microwaves, antennas & propagation. [Print ed.], 2010, vol. 4, no. 5, pp. 571-582.

5. Farukh Nadeem, Tomaž Javornik, Erich Leitgeb, Vaclav Kvicera, Gorazd Kandus. Continental fog attenuation empirical relationship from measured visibility data. Radioengineering (Prague), 2010, vol. 919, no. 4, pp. 596-600.
6. Ivan Tomašić, Roman Trobec, Optimized positioning of ECG electrodes for WSN applications,in Liljana Gavrilovska, Srdjan Krco, Veljko Milutinović, Ivan Stojmenović, Roman Trobec (Eds), Application and multidisciplinary aspects of wireless sensor networks : concepts, integration, and case studies, (Computer communications and networks). London, Springer, 2011, pp. 185-211.

Organization of conferences, congress and meetings

1. Networking Meeting and Training of FP7 AgroSense Project, Ljubljana, 19-21 April 2010
2. ProSense Workshop Ljubljana, 20 May 2010
3. Management Board Meeting 6 of FP7 AgroSense Project, Ljubljana, 19-21 October 2010
4. AgroSense Workshop "Design and implementation of Wireless sensor nodes", Ljubljana, 19-21 October 2010

INTERNATIONAL PROJECTS

1. Balkan GEO Network - Towards Inclusion of Balcan Countries into Global Earth Observation Initiatives
   BalkanGEONet
   7. FP, 265176
   EC; Prof. Vladimir Crnojevic, Univerzitet u Novom Sadu, University of Novi Sad, Novi Sad, Serbia
   Asst. Prof. Mihael Mohorčič
2. Planet Data
   7. FP, 257641
   EC; Alice Carpentier, Dieter Fensel, Universitaet Innsbruck, Innsbruck, Austria
   Asst. Prof. Mihael Mohorčič, Marko Grobelnik, Prof. Dunja Mladenić, Mitja Jermol, M. Sc.
3. Enabling the Knowledge Powered Enterprise
   ACTIVE
   7. FP, 215040
   EC; Philip Hewitt, British Telecommunications plc, London, Great Britain
   Asst. Prof. Mihael Mohorčič, Mitja Jermol, M. Sc., Marko Grobelnik, Prof. Dunja Mladenić
4. Promote, Mobilize, Reinforce and Integrate Wireless Sensor Networking Research and Researchers: Towards Pervasive Networking of WBC and the EU
   ProSense
   7. FP, 205494
   EC; Alex Gluhaw, LM Ericsson Ltd., Dublin, Ireland
   Prof. Roman Trobec
5. Trans-national Cooperation among ICT NCPs
   IDEALIST2011
   7. FP, 231367
   EC; Deutsches Zentrum für Luft- und Raumfahrt E. V. (DLR), Köln, Germany
   Asst. Prof. Mihael Mohorčič
6. Wireless Sensor Networks and Remote Sensing - Foundation of a Modern Agricultural Infrastructure in the Region
   AgroSense
   7. FP, 204472
   EC; University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia
   Asst. Prof. Mihael Mohorčič, Prof. Kandus Gorazd
7. Cognitive Radio and Networking for Cooperative Coexistence of Heterogeneous Wireless Networks
   COST IC0902
   EC
   Asst. Prof. Mihael Mohorčič
8. Open European Network for High Performance Computing on Complex Environments
   COST IC0805
   EC
   Prof. Roman Trobec
9. Propagation Tools and Data for Integrated Telecommunication, Navigation and Earth Observation Systems
   COST IC0802
   EC
   Prof. Gorazd Kandus
10. Prevasive Mobile & Ambient Wireless Communications
    COST 2100
    EC; Prof. Roberto Verdone, DEIS- Università degli Studi di Bologna, Bologna, Italy
    Asst. Prof. Tomaž Javornik
11. Teledoctorate Project
    UNESCO-ROSTE Grant
    Silvano Pupolin, Università di Padova, Dipartimento di Ingegneria dell'Informazione, Padova; Dr. Paola Magri, Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Parma, Italy
    Prof. Gorazd Kandus
12. Study relating to the Measurement of the Effects of Cryotherapy on a Human Body Research Agreement
    Konrad Lang, Levi Dewaegenaere, Waegener Research & Development N.V., Beerse, Belgium
    Prof. Roman Trobec
13. VSN Development Kit
    Adnan Mededović, IPSA Institut d.o.o., Sarajevo, Bosnia and Herzegovina
    Asst. Prof. Mihael Mohorčič
14. Acceleration of Matrix Operations on a Reconfigurable Computing Architecture Based on the Whole Silicon Wafer
    BI-UA/09-10-001
    Dr. Andriy Lutsyk, Institute of Physics and Mechanics, Lviv, Ukraine
    Prof. Roman Trobec

R&D GRANTS AND CONTRACT

1. Multi-antenna Systems for Mobile WiMAX
   Prof. Gorazd Kandus

RESEARCH PROGRAMS

1. Telecommunication Systems
   Prof. Gorazd Kandus
2. Parallel and Distributed Systems
   Prof. Roman Trobec

NEW CONTRACTS

1. Co-funding of project L2-1109-0106-08 "Multi-antenna systems for mobile WiMAX"
   COSYLAB, control system laboratory
   Prof. Gorazd Kandus
2. Input data adaptation and implementation of advanced modules for calculation and presentation of radio coverage.
   Mobitel, d.d.
   Asst. Prof. Tomaž Javornik
3. Testing of numerical simulation speed-ups on parallel computer LCS ADRIA
   Turboinštitut, d.d.
   Prof. Roman Trobec
4. Measuring equipment set - NEURO ECG
   University Medical Centre Ljubljana
   Prof. Roman Trobec

MENTORING

Ph. D. Theses

1. Tine Celcer, Adaptive resource allocation in multiuser distributed MIMO systems (mentor Tomaž Slivnik; co-mentor Gorazd Kandus)
2. Matjaž Depolli, Parallelization of an evolutionary algorithm for multiobjective optimization (mentor Bogdan Filipič; co-mentor Roman Trobec)
3. Hugo Correia Duarte Furtado, Augmented reality and wireless sensor networks applications to support minimally invasive cardiac surgery (mentor Roman Trobec; co-mentor Wolfgang Birkfellner)
4. Rok Libnik, Handover in heterogeneous networks using SIP protocol (mentor Aleš Švigelj; co-mentor Gorazd Kandus)

VISITORS FROM ABROAD

1. Prof. Erich Leitgeb, Institute of Broadband Communications, Technische Universität Graz, Graz, Austria, 12 May 2010
2. Dr. Veljko Milutinović, University of Belgrade, Electro Technical Faculty, Serbia, 13 May 2010
3. Vladimir Petrović, University of Belgrade, Electro Technical Faculty, Serbia, 13 May 2010
4. Dr. Nadeem Farukh, University of Technology, Graz, Austria, 10- 25 July 2010
5. Dr. Hugo Furtado, Medical University of Vienna, Vienna, Austria, 9-10 March 2010
6. Ivan Tomašić M.Sc, Institut Ruđer Bošković, Zagreb, Croatia, 28- 30 April 2010
7. Osman Musa M.Sc, IPSA Institute Sarajevo, Bosnia and Herzegovina, 1 August to 1 October 2010
8. Amir Ligata M.Sc, IPSA Institute Sarajevo, Bosnia and Herzegovina, 1 August to 1 October 2010
9. Miloš Rovčanin, Faculty of Technical Sciences, Novi Sad, Serbia, 1- 15 November 2010
10. Martin Czaputa, Technische Universität Graz, Graz, Austria, 15-28 November 2010
11. Dr. Hugo Furtado Medical University of Vienna, Vienna, Austria, 16-18 November 2010
12. Ivan Tomašić M.Sc, Institut Ruđer Bošković, Zagreb, Croatia, 1-3 December 2010

STAFF

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1. Dr. Viktor Avbelj
2. Asst. Prof. Tomaž Javornik
3. Prof. Gorazd Kandus
4. Prof. Monika Kapus Kolar
5. Dr. Andrej Lipej*
6. **Asst. Prof. Mihael Mohorčič, Head**
7. Asst. Prof. Roman Novak
8. Dr. Igor Ozimek
9. Asst. Prof. Aleš Švigelj
10. Prof. Roman Trobec

Postdoctorial associates

11. Dr. Tine Celcer, left 01.07.10
12. Dr. Matjaž Depolli
13. Dr. Srečo Plevel*
14. Dr. Marjan Šterk*
15. Dr. Andrej Vilhar

Postgraduates

16. Kemal Alič, M. Sc.
17. Gregor Berke, B. Sc.
18. Carolina Fortuna, B. Sc.
19. Andrej Hrovat, M. Sc.
20. Erik Pertovt, B. Sc.
21. Aleksandra Rashkovska, B. Sc.
22. Miha Smolnikar, B. Sc.

Technical officers

23. Matevž Vučnik, B. Sc.

Technical and administrative staff

24. Polona Anžur, B. Sc.
25. Tomaž Krištofelc

Note:
* part-time JSI member

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COMPUTER SYSTEMS DEPARTMENT E-7

The department is concerned primarily with the design automation of computing structures and systems. Within this broad area we are concentrating on a meta-heuristic approach to engineering design and logistics problems as well as system design and test. As an integral part of our research activity, members of the department have close contacts and collaboration with scientists world-wide, through academic links and industrial contacts, thus enabling us to keep at the forefront of this rapidly developing field

Head:
Prof. Franc Novak

The research of system design and test was focused on reconfigurable computing structures. As an initial step toward the design of a self-repairable reconfigurable system, we developed a mechanism for internal FPGA configuration check and repair with a low hardware overhead. The proposed recovery mechanism occupies fewer hardware resources and has a shorter fault-recovery time than the solutions reported so far.

In the area of hardware/software co-design we collaborate with FERI, University of Maribor, in the application project "Processing of massive geometric LIDAR data".

We are developing a hardware accelerator for the compression of LIDAR data. In the past year the arithmetic coding, which is part of the overall compression architecture, was developed in the VHDL language and tested with a Cadence simulator.

In cooperation with the Institute of Electronics of the Silesian University of Technology we used a genetic algorithm for the optimization of a test-pattern generator design. The results show the improvements in comparison with previous design approaches. The results were presented in an international journal, and one book chapter was submitted.

We developed efficient, built-in, self-test solutions for testing embedded cores in a system-on-chip, conforming with IEEE Std 1500.

We developed built-in, self-test solutions for testing an embedded ADC core in a system-on-chip using the popular histogram-based technique. The developed solutions targeted a minimized hardware overhead, a minimized test time and scalability. We also studied the oscillation-based test approach for a possible application in a built-in, self-test of the embedded ADC core in a system-on-chip. We investigated the measurement conditions and noticed an inherent measurement uncertainty, which has to be considered when deriving the parameters from the oscillation frequency. We further elaborated this issue and derived a theoretical background for computing the measurement uncertainty of the approach.

An important part of our research activities is related to the development of metaheuristic optimization methods and their applications. We have developed a new Continuous Differential Ant-Stigmergy Algorithm (CDASA) suitable for solving continuous numerical optimization problems on several real-world applications. We have used this approach to the problem of the parameter estimation of nonlinear dynamic systems represented by ordinary differential equations. More precisely, we address the parameter estimation of the dynamics of the Rab5-to-Rab7 conversion in endocytosis.

Within the industrial project "Pilot model for optimization of deadline planning in the cooking plates production" for the ETA Cerkno d.o.o., we tested different evolutionary optimization algorithms. For use in the production planning we implemented the most appropriate one. Based on the efficient results the project will continue to make the overall application for product planning and management. The results of the optimization were presented at several international conferences.

In the field of evolutionary optimization, we also developed a methodology for the distance learning of elementary-school mathematics. It is supported by a decision-making system based on evolutionary computation, which leads a student in selecting an optimal subset of math items to effectively upgrade the knowledge. The pilot application called MatPort (http://sinica.ijs.si/matport) provides a set of verified math items for chil-

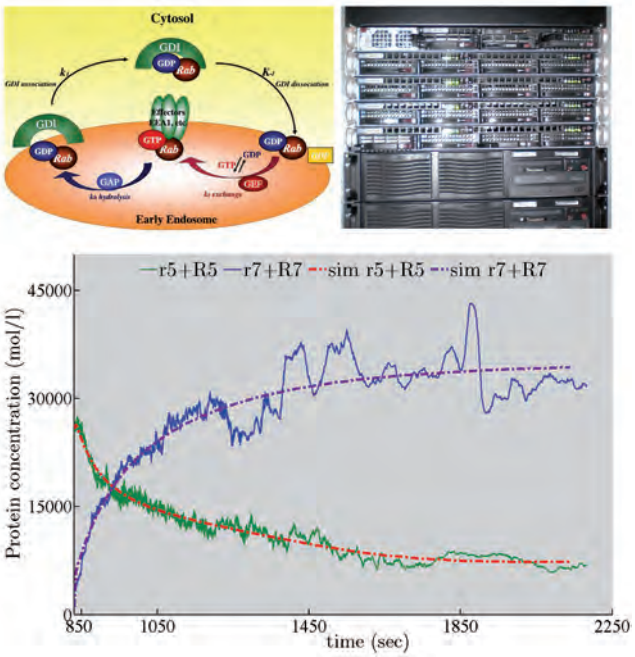

Figure 1: Modeling dynamics of the Rab5-to-Rab7 conversion in endocytosis: The best predicted model was obtained by parameter estimation with the DASA metaheurstic optimization algorithm.

In collaboration with ETA Cerkno we implemented an efficient procedure for the product-planning optimization of cooking plates.

dren under 15 years of age and is based on the Slovenian curriculum for elementary-school mathematics.

In the area of computer vision we developed an automated cell-counting procedure based on a novel artificial neural network optimization of the Image-based Tool for Counting Nuclei (ITCN) algorithm parameters to be used in an electroporation treatment. Within the procedure, an expert manual counting is needed for a very small amount of images from a given set to determine the ITCN parameters, which are then used to count cells in all the images from the set with an accuracy of over 90%. This is comparable to user manual counting, especially taking into account an inter-person error that can be up to 10%. This procedure can also be used for fluorescent cell images with a similar counting accuracy, enabling us to determine the electroporation efficiency.

Within the EUREKA project DIPIMAM a computer program was implemented that can learn from examples and is based on artificial neural networks. Its intended use is to assist injection-moulding-machine operators to setup the injection parameters (time, pressure, tool temperature, pipe temperature,) with regard to the feedstock properties and the desired properties of molten parts.

In collaboration with the Department of Environmental Sciences we continue to investigate the dependence of radon concentrations on seismological events. We applied a method developed previously that can distinguish radon-concentration anomalies due to earthquakes from the ones due to other environmental parameters, to newly adopted data and achieved a positive result in over 70% cases.

In collaboration with the Faculty of Health Studies, University of Ljubljana, we developed a procedure for performing a Wartenberg pendulum test where the time dependence of the knee angle is tracked and then compared to a damped oscillation curve. The parameters of this curve are used to determine the viscosity of the knee's synovial fluid and to detect anomalies. Besides several groups of people belonging to the healthy population, we also included an elderly group and a diabetic group.

We developed a pilot mobile application for informing consumers about the composition of food products. The application enables a consumer to scan a barcode of a given food product using a camera-equipped mobile phone. In return, he or she receives information about the food's composition displayed on the mobile-phone display in real time. The application enables one-dimensional (EAN-8 or EAN-13) and two-dimensional (e.g., QR Code) barcode recognition, and is both lightweight and fast. The application framework is based on the freely available Barcode recognition toolkit, developed by Robert Adelmann from ETH Zürich (http://people.inf.ethz.ch/adelmanr/batoo). We extended its functionality to support mobile platforms from different vendors and redesigned the execution flow to avoid any network activities without a user demand. The work has been done in cooperation with the Public Health Institute, Ljubljana, the Slovene Consumers Association and Slovenian medical associations for arterial hypertension, cardiovascular diseases and diabetes, with the support of the Slovenian Ministry of Health.

Figure 2: The pilot mobile application recognizes a barcode and provides the user with information on food composition and its quality in real-time.

In cooperation with an SME Sonce.net, we developed a web- and mobile-based application called Open Platform for Clinical Nutrition (OPCN; available at http://opkp.si), which provides e-contents and e-services for supporting clinical nutrition and the nutrition of people with special nutritional needs. The OPCN is built upon a set of modular software frameworks that enable e-learning and e-services tailored for citizens and physicians. Its feature is a connection with the EuroFIR (European Food Information Resource Network) Information Platform that provides a (pan-)European distributed food composition database. The OPCN guarantees the high level of security required for e-health information systems. Its efficiency has been validated in a clinical study performed on the Oncology Institute Ljubljana and the Pediatric Clinic Ljubljana. The work was co-funded by the Ministry of Higher Education, Science and Technology of the Republic of Slovenia through the European Regional Development Fund.

The bilateral project that runs in cooperation with colleagues from the University of Pecs in Hungary is aimed at the design and development of a set of web ontologies for food, dietary intake references, and guidelines and recommendations for clinical nutrition. The main objective of the project is to: a) gather beside data and information also knowledge on clinical nutrition, and b) provide tools for ontologies reasoning.

In cooperation with Department of Intelligent Systems we organized the BIOMA 2010 conference (Bioinspired Optimization Methods and their Applications). The fourth biennial conference included presentations and

discussions on the newest theoretical and practical results on nature-inspired optimization methods and their applications. The conference presentations are included in the conference proceedings.

In cooperation with the Department of Intelligent Systems and the Laboratories for Computer Architecture and Languages, and Programming Methodologies from University of Maribor we organized, for the sixth consecutive year, the workshops on "Nature-inspired algorithms" about stochastic optimization techniques.

We developed a mobile application that provides the consumer with information about food quality in real time.

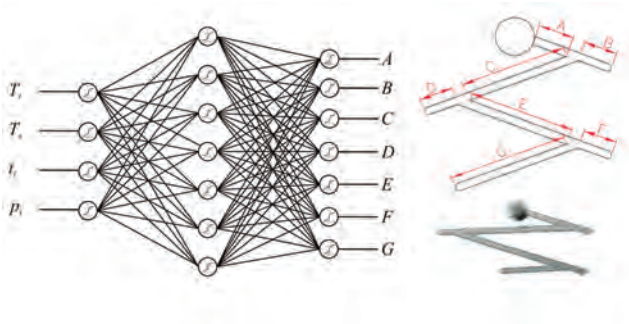

Figure 3: Geometry prediction of molten ceramic parts with artificial neural networks.

Some outstanding publications in the past three years

1. B. Koroušić Seljak, " Computer-based dietary menu planning", J. Food Compos. Anal., 2009, vol. 22, no. 5, pp. 414-420.
2. P. Korošec, J. Šilc, " The distributed multilevel ant-stigmergy algorithm used at the electric-motor design", Eng. Appl. Artif. Intell., 2008, vol. 21, no. 6, pp. 941-951.
3. D. Torkar, S. Novak, F. Novak, "Apparent viscosity prediction of alumina-paraffin suspensions using artificial neural networks". J. Mater. Process. Technol., 2008, vol. 203, no. 1/3, pp. 208-215.
4. R. Pačnik, F. Novak, , "A high-sensitivity hydraulic load cell for small kitchen appliances", Sensors, 2010, vol. 10, no. 9, str. 8452-8465.
5. P. Korošec, J. Šilc, B. Filipič, " The differential ant-stigmergy algorithm, " Inf. sci.. [Print ed.], [in press 2010].

Organization of conferences, congress and meetings

1. BIOMA 2010, The 4th International Conference on Bioinspired Optimization Methods and their Applications, Ljubljana, Slovenia, 20–21 May 2010
2. AVN, The 17th workshop "Nature-inspired algorithms" 2009/2010, 16 June 2010, Ljubljana, Slovenia

INTERNATIONAL PROJECTS

1. Enhancing Lifelong Learning for the Electrical and Information Engineering Community
   ELLEIEC – Surveyor
   ERASMUS
   2008-3199/001-001, 142814-LPP-1-2008-FR-ERASMUS-ENV
   EC; M. Hamed Yahoui, L'Université Claude Bernard Lyon 1, Villeurbanne, France
   Prof. Franc Novak
2. Development and Implementation of New PIM Binder System Using Advanced Methods
   DIPIMAM
   EUREKA
   Hidria AET d.o.o., Tolmin, Slovenia
   Dr. Drago Torkar
3. Open Platform for Clinical Nutrition: OPKP
   E-contents and E-services
   3211-09-000538
   Zoran Trojan, SONCE.NET d.o.o, Ljubljana, Slovenia
   Asst. Prof. Barbara Koroušić Seljak
4. High-Performance Computer-Based Dietary Menu Planning
   BI-HU/10-11-015
   Asst. Prof. Istvan Vassanyi, University of Pannonia, Dept. of Information Systems, Veszprem, Hungary
   Asst. Prof. Barbara Koroušić Seljak

R & D GRANTS AND CONTRACTS

1. Processing of Massive Geometric LIDAR Data
   Prof. Franc Novak
2. Optimization of Packaging, Loading and Transportation of Prefabricated Building Elements
   Asst. Prof. Peter Korošec

RESEARCH PROGRAM

1. Computing Structures and Systems
   Prof. Franc Novak

NEW CONTRACT

1. Consulting on the project "Development of key components of the new-High Efficiency" - environmentally friendly generation of alternators
   ETA d.o.o. Cerkno
   Asst. Prof. Peter Korošec
2. Implementation of optimization for planning and scheduling of production of cooking plates for the use in manufacturing.
   ETA d.o.o. Cerkno
   Asst. Prof. Peter Korošec

MENTORING

Ph. D. Thesis

1. Peter Mrak, *Test infrastructure design for ADC cores in system-on-chip* (mentor Franc Novak)

VISITORS FROM ABROAD

1. Assistant Prof. Istvan Vassanyi, Balazs Gaal, Msc in Balazs Pinter, BSc, University of Pannonia, Department of Information Systems, Veszprém, Egyetema, Madžarska, 17–26 November 2010

STAFF

Researchers
1. Asst. Prof. Anton Biasizzo
2. Asst. Prof. Peter Korošec
3. Asst. Prof. Barbara Koroušić Seljak
4. **Prof. Franc Novak, Head**
5. Asst. Prof. Gregor Papa
6. Asst. Prof. Jurij Šilc

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9. Uroš Legat, B. Sc.
10. Katerina Tashkova, B. Sc.
11. Vida Vukašinović, B. Sc.

Technical and administrative staff
12. Jolanda Jakofčič

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

1. Nathann Cohen, Darko Dimitrov, Roi Krakovski, Riste Škrekovski, Vida Vukašinović, "On Wiener index of graphs and their line graphs", *MATCH Commun. Math. Comput. Chem. (Krag.)*, vol. 64, no. 3, pp. 683-698, 2010.
2. Tomasz Garbolino, Gregor Papa, "Genetic algorithm for test pattern generator design, Automatic evolution of circuits", *Appl. intell. (Boston)*, vol. 32, no. 2, pp. 193-204, 2010.
3. Peter Korošec, Gregor Papa, Vida Vukašinović, "Production scheduling with a memetic algorithm", *International journal of innovative computing and applications*, vol. 2, no. 4, pp. 244-252, 2010.
4. Peter Korošec, Jurij Šilc, "Stigmergični pristop za reševanje dinamičnih optimizacijskih problemov", *Elektroteh. vestn.*, vol. 77, no. 1, pp. 19-24, 2010.
5. Peter Mrak, Anton Biasizzo, Franc Novak, "Measurement accuracy of oscillation-based test of analog-to-digital converters", *ETRI J.*, vol. 32, no. 1, pp. 154-156, 2010.
6. Roman Pačnik, Franc Novak, "A high-sensitivity hydraulic load cell for small kitchen appliances", *Sensors*, vol. 10, no. 9, pp. 8452-8465, 2010.
7. Drago Torkar, Boris Zmazek, Janja Vaupotič, Ivan Kobal, "Application of artificial neural networks in simulating radon levels in soil gas", *Chem. geol.*, vol. 270, no. 1/4, pp. 1-8, 2010.
8. Boris Zmazek, Sašo Džeroski, Drago Torkar, Janja Vaupotič, Ivan Kobal, "Identification of radon anomalies in soil gas using decision trees and neural networks", In: *Proceedigs of the International Conference Radon in Environment, May 20-14, 2009, Zakopane, Poland*, (Nukleonika, vol. 55, no. 4), Jadwiga Mazur, ed., Krzysztof Kozak, ed., Ivan Kobal, ed., Warszawa, Institute of Nuclear Chemistry and Technology, 2010, pp. 501-505.

Published Conference Papers

Regular papers

1. Lucas Benedičič, Mitja Štular, Peter Korošec, "Pilot power optimization in UMTS: a multi-agnet approach", In: *Zbornik 13. mednarodne multikonference Informacijska družba - IS 2010, 11.-15. oktober 2010: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 7-10.
2. Uroš Bole, Gregor Papa, Jure Žabkar, "Organizacijski vidik uvajanja napovedne analitike v organizacije", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniske konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, zv. B, pp. 82-85.
3. Peter Korošec, Gregor Papa, Vida Vukašinović, "Application of memetic algorithm in production planning", In: *Bioinspired optimization methods and their applications: proceedings of the Fourth International Conference on Bioinspired Optimization Methods and their Applications, BIOMA 2010, 20-21 May 2010, Ljubljana, Slovenia*, Bogdan Filipič, ed., Jurij Šilc, ed., Ljubljana, Jožef Stefan Institute, 2010, pp. 163-175.
4. Peter Korošec, Katerina Taškova, Jurij Šilc, "The differential ant-stigmergy algorithm for large-scale global optimiation", In: *Proceedings*, 2010 IEEE World Congress on Computational Intelligence, WCCI 2010, [composed of] IJCNN 2010, FUZZ-IEEE 2010, and IEEE CEC 2010, July 18-23, Barcelona, Spain, [S. l.], IEEE, 2010, pp. 4288-4294.
5. Barbara Koroušić-Seljak, "Computer-based dietary menu planning: how to support it by complex knowledge?", In: *Knowledge-based and intelligent information and engineering systems: 14th International Conference, KES 2010, Cardiff, UK, September 8-10, 2010: proceedings: part 1*, (Lecture notes in computer science, Lecture notes in artifical intelligence, vol. 6276), Rossitza Setchi, ed., Berlin, Heidelberg, Springer, 2010, vol. 6276, pp. 587-596, 2010.
6. Barbara Koroušić-Seljak, "Web-based eHealth applications with reference to food composition data", In: *European food composition data for better diet, nutrition and food quality: proceedings of the 3rd International EuroFIR Congress, 8th -10th September 2009, Vienna, Austria*, (European journal of clinical nutrition, vol. 64, suppl. S3), London, Paris, John Libbey, 2010, pp. S121-S127.
7. Barbara Koroušić-Seljak, Peter Korošec, Gregor Papa, Jure Čelesnik, Tomo Glažar, Aleš Lekše, Katarina Valentinčič, Jure Vižintin, "Odprta platforma za klinično prehrano", In: *Trendi in izzivi v živilstvu, prehrani, gostinstvu in turizmu: zbornik prispevkov 1. mednarodne strokovne konference, 25.-27. oktober 2010, Ljubljana, Slovenija: conference proceedings of papers of the 1st international expert conference, 25-27 October 2010, Ljubljana, Slovenia*, Dejan Cvitkovič, ed., Vesna Loborec, ed., Gordana Vulić, ed., Ljubljana, Biotehniški izobraževalni center, Višja strokovna šola, = Educational Centre of Biotechnology, Vocational College, 2010, pp. 131-139.
8. Barbara Koroušić-Seljak, Gregor Papa, "Bioinspired online mathematics learning", In: *Bioinspired optimization methods and their applications: proceedings of the Fourth International Conference on Bioinspired Optimization Methods and their Applications, BIOMA 2010, 20-21 May 2010, Ljubljana, Slovenia*, Bogdan Filipič, ed., Jurij Šilc, ed., Ljubljana, Jožef Stefan Institute, 2010, pp. 193-203.
9. Barbara Koroušić-Seljak, Gregor Papa, "Spletna aplikacija MatPort za osnovnošolsko matematiko", In: *Nova vizija tehnologij prihodnosti*, Mednarodna konferenca InfoKomTeh 2010, Ljubljana 27. oktober 2010 = International Conference InfoKomTeh 2010, 27th October 2010, Mojca Orel, ed., Ljubljana, Evropska svetovalnica, 2010, pp. 287-296.
10. Uroš Legat, Anton Biasizzo, Franc Novak, "Automated SEU fault emulation using partial FPGA reconfiguration", In: *Proceedings of the 13th IEEE Symposium on Design and Diagnostics of Electronic Circuits and Systems, April 14-16, 2010, Vienna, Austria*, Zdeněk Kotásek, ed., [Vienna], IEEE, = Institute of Electrical and Electronics Engineers, 2010, pp. 24-27.
11. Uroš Legat, Anton Biasizzo, Franc Novak, "Concurent self test and repair of embedded multi-core SOC on FPGA using dynamic partial reconfiguration", In: *Proceedings*, Denis Đonlagić, ed., Iztok Šorli, ed., Polona Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2010, str, 261-264.

12. Gregor Papa, Peter Korošec, Vida Vukašinović, "Influence of fixed-deadline orders on memetic algorithm performance production planning", In: *Proceedings*, MCPL 2010, 5th Conference on Management and Control of Production and Logistics, September 8-10, 2010, Coimbra, Portugal, [S. l.], IFAC, 2010, 4 pp.
13. Gregor Papa, Peter Mrak, "Optimization of cooling appliance control parameters", In: *CD-ROM proceedings*, EngOpt2010, 2nd International Conference on Engineering Optimization, 6-9 September 2010, Lisboa, Portugal, Lisboa, APMTAC, = Associaçao Portuguesa de Mecânica Teórica, Aplicada e Computacional, 2010, 8 pp.
14. Gregor Papa, Peter Mrak, "Thermal simulations for development speed-up", In: *SIMUL 2010*, The Second International Conference on Advances in System Simulation, 22-27 August 2010, Nice, France, Edward Williams, ed., Pascal Lorenz, ed., Piscataway, IEEE Computer Society Conference Publications, 2010, pp. 11-15.
15. Katerina Taškova, Peter Korošec, Jurij Šilc, "A distributed multilevel ant-colony approach for finite element mesh decomposition", In: *Parallel processing and applied mathematics. Part II: proceedings*, (Lecture notes in computer science, Theoretical computer science and general issues, vol. 6068), 8th International Conference, PPAM 2009, Wroclaw, Poland, September 13-16, 2009, Roman Wyrzykowski, ed., Berlin, Heidelberg, Springer, 2010, pp. 398-407.
16. Katerina Taškova, Peter Korošec, Jurij Šilc, Ljupčo Todorovski, Sašo Džeroski, "Parameter estimation in an endocytosis model", In: *Machine learning in system biology: proceedings of the Fourth International Workshop [ICSB 2010], Edinburgh, Scotland, October 15-16, 2010*, Sašo Džeroski, ed., Simon Rogers, ed., Guido Sanguinetti, ed., [s. l., s. n.], 2010, pp. 75-80.
17. Katerina Taškova, Peter Korošec, Jurij Šilc, Ljupčo Todorovski, Sašo Džeroski, "Parameter estimation in an endocytosis model with bioinspired optimization algorithms", In: *Bioinspired optimization methods and their applications: proceedings of the Fourth International Conference on Bioinspired Optimization Methods and their Applications, BIOMA 2010, 20-21 May 2010, Ljubljana, Slovenia*, Bogdan Filipič, ed., Jurij Šilc, ed., Ljubljana, Jožef Stefan Institute, 2010, pp. 67-82.
18. Vida Vukašinović, Peter Korošec, Gregor Papa, "Hybrid parameter-less evolutionary algorithm in production planning", In: *Proceedings*, IJCCI 2010, 2nd International Joint Conference on Computational Intelligence, ICEC 2010, International Conference on Evolutionary Computation, ICFC 2010, International Conference on Fuzzy Computation, ICNC 2010, International Conference on Neural Computation, 24-26 October 2010, Valencia, Spain, Joaquim Filipe, ed., Janusz Kacprzyk, ed., [S. l.], SciTePress, = Science and Technology Publications, 2010, pp. 231-236.
19. Vida Vukašinović, Gregor Papa, Peter Korošec, "Vpliv časovnih omejitev na učinkovitost memetskega algoritma pri planiranju proizvodnje", In: *Zbornik devetnajste mednarodne Elektrotehniške in računalniške konference ERK 2010, Portorož, Slovenija, 20.-22. september 2010*, (Zbornik ... Elektrotehniške in računalniske konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2010, pp. 161-164.

Textbooks and Lecture Notes

1. Franc Novak, *Interakcija človek -stroj. 1. del: zapiski predavanj*, Ljubljana, Institut Jožef Stefan, 2010.

DEPARTMENT OF KNOWLEDGE TECHNOLOGIES E-8

The Department of Knowledge Technologies performs research in advanced information technologies, aimed at acquiring, storing and managing knowledge to be used in the development of knowledge-based applications. The established areas of knowledge technologies include intelligent data analysis (machine learning, data mining, knowledge discovery in databases), text and web mining, semantic web, social network analysis, language technologies and computational linguistics, decision support and knowledge management. The research areas of the department also include Web 2.0, management of virtual organizations, new media and e-science. Apart from knowledge technologies research, we also develop applications in environmental sciences and ecology, medicine and health care, biomedicine and genetics, economy and marketing.

Head:
Prof. Nada Lavrač

In 2010 we were involved in 21 EU projects, mainly the projects of the seventh framework programme (FP7). In terms of our collaboration in EU projects, we are the most successful research group in Slovenia.

In the area of **intelligent data analysis and data mining** we have developed several new methods. (a) We developed new methods for noise and outlier detection. We have also shown that outlier detection can help us in finding bridging terms in medical cross-domain knowledge discovery; this work was published in the Computer Journal. (b) Methods of semantic data mining have been upgraded to enable the use of general ontologies as background knowledge in relational data mining. (c) A new service-oriented knowledge-discovery platform Orange4WS was made publicly available to a broader community of data-mining researchers. (d) Our lemmatisation engine LemmaGen was made publicly available; this work was published in the Journal of Universal Computer Science. (e) We have developed some improved methods for predicting structured target variables (i.e., multi-target regression, hierarchical multi-label classification and predictive clustering of short time-series), e.g., methods for learning rule ensembles. (f) We have developed new methods for learning from data streams, especially for the learning of different types of regression trees (including trees for multi-target regression).

We have successfully collaborated in the FP7 project PHAGOSYS (Systems biology of phagosome formation and maturation - modulation by intracellular pathogens) in the area of systems biology. For this project we have developed new methods for the analysis of complex data and equation discovery for the modeling of dynamic systems, and have applied them to a series of practically relevant problems. Examples include gene-function prediction, modeling of gene expression response to infection, and modeling of different processes within immune response. We are partners in the FP7 project BISON (Bisociation Networks for Creative Information Discovery). The project aims at developing methods for discovering bisociative links between different contexts and domains. We have shown that outlier detection methods can be used to find hidden relationships between different medical domains. We have also developed the SegMine methodology for microarray data analysis which enables the discovery and visualization of groups of differentially expressed genes. We became partners of two new FP7 projects in the area of data mining and text mining: e-LICO (e-Laboratory for Interdisciplinary Collaborative Research in Data Mining and Data-Intensive Sciences) and FIRST (Large scale information extraction and integration infrastructure for supporting financial decision making). The goal of the e-LICO project is to build a virtual laboratory for interdisciplinary collaborative research in data mining and data-intensive sciences. A meta-miner is being developed for this purpose, to provide suggestions about the most appropriate workflows for a given data-mining task. The FIRST project is more domain oriented, it provides an information-extraction, information-integration and decision-making infrastructure for information management in the financial domain.

In the area of **decision support**, our long-term goal is to develop methods and techniques of decision modeling, support them with software and integrate them with data-mining systems. In 2010 we started implementing a method for qualitative multi-attribute decision making DEX into the Decision Deck platform. Decision Deck is an open platform that facilitates a uniform incorporation and connection of various multi-attribute modeling methods

- **In 2010 we were partners in 21 EU projects.**
- **Tomaž Erjavec, together with Matija Ogrin from ZRC SAZU, received a Google Digital Humanities Research Award to support their research on Language Models for Historical Slovene.**
- **Nada Lavrač was a keynote speaker at the MedInfo World Congress on Medical Informatics in Cape Town, South Africa, held in September 2010.**
- **Tomaž Erjavec gave an invited lecture at the 2010 Conference and Members' Meeting of the Text Encoding Initiative, held in November 2010 in Zadar, Croatia.**

Figure 1: The book "Inductive Databases and Constraint-based Data Mining", edited by S. Džeroski, B. Goethals and P. Panov, was published in 2010 by Springer. The book gives an introduction to the area of inductive databases, an overview of the methods for constraint data mining and their applications in bioinformatics. It presents the main achievements of the FP7 project IQ, which was coordinated by our department

and algorithms. Also, we started with the development of new methods for the ranking of alternatives in qualitative, multi-attribute models, with the aim to improve their sensitivity.

We used the method DEX and the supporting computer program DEXi in the European project HEALTHREATS (Integrated Decision Support System for HEALTH THREATS and crises management), which was successfully concluded in 2010. We developed models for an internal evaluation of project's results. We have also collaborated in the development of various decision models in agronomy: models of the assessment of soil quality and the suitability of cropping systems. These models were successfully applied in the European project ENDURE (European Network for the Durable Exploitation of Crop Protection Strategies) as well as in collaboration with INRA, the French National Institute of Agronomical Research.

In the area of **text and web mining** our work activities on the FP7 Network of Excellence PASCAL2 (Pattern Analysis, Statistical Modeling and Computational Learning 2) were mainly on research in text mining and natural language processing. Activities on the FP7 project VIDI (Visualising the impact of legislation by analyzing public discussions using statistical means) were mainly on the visualization of dynamic text data – discussion forums and on user profiling and recommendation based on previously read discussion items. We have started work on two new FP7 projects. In METANet (Net Technologies for the Multilingual European Information Society) we have mainly focused on developing methods and services for automatic constructions on multilingual corpora. In the MultilingualWeb project we are dealing with standards and best practices that support the creation, localization and use of multilingual web-based information.

In the area of the **Semantic Web** we have successfully concluded our work in the FP6 project NeOn (Lifecycle Support for Networked Ontologies) that resulted in an extension of the NeOn Toolkit with several plug-ins related to contextualized access to ontologies. Activities in the FP7 IP project ACTIVE (Enabling the Knowledge Powered Enterprise) were mainly in the direction of modeling informal knowledge processes in an organization based on context mining and process mining. We have started work on the FP7 project ENVISION (ENVIronmental Services Infrastructure with ONtologies) where we have focused on semantic annotations, stream mining and semantic sensor data.

In the area of **knowledge management** we are continuing with the research and development work in the areas of networked organizations, interoperability and collaboration in the FP7 integrated project COIN (COllaboration and INteroperability for networked enterprises) with the focus on the extracting and modeling of internal competences for professional communities. We have continued with the development of Cargo Intelligence (CI) services for the FP7 project EURIDICE (European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics), where we have finished with anomaly detection, knowledge extraction and prediction services. We have also introduced the CI framework, which is now being integrated into the solution.

In the area of **language technologies** we, have in 2010, joined the 7FP EU project IMPACT (Improving Access to Text), which aims to significantly improve access to historical text and to take away the barriers that stand in the way of the mass digitisation of the European cultural heritage. Apart from the JSI, the National and University Library of Slovenia is also a member of the project, and together we are now working on achieving the project aims for Slovene language and literature from the XIXth and XVIIIth centuries. At the JSI we have started working on a lexicon of archaic Slovene words and have implemented a prototype tagger and lemmatiser for historic Slovene texts. At the end of the year we have also joined the COST action MUMIA (Multilingual and multifaceted interactive information access).

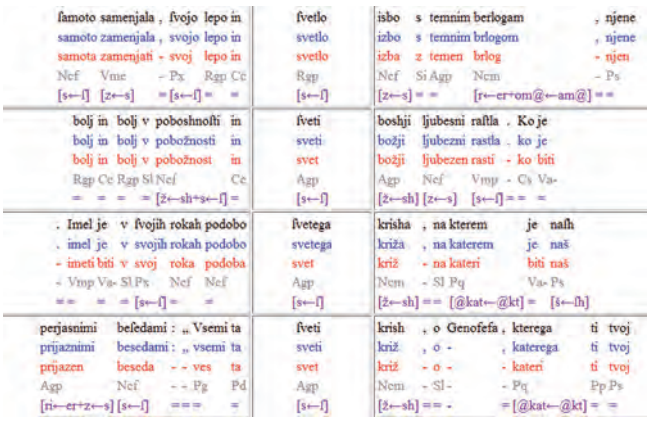

Figure 2: Concordances of old Slovene texts, together with automatically assigned modern-day equivalents, lemmas, morphosyntactic descriptions and transcription rules.

In 2010 we concluded our work in the EU project MondiLex (Conceptual Modelling of Networking of Centres for High-Quality Research in Slavic Lexicography and their Digital Resources), in which we have in the last three years investigated the possibilities of using Grid technologies for the processing and dissemination of large corpora, extended the MULTEXT-East multilingual language resources by several new Slavic languages, and organized a project meeting and open workshop with published proceedings. We have also finished work in the bilateral Slovenia-France project with the INALCO institute in Paris, where we investigated the definition of syntactic-semantic structure of the Slovene verb. In the EU project FlareNet (Fostering Language Resources Network) we continued working on the compilation of language resources for the Slovene language.

Some outstanding publications in the past year

1. Elena Ikonomovska, João Gama, Sašo Džeroski. Learning model trees from evolving data streams. Data Mining and Knowledge Discovery, 2010, doi:10.1007/s10618-010-0201-y.
2. Ingrid Petrič, Bojan Cestnik, Nada Lavrač, Tanja Urbančič. Outlier detection in cross-context link discovery for creative literature mining. The Computer Journal, 2010, doi:10.1093/comjnl/bxq074.
3. Mojca Arsenijević, Marko Bohanec. Towards the ecotourism : a decision support model for the assessment of sustainability of mountain huts in the Alps. Journal of environmental management, 2010, vol. 91, no. 12, pp. 2554-2564.
4. Matjaž Juršič, Igor Mozetič, Tomaž Erjavec, Nada Lavrač. LemmaGen : multilingual lemmatisation with induced Ripple-Down rules. Journal of Universal Computer Science, 2010, vol. 16, no. 9, pp. 1190-1214.
5. Elena Simperl, Ian Thurlow, Paul Warren, Frank Dengler, J. Davies, Marko Grobelnik, Dunja Mladenić, Jose Gomez-Perez, Carlos Ruiz Moreno. Overcoming information overload in the enterprise : the active approach. IEEE internet computing, 2010, vol. 14, no. 6, pp. 39-46.

Awards and appointments

1. Blaž Fortuna, Marko Grobelnik and prof. dr. Dunja Mladenič: Inovations for Economy, Ljubljana, Technology Transfer Conference, Jožef Stefan Institute, OntoGen
2. Asst. Prof. Tomaž Erjavec, Google Digital Humanities Research award, California, USA, Google Inc., Research on language models for Historical Slovene

Organization of conferences, congress and meetings

1. EBI Bionformatics Roadshow, Ljubljana, Slovenia, 16–18 Feb. 2010
2. Workgroup meeting of European project GENDERA, Ljubljana, Slovenia, 10 May 2010
3. Subconference: Third Generation Data Mining: Towards Service-Oriented Knowledge Discovery on European Conference ECML/PKDD 2010, Barcelona, Spain, 24 Sept. 2010
4. Subconference: Conference on Data Mining and Data Warehouses on conference Information Society - IS 2010, Ljubljana, Slovenia, 12 Oct. 2010.
5. Project meeting of European project GENDERA, Bled, Slovenia, 22 and 23 Nov. 2010
6. Project meeting of European project e-LICO, Ljubljana, Slovenia, 8 and 9 Nov. 2010

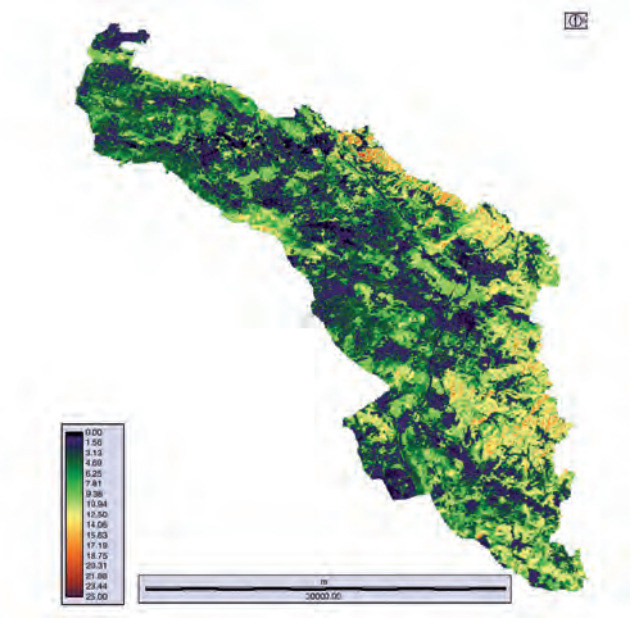

Figure 3: Map of the vegetation height for the Kras region, generated by using a random forest of a multi-target regression-trees model. The legend shows the vegetation height in metres.

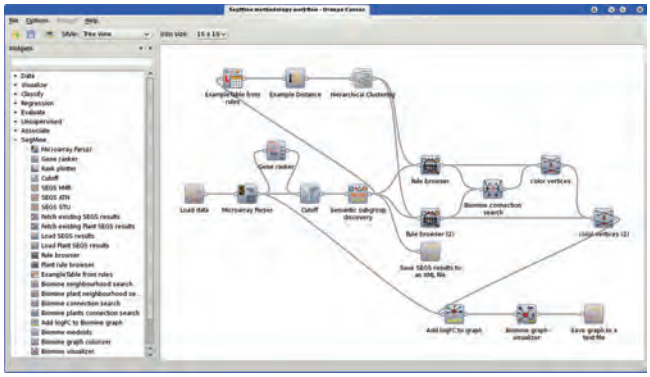

Figure 4: A screenshot of Orange4WS running a workflow of components for a semantic analysis of microarray data. Orange4WS is a service-oriented environment for knowledge discovery that integrates the concepts of data-mining workflows and service-oriented computing.

INTERNATIONAL PROJECTS

1. e-Laboratory for Collaborative Interdisciplinary Research in Data Mining and Data Intensive Sciences
   e-LICO
   7. FP, 257680
   EC; Dr. Mélanie Hilario, Universite de Geneve, Carouge, Switzerland
   Prof. Nada Lavrač, Dr. Martin Žnidaršič
2. Active Support and Real-time Coordination based on Event Processing in Open Source Software Development
   ALERT
   7. FP, 258098
   EC; Dr. Ljiljana Stojanovic, Forschungszentrum Informatik an der Universität Karlsruhe, Karlsruhe, Germany
   Prof. Dunja Mladenić, Marko Grobelnik, Mitja Jermol, M. Sc.
3. Large Scale Information Extraction and Integration Infrastructure for Supporting Financial Decision Making
   FIRST
   7. FP, 257928
   EC; Tomas Pariente Lobo, Atos Origin Sociedad Anónima Espanola, Madrid, Spain
   Miha Grčar, B. Sc., Prof. Nada Lavrač
4. PlanetData
   7. FP, 257641
   EC; Dieter Fensel, Universitaet Innsbruck, Christoph-Probst-Platz, Innsbruck, Austria
   Marko Grobelnik, Prof. Dunja Mladenić, Mitja Jermol, M. Sc., Asst. Prof. Mihael Mohorčič
5. Reflecting Knowledge Diversity
   RENDER
   7. FP, 257790
   EC; Hartmut Schmeck, Karlsruhe Institute of Technology, Karlsruhe, Germany
   Prof. Dunja Mladenić, Marko Grobelnik, Mitja Jermol, M. Sc.

6. Improving Access to Text
   IMPACT
   7. FP, 215064
   EC; Lieke Ploeger, Koninklijke Biblioteek, Haag, The Netherlands
   Asst. Prof. Tomaž Erjavec, Jan Jona Javoršek, B. Sc.
7. Technologies for the Multilingual European Information Society
   MetaNet
   7. FP, 249119
   EC; Dr. Stefhan Busemann, DFKI - German Research Center for Artificial Intelligence, Saarbrücken, Germany
   Marko Grobelnik, Prof. Dunja Mladenić, Mitja Jermol, M. Sc.
8. Environmental Services Infrastructures with Ontologies
   ENVISION
   7. FP, 249120
   EC; Bjorn Skjellaug, Arne J. Berre, Stiftelsen Sintef, Trondheiim, Norway
   Prof. Dunja Mladenić, Miha Grčar, B. Sc., Prof. Nada Lavrač, Mitja Jermol, M. Sc.
9. Gender Debate in the European Research Area
   GENDERA
   7. FP, 244499
   EC; Dr. Dora Groo, Hungarian Science and Technology Foundation, Tudomanyos Es Technologiai Alapitvany, Budapest, Hungary
   Prof. Dunja Mladenić, Mitja Jermol, M. Sc.
10. Systems Biology of Phagosome Formation and Maturation, Modulation by Intracellular Pathogens
    PHAGOSYS
    7. FP, 223451, HEALTH-F4-2008-223451
    EC; Dr. Brian D. Robertson, Imperial College London, Centre for Molecular Microbiology and Infection, London, Great Britain
    Prof. Sašo Džeroski
11. Bisociation Networks for Creative Information Discovery
    BISON
    7. FP, 211898
    EC; Prof. Michael Berthold, Universität Konstanz, Konstanz, Germany
    Prof. Nada Lavrač
12. Conceptual Modelling of Networking of Centres for High-Quality Research in Slavic Lexicography and Their Digital Resources
    MONDILEX
    7. FP, 211938
    EC; Prof. Ludmila Dimitrova, Institute of Mathematics and Informatics of the Bulgarian Academy of Science, Sofia, Bulgaria
    Asst. Prof. Tomaž Erjavec, Jan Jona Javoršek, B. Sc.
13. Enabling the Knowledge Powered Enterprise
    ACTIVE
    7. FP, 215040
    EC; Dr. Paul Warren, British Telecommunications plc, London, Great Britain
    Marko Grobelnik, Prof. Dunja Mladenić, Mitja Jermol, M. Sc., Asst. Prof. Mihael Mohorčič
14. Pattern Analysis, Statistical Modelling and Computational Learning 2
    PASCAL 2
    7. FP, 216886
    EC; Prof. John Shawe-Taylor, University of Southampton, Southampton, Great Britain
    Prof. Dunja Mladenić, Marko Grobelnik, Mitja Jermol, M. Sc.
15. European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics
    EURIDICE
    7. FP, 216271
    EC; Dr. Paolo Paganelli, INSIEL - Informatica per il Sistema degli Enti Locali s.p.a, Trieste, Italy
    Marko Grobelnik, Prof. Dunja Mladenić, Mitja Jermol, M. Sc.
16. Collaboration and INteroperability for networked enterprises
    COIN
    7. FP, 216256
    EC; Dr. Claudia Guglielmina, TXT e-Solutions Spa, Milano, Italy
    Prof. Dunja Mladenić, Marko Grobelnik, Mitja Jermol, M. Sc.
17. Lifecycle Support for Networked Ontologies
    NEON
    6. FP, 027595
    EC; Prof. Enrico Motta, Kmi, The Open University, Milton Keynes, Great Britain
    Prof. Dunja Mladenić, Marko Grobelnik, Mitja Jermol, M. Sc.
18. Advancing the Multilingual Web
    MultilingualWeb
    CIP - Competitiveness and Innovation
    250500
    EC; Jérôme Chailloux, Caroline Baron, Celine Bitoune, GEIE ERCIM, Sofhia Antipolis, France
    Marko Grobelnik, Asst. Prof. Dunja Mladenić
19. Integrated Decision Support System for HEALTH THREATS and Crises Management
    HEALTHREATS
    Public Health Programme (PHEA)
    2006203
    EC; Carmelo Scarcella, Azienda Sanitaria Locale di Brescia (ASL Brescia), Brescia, Italy
    Prof. Nada Lavrač, Dr. Martin Žnidaršič
20. Visualising the Impact of the Legislation by Analysing Public Discussions Using Statistical Means
    VIDI
    e-PARTICIPATION, EP-08-01-014
    EC; Nenad Stojanović, Forschungszentrum Informatik an der Universität Karlsruhe, Karlsruhe, Germany
    Prof. Dunja Mladenić, Marko Grobelnik
21. Fostering Language Resources Network
    FLaReNet
    e-Contentplus, ECP-2007-LANG-617001
    EC; CNR-ILC, Consiglio Nazionale delle Ricerche, Rome, Italy
    Asst. Prof. Tomaž Erjavec
22. Communication in Slovenian Language
    MŠŠ
    Simon Krek
23. Network of Research Values Development in Youth
    SIM-RIS, 3311-09-986011
    Prof. Dunja Mladenić
24. European Concepts and Approaches to GM Maize Production
    Training Placement Agreement
    Florence Leprince, ARVALIS - Institut du Végétal, Montardon; Paris, France
    Prof. Marko Debeljak
25. Regional Level Co-existence Advisory Systems for Maize
    Contractual Agreement
    Florence Leprince, ARVALIS - Institut du Végétal, Montardon, France
    Prof. Marko Debeljak
26. The Effects of Genetically Modified Maze on Conventional Maize Production: Co-existance Advisory System (CAS)
    BI-FR/09-10-PROTEUS-018
    PROTEUS
    Dr. Florenco Leprince, Arvalis Institut du végétal, Montardon, France
    Prof. Marko Debeljak
27. Definition of a Syntaxico-Semantic Verbal Frame of the Slovenian on the Model of Czech Vallex (Action Coordinated with a Barrande Project)
    BI-FR/09-10-PROTEUS-015
    PROTEUS
    Prof. Patrice Pognan, Inalco et Universite de Paris 4, Paris, France
    Asst. Prof. Tomaž Erjavec
28. Decision Support System for a Safe Vegetable Production on Garden Soils in Urban Environments (Gardentox)
    BI-FR/09-10-INRA-003
    Prof. Christophe Schwartz, Nancy Université, INPL (ENSAIA) / INRA, UMR 1120, Laboratoire Sols et Environnement (Laboratory for Soil and Environment), Vandoeuvre-lès-Nancy, France
    Prof. Marko Debeljak
29. Inductive Rule Learning
    BI-HR/09-10-019
    Dr. Dragan Gamberger, Ruđer Bošković Institute, Zagreb, Croatia
    Prof. Nada Lavrač
30. Japanese/Slovene Resources for Second Language Learners
    BI-JP/08-10/006
    Prof. Yoshiko Kawamura, Tokyo International University, Saitama, Japan
    Asst. Prof. Tomaž Erjavec
31. Understanding Human Behavior for Video Surveillance Applications
    BI-RO/10-11-010
    Dr. Maria Magdalena Zaharescu, Ilie Murgulescu Institute of Physical Chemistry, Bucharest, Romania
    Prof. Dunja Mladenić
32. Correlating Images and Words: Enhancing Image Analysis through Machine Learning and Semantic Technologies
    BI-SR/10-11-029
    dr. Mirjana Ivanović, Faculty of Science, Department of Mathematics and Informatics, Novi Sad, Serbia
    Prof. Dunja Mladenić
33. Google Digital Humanities Award
    Award dtd. 15.12.2010
    Alfred Spector, Google Inc, Mountain View, CA, USA
    Asst. Prof. Tomaž Erjavec

R & D GRANTS AND CONTRACTS

1. Analysis and Scenario of Development and Exploration of Forests in Slovenia
   Prof. Marko Debeljak
2. Slovene Research Atlas
   Prof. Dunja Mladenić
3. Advanced ML Methods for Automated Modelling of Dynamic Systems
   Prof. Sašo Džeroski
4. Data Mining for Integrative Data Analysis in Systemic Biology
   Prof. Sašo Džeroski

5. Systemic Biology Approaches to Analyzing Interactions between Pathogens and Plants
   Prof. Nada Lavrač
6. Basic Research Project: Semantic Rule Discovery in the Context of Web Services
   Prof. Nada Lavrač
7. Slovene Translation Studies - Resources and Research
   Asst. Prof. Tomaž Erjavec
8. Influence of Gene Transfer, Genetic Diversity and Cultivation Technology on Sustainability and Tracing Methods
   Prof. Marko Debeljak
9. NRSS - Unknown 17th and 18th Century Manuscripts of Slovenian Literature: Information Technology Aided Register, Scholarly Editions and Analyses
   Asst. Prof. Tomaž Erjavec

RESEARCH PROGRAM

1. Knowledge technologies
   Prof. Nada Lavrač

MENTORING

Ph. D. Thesis

1. Aneta Trajanov, *Analysis of results of ecological simulation models with machine learning* (mentor Sašo Džeroski)

M. Sc. Theses

1. Janez Bucik, *A program module for online analytical data processing in the Navision information System* (mentor Marko Bohanec)
2. Mateja Košir, *Slovenian Film Terminology in a Corpus of Film Reviews* (mentor Tomaž Erjavec)
3. Janez Kralj, *Targeting clients through knowledge discovery from databases* (mentor Marko Bohanec)
4. Helena Plahuta, *Corpus Linguistics Methods in the Drafting of Equestrian Terminology Dictionary* (mentor Tomaž Erjavec)
5. Damjana Šajne, *Preparation and assessment of e-learning materials for primary schools with an example in teaching engineering and technology* (mentor Tanja Urbančič)
6. Petra Vide Ogrin, *Development of digital library tools for history studies* (mentor Maja Žumer; co-mentor Tomaž Erjavec)
7. Aljaž Vidmar, *Usage of WEB 2.0 technologies for the development of modern web applications* (mentor Branko Kavšek)

VISITORS FROM ABROAD

1. Dr. Monika Žakova, Czech Technical University in Prague (CTU), Prague, Czech, 18 Jan.–12 Feb. 2010
2. Peter Hollis and Michael Witbrock, Cycorp, Austin, Teksas, USA, 22–31 Jan. 2010
3. Hannu Toivonen, Kimmo Kulovesi, Laura Longohr, Atte Hinkka, University of Helsinki, Faculty of Science, Department of Computer Science, Helsinki, Finland, 25–28 Jan. 2010
4. Raluca Brehar and Sergiu Nedevschi, Techincal University of Cluj-Napoca, Romania, 8–12 Feb. 2010
5. Dr. Dragan Gamberger, Rudjer Bošković Institute, Zagreb, Croatia, 12 Feb. 2010
6. Mario Karlovčec, Faculty of Organization and Informatics, University of Zagreb, Zagreb, Croatia, 4–31 Mar. 2010
7. Jerome Corte, Cristophe Schwartz and Benjamin Key, Vandoeuvre-les-Nancy, France, 8–16 Mar. 2010
8. Dr. Elizabeth Coppock, Cycorp, Austin, Teksas, USA, 1–20 Mar. 2010, 5–10 June 2010
9. Dr. Igor Trajkovski, Faculty of Electrical Engineering and Information Technologies, University "Ss.Cyril & Methodius", Skopje, Macedonia, 18 Mar.–4 Apr. 2010 and 9–21 Aug. 2010
10. Dr. Primož Škraba, INRIA, Le Chesnay Cedex, France, 26 Mar. 2010
11. Dr. Stephen Muggleton, Department of Computing, Imperial College, London, United Kingdom, 7–8 Apr. 2010
12. Jasmina Smailović, Hermes SoftLab, Banja Luka, Bosnia and Herzegovina, 8–10 Apr. 2010
13. Dr. Werner Dubitzky, University of Ulster, Ulster, Ireland, 1–17 Apr. 2010
14. Rayid Ghani, Accenture, Chicago, USA, 9 Apr. 2010
15. Dr. Geoff Squire, Scottish Crop Research Institute, Invergowrie, Dundee, Scotland, United Kingdom, 11–15 Apr. 2010
16. Dr. Mirjana Ivanovič, Miloš Radovanovič and Dejan Mitrovič, University of Novi Sad, Faculty of Science, Novi Sad, Serbia, 18–23 Apr. 2010
17. Dr. Florence Leprince, ARVALIS - Institut du végétal, Montardon, France, 24–27 May 2010 and 5–7 Oct. 2010
18. Claudiu Mihăilă, Universitatea "Alexandru Ioan Cuza", Faculty of Computer Science, Iaşi, Romania, 30 May–6 June 2010
19. Dr. Donald G. Hodges, University of Tennessee, Forestry, Wildlife, and Fisheries, USA, 2 June 2010
20. Thomas Michael Bohnert, University of Coimbra, Portugal, 9–11 June 2010
21. Dr. Sabrina Guettes, Mathematics Department, University of Wisconsin, USA, 18 Aug. 2010
22. Marko Brakus, Varaždin, Croatia, 1–30 Sept. 2010
23. Dr. Alexander Komarov, Institute of Physico-Chemical and Biological Problems in Soil Science of Russian Academy of Sciences, Moscow, Russia, 3 Sept. 2010
24. Stefan Haun, University of Magdeburg, Magdeburg, Germany, 7–11 Sept. 2010
25. Dr. Sonia Ayachi Ghannouchi, Tunisian Institut Supérieur de Gestion de Sousse, Tunisia, dr. Karim Moustaghfir, University of Ifrane, Marocco and dr. Božidar Šarler, University of Nova Gorica, Slovenia, 28 Sept. 2010.
26. Dr. Jean Tsao, Michigan State University and dr. Graham Hickling, University of Tennessee, USA, 28 Sept. 2010
27. Laura Langohr, University of Helsinki, Helsinki, Finland, 1 Oct. 2010–22 Mar. 2011
28. Andreea Bizau, Babes-Bolyai University, Cluj-Napoca, Faculty of Mathematics and Informatics, Cluj, Romania, 7 Oct. 2010 and 19 Oct.–21 Dec. 2010
29. Achim Klein, University of Hohenheim, Hohenheim, Germany, 18–19 Oct. 2010
30. John Shawe-Taylor, University College London, Great Britain and Michael Witbrock, Cycorp, Austin, Teksas, USA, 25–29 Oct. 2010
31. Rayid Ghani, Divna Djordjevič and Chad Cumby, Accenture, Chicago, USA, 2–5 Nov. 2010.
32. Dr. Larisa Soldatova, Aberystwyth University, Department of Computer Science, Aberystwyth, Great Britain, 3 Nov. 2010–3 Jan. 2011
33. Liqun Wu, Institute for Geoinformatics, University of Münster, Münster, Germany, 22 Nov.–6 Dec. 2010
34. Dr. Patrice Pognan, INALCO (Institut National des Langues et Civilisations Orientales) and LALIC-CERTAL (Langues, Logiques, Informatique et Cognition - Centre d'études et de recherche en traitement automatique des langues), Paris, France, 5–15 Dec. 2010

STAFF

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5. Prof. Sašo Džeroski
6. Asst. Prof. Tomaž Erjavec
7. **Prof. Nada Lavrač, Head**
8. Prof. Dunja Mladenić
9. Prof. Tanja Urbančič*

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11. Dr. Petra Kralj Novak
12. Dr. Aneta Trajanov
13. Asst. Prof. Bernard Ženko
14. Asst. Prof. Martin Žnidaršič

Postgraduates

15. Luka Bradeško, B. Sc.
16. Janez Brank, M. Sc.
17. Darko Čerepnalkoski, B. Sc.
18. Blaž Fortuna, B. Sc.
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20. Miha Grčar, B. Sc.
21. Elena Ikonomovska, M. Sc.
22. Mitja Jermol, M. Sc.
23. Matjaž Juršič, B. Sc.
24. Dragi Kocev, B. Sc.
25. Simon Krek*, B. Sc.
26. Blaž Novak, B. Sc.
27. Panče Panov, B. Sc.
28. Vid Podpečan, B. Sc.
29. Jan Rupnik, B. Sc.
30. Ivica Slavkov, B. Sc.
31. Borut Sluban, B. Sc.
32. Tadej Štajner, B. Sc.
33. Mitja Trampuš, B. Sc.
34. *Dr. Miha Volovšek*, left 01.04.10*

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35. Marko Brakus, B. Sc.
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37. Dr. Igor Mozetič
38. Matjaž Rihtar, B. Sc.

39. Maja Škrjanc, B. Sc.

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40. Živa Antauer, B. Sc.
41. Tina Anžič, B. Sc.
42. Milica Bauer, B. Sc.
43. Dr. France Dacar
44. Dr. Damjan Demšar
45. Marko Grobelnik
46. Jolanda Jakofčič
47. Mojca Kregar Zavrl, B. Sc.
48. Boštjan Pajntar
49. Mateja Zver

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

1. Tina Anžič, Marjan Jenko, Tatjana Rijavec, "Vključenost Slovenije v raziskovalne projekte na področju inteligentnih tekstilij v Evropski uniji, stanje in možnosti", *Tekstilec*, vol. 53, no. 1/3, pp. 59-73, 2010.
2. Mojca Arsenijević, Marko Bohanec, "Towards the ecotourism: a decision support model for the assessment of sustainability of mountain huts in the Alps", *J. environ. manag.*, vol. 91, no. 12, pp. 2554-2564, 2010.
3. Ludmila Dimitrova, Radovan Garabík, Leonid Leibovich Iomdin, Violetta Koseska-Toszewa, Tomaž Erjavec, Volodymyr Anatoliiovych Shyrokov, "MONDILEX - towards the research infrastructure for digital resources in slavic lexicography", *Stud. Kogn.*, no. 10, pp. 155-170, 2010.
4. Tomaž Erjavec, "Text encoding initiative guidelines and their localisation", *Infoteka*, vol. 11, no. 1, pp. 3a-14a, 2010.
5. Franc Gider, Tanja Urbančič, "Developing soft skills for engineering: experience with student Team projects", *Organizacija (Kranj)*, vol. 43, no. 1, pp. 35-39, jan./feb. 2010.
6. Bryan Griffiths, B. C. Ball, T. J. Daniell, P. Hallett, R. Neison, R. E. Wheatley, G. Osler, Marko Bohanec, "Integrating soil quality changes to arable agricultural systems following organic matter addition, or adoption of a ley-arable rotation", *Agric., ecosyst. environ., Appl. soil ecol.*, vol. 46, no. 1, pp. 43-53, 2010.
7. Kristina Hmeljak Sangawa, Tomaž Erjavec, "The Japanese-Slovene dictionary JASLO: its developments, enhancement and use", *Stud. Kogn.*, no. 10, pp. 211-224, 2010.
8. Matjaž Juršič, Igor Mozetič, Tomaž Erjavec, Nada Lavrač, "LemmaGen: multilingual lemmatisation with induced Ripple-Down rules", *J. univers. comput. sci. (Print)*, vol. 16, no. 9, pp. 1190-1214, 2010.
9. Dragi Kocev, Andreja Naunovski, Kosta Mitreski, Svetislav Krstić, Sašo Džeroski, "Learning habitat models for the diatom community in Lake Prespa", *Ecol. model.*, vol. 221, issue 2, pp. 330-337, 2010.
10. Igor Lipuščck, Marko Bohanec, Leon Oblak, Lidija Zadnik Stirn, "A multi-criteria decision-making model for classifying wood products with respect to their impact on environment", *Int. j. life cycle assess.*, vol. 15, no. 4, pp. 359-367, 2010.
11. Luca Lovrečić, Ivica Slavkov, Sašo Džeroski, Borut Peterlin, "ADP-ribosylation factor Guanine nucleotide-exchange factor 2 (ARFGEF2): a new potential biomarker in Huntington's disease", *J. int. med. res.*, vol. 38, no. 5, pp. 1653-1662, 2010.
12. Inna Novalija, Dunja Mladenić, "Ontology extension towards analysis of business news", *Informatica (Ljublj.)*, vol. 34, no. 4, pp. 517-522, 2010.
13. Ingrid Petrič, Bojan Cestnik, Nada Lavrač, Tanja Urbančič, "Outlier detection in cross-context link discovery for creative literature mining", *Comput. j.*, 15 pp., Published online November 2, 2010.
14. Aleksander Pur, Marko Bohanec, Nada Lavrač, Bojan Cestnik, "Primary health-care network monitoring: a hierarchical resource allocation modeling approach", *Int. j. health plann. manage.*, vol. 25, no. 2, pp. 119-135, 2010.
15. Ana Rotter, Petra Kralj Novak, Špela Baebler, Nataša Toplak, Andrej Blejec, Nada Lavrač, Kristina Gruden, "Gene expression data analysis using closed itemset mining for labeled data", *Omics (Larchmt. N.Y.)*, vol. 14, no. 2, pp. 177-186, 2010.
16. Jan Rupnik, Miha Grčar, Tomaž Erjavec, "Improving morphosyntactic tagging of Slovene language through meta-tagging", *Informatica (Ljublj.)*, vol. 34, no. 2, pp. 169-175, 2010.
17. Tom Ruttink, Dany Morisset, Bart Van Droogenbroeck, Nada Lavrač, G. van den Eede, Jana Žel, Marc De Loose, "Knowledge-technology-based discovery of unauthorized genetically modified organisms", *Anal. bioanal. chem.*, vol. 396, no. 6, pp. 1951-1959, 2010.
18. Leander Schietgat, Celine Vens, Jan Struyf, Hendrik Blockeel, Dragi Kocev, Sašo Džeroski, "Predicting gene function using hierarchical multi-label decision tree ensembles", *BMC bioinformatics*, vol. 11, no. 2, pp. 1-14, 2010.
19. Elena Simperl, Ian Thurlow, Paul Warren, Frank Dengler, J. Davies, Marko Grobelnik, Dunja Mladenić, Jose Manuel Gomez-Perez, Carlos Ruiz Moreno, "Overcoming information overload in the enterprise: the active approach", *IEEE internet computing*, vol. 14, no. 6, pp. 39-46, 2010.
20. Ivica Slavkov, Valentin Gjorgjioski, Jan Struyf, Sašo Džeroski, "Finding explained groups of time-course gene expression profiles with predictive clustering trees", *Molecular bioSystems*, vol. 6, no. 4, pp. 729-740, 2010.
21. Daniela Stojanova, Panče Panov, Valentin Gjorgjioski, Andrej Kobler, Sašo Džeroski, "Estimating vegetation height and canopy cover from remotely sensed data with machine learning", *Ecological informatics*, vol. 5, no. 4, pp. 256-266, 2010.
22. Tadej Štajner, Delia Rusu, Lorand Dali, Blaž Fortuna, Dunja Mladenić, Marko Grobelnik, "A service oriented framework for natural language text enrichment", *Informatica (Ljublj.)*, vol. 34, no. 3, pp. 307-313, 2010.
23. Nenad Tomašev, Dunja Mladenić, "Social network analysis of ontology edit logs", *CIT. J. Comput. Inf. Technol.*, vol. 18, no. 2, pp. 191-200, 2010.
24. Boris Zmazek, Sašo Džeroski, Drago Torkar, Janja Vaupotič, Ivan Kobal, "Identification of radon anomalies in soil gas using decision trees and neural networks", In: *Proceedigs of the International Conference Radon in Environment, May 20-14, 2009, Zakopane, Poland*, (Nukleonika, vol. 55, no. 4), Jadwiga Mazur, ed., Krzysztof Kozak, ed., Ivan Kobal, ed., Warszawa, Institute of Nuclear Chemistry and Technology, 2010, pp. 501-505.

Review Articles and Chapters in Books

1. Sašo Džeroski, "Inductive databases and constraint-based Ddta mining: introduction and overview", In: *Inductive databases and constraint-based data mining*, Sašo Džeroski, ed., Bart Goethals, ed., Panče Panov, ed., New York ... [etc.], Springer, 2010, pp. 3-26.
2. Sašo Džeroski, Ljupčo Todorovski, "Modeling the dynamics of biological networks from time course data", In: *Systems biology for signaling networks*, (Systems biology, vol. 1), Sangdun Choi, ed., New York ... [etc.], Springer, pp. 275-294.
3. Panče Panov, Larisa N. Soldatova, Sašo Džeroski, "Representing entities in the OntoDM data mining ontology", In: *Inductive databases and constraint-based data mining*, Sašo Džeroski, ed., Bart Goethals, ed., Panče Panov, ed., New York ... [etc.], Springer, 2010, pp. 27-58.
4. Ivica Slavkov, Sašo Džeroski, "Analyzing gene expression data with predictive clustering trees", In: *Inductive databases and constraint-based data mining*, Sašo Džeroski, ed., Bart Goethals, ed., Panče Panov, ed., New York ... [etc.], Springer, 2010, pp. 389-406.
5. Jan Struyf, Sašo Džeroski, "Constrained predictive clustering", In: *Inductive databases and constraint-based data mining*, Sašo Džeroski, ed., Bart Goethals, ed., Panče Panov, ed., New York ... [etc.], Springer, 2010, pp. 155-175.
6. Celine Vens, Leander Schietgat, Jan Struyf, Hendrik Blockeel, Dragi Kocev, Sašo Džeroski, "Predicting gene function using predictive clustering trees", In: *Inductive databases and constraint-based data mining*, Sašo Džeroski, ed., Bart Goethals, ed., Panče Panov, ed., New York ... [etc.], Springer, 2010, pp. 365-387.

Published Conference Papers

Invited Papers

1. Marko Bohanec, Martin Žnidaršič, "Izkušnje z večparametrskimi odločitvenimi modeli pri podpori odločanja o gensko spremenjenih organizmih", In: *Sodobni izzivi menedžmenta v agroživilstvu*, 5. konferenca DAES, Pivola, 18.-19. marec 2010, Črtomir Rozman, ed., Stane Kavčič, ed., 1. izd., Ljubljana, Društvo agrarnih ekonomistov Slovenije - DAES, 2010, pp. 29-37.
2. Marko Debeljak, "Pomen sistemske obravnave kompleksnih živih sistemov za trajnostni razvoj", In: *Organizmi kot živi sistemi: zbornik prispevkov: proceedings*, Simona Strgulc-Krajšek, ed., Andraž Stožer, 1. izd., Ljubljana, Zavod RS za šolstvo, 2010, pp. 28-32.

Regular papers

1. Pietro Baroni, Daniela Fogli, Massimiliano Giacomin, Giovanni Guida, Loredana Parasiliti Provenza, Michele Rossi, Marko Bohanec, Martin Žnidaršič, "Supporting DSS acceptability through a user-centered design methodology: experiences in emergency management", In: *Bridging the socio-technical gap in decision support systems: challenges for the next decade: [15th IFIP Working Group 8.3 International Conference DSS 2010, July 7-10, 2010, Lisbon, Portugal]*, (Frontiers in artificial intelligence and applications, vol. 212), Ana Respício, ed., Amsterdam [etc.], IOS Press, pp. 87-98.
2. Maja Bračič Lotrič, Tanja Urbančič, "Learning to connect different contexts: new perspectives through knowledge technologies", In: *Socio-cultural and human values in science and technology education: proceedings*, XIV. IOSTE Symposium, International Organization for Science and Technology Education, June 13.-18. 2010, Bled, Slovenia, Slavko Dolinšek, ed., Ljubljana, Institute for Innovation and Development of University, 2010, 8 pp.
3. Luka Bradeško, Lorand Dali, Blaž Fortuna, Marko Grobelnik, Dunja Mladenić, Inna Novalija, Boštjan Pajntar, "Contextualized question answering", In: *ITI 2010: proceedings of the ITI 2010*, (ITI ... (Tisak)), 32nd International Conference on Information Technology Interfaces, June 21-24, 2010, Cavcat / Dubrovnik, Croatia, Vesna Lužar - Stiffler, ed., Iva Jarec, ed., Zoran Bekić, ed., Zagreb, SRCE University Computing Centre, cop. 2010, pp. 73-78.
4. Lorand Dali, Delia Rusu, Blaž Fortuna, Dunja Mladenić, Marko Grobelnik, "AnswerArt - contextualized question answering", In: *Machine learning and knowledge discovery in databases: European conference, ECML PKDD 2010, Barcelona, Spain, September 20-24, 2010: proceedings: part III*, (Lecture notes in computer science, Lecture notes in artifical intelligence, vol. 6323), José Luis Balcázar, ed., Berlin, Heidelberg, New York, Springer, 2010, vol. 6323, pp. 579-582, 2010.
5. Ivica Dimitrovski, Dragi Kocev, Suzana Loskovska, Sašo Džeroski, "Detection of visual concepts and annotation of images using ensembles of trees for hierarchical multi-label classification", In: *Recognizing patterns in signals, speech, images and videos: ICPR 2010 Contests, Istanbul, Turkey, August 23-26, 2010: contest reports*, (Lecture notes in computer science, Vol. 6388), Ünay Devrim, ed., Çataltepe Zehra, ed., Aksoy Selim, ed., Berlin, Heidelberg, New York, Springer, 2010, vol. 6388, pp. 152-162, 2010.
6. Ivica Dimitrovski, Dragi Kocev, Suzana Loskovska, Sašo Džeroski, "ImageCLEF 2009 medical image annotation task: PCTs for hierarchical multi-label classification", In: *Multilingual information access evaluation II: multimedia experiments: revised selected papers*, (Lecture notes in computer science, Information systems and applications, vol. 6242), 10th Workshop of the Cross-language Evaluation Forum, Clef 2009, Corfu, Greece, September 30 - October 2, 2009, Carol Peters, ed., Berlin, Heidelberg, New York, 2010, pp. 231-238.
7. Tomaž Erjavec, "MULTEXT-East version 4: multilingual morphosyntactic specifications, lexicons and corpora", In: *Proceedings*, LREC 2010, 7th International Conference on Language Resources and Evaluations, 19-21 May 2010, Valletta, Malta, [S. l., s. n.], 2010, pp. 2544-2547.
8. Tomaž Erjavec, "Slovenska terminologija in svetovni splet", In: *Nacionalni jeziki v visokem šolstvu: [zbornik prispevkov z Mednarodne konference Jezikovna različnost in nacionalni jeziki v visokem šolstvu]: [collected papers from the International Conference Language Diversity and National Languages in Higher Education]*, Marjeta Humar, ed., Mojca Žagar, ed., Ljubljana, Založba ZRC, ZRC SAZU, 2010, pp. 109-112.
9. Tomaž Erjavec, Darja Fišer, Simon Krek, Nina Ledinek, "The JOS linguistically tagged corpus of Slovene", In: *Proceedings*, LREC 2010, 7th International Conference on Language Resources and Evaluations, 19-21 May 2010, Valletta, Malta, [S. l., s. n.], 2010, pp. 1806-1809.
10. Darja Fišer, Tomaž Erjavec, "sloWnet: construction and corpus annotation", In: *Principles, construction and application of multilingual wordnets: proceeding [!] of the 5th Global Wordnet Conference*, 5th Global WorldNet Conference, Pushpak Bhattacharyya, ed., New Delhi [etc.], Narosa Publishing House, cop. 2010, pp. 177-183.
11. Blaž Fortuna, Carolina Fortuna, Dunja Mladenić, "Real-time news recommender system", In: *Machine learning and knowledge discovery in databases: European conference, ECML PKDD 2010, Barcelona, Spain, September 20-24, 2010: proceedings: part III*, (Lecture notes in computer science, Lecture notes in artifical intelligence, vol. 6323), José Luis Balcázar, ed., Berlin, Heidelberg, New York, Springer, 2010, vol. 6323, pp. 583-586, 2010.
12. Miha Grčar, Vid Podpečan, Matjaž Juršič, Nada Lavrač, "Efficient visualization of document streams", In: *Discovery science: 13th International Conference, Ds 2010, Canberra, Australia, October 6-8, 2010: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, vol. 6332), Bernhard Pfahringer, ed., Geoff Holmes, ed., Achim Hoffmann, ed., Berlin, Heidelberg, Springer, 2010, vol. 6332, pp. 174-188, 2010.
13. Elena Ikonomovska, João Gama, Sašo Džeroski, "Incremental option trees for handling gradual concept drift", In: *HaCDAIS 2010: proceedings of the First International Workshop on Handling Concept Drift in Adaptive Information Systems: importance, challenges and solutions, held in conjunction with EMCL/PKDD 2010, September 24, 2010, Barcelona, Spain*, Mykola Pechenizkiy, ed., Indre Žliobaité, ed., [S. l., s. n.], 2010, pp. 17-27.
14. Jan Jona Javoršek, Tomaž Erjavec, "Experimental deployment of a grid virtual organization for human language technologies", In: *Proceedings*, LREC 2010, 7th International Conference on Language Resources and Evaluations, 19-21 May 2010, Valletta, Malta, [S. l., s. n.], 2010, pp. 239-245.
15. Matjaž Juršič, Igor Mozetič, Miha Grčar, Bojan Cestnik, Nada Lavrač, "Identification of concepts bridging diverse biomedical domains", In: *Workshop on Advances in Bio Text Mining, 10-11 May 2010, Ghent, Belgium*, (BMC bioinformatics, vol. 11, suppl. 11), Thomas Abeel, ed., Sofie Van Landeghem, ed., London, BioMed Central, 2010, pp. P4-1-P4-2.
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18. Nada Lavrač, Borut Sluban, Matjaž Juršič, "Cross-domain literature mining through outlier document and bridging concept detection", In: *ACNE 2010*, Workshop on Analysis of Complex NEtworks at ECML PKDD, September 20, 2010, Barcelona, Sapin, Michele Berlingerio, ed., Björn Bringmann, ed., Andreas Nürenberger, ed., [S. l., s. n.], 2010, pp. 35-47.
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Textbooks and Lecture Notes

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2. Dunja Mladenić, Blaž Fortuna*, Data mining and knowledge discovery, Information and communication technologies. II. level study program*, Ljubljana, Jožef Stefan International Postgraduate School, 2010.
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4. Davor Orlič, Mitja Jermol*, D2.3.2. KSC ICT infrastructure*, Ljubljana, Jožef Stefan Institute, 2010.

Theses

Ph. D. Thesis

1. Aneta Trajanov*, Analysis of results of ecological simulation models with machine learning: doctoral dissertation*, Ljubljana, [A. Trajanov], 2010.

B. Sc. Thesis

1. Luka Bradeško*, Automatic plug-in workflow construction: undergraduate thesis*, Ljubljana, [L. Bradeško], 2010.

DEPARTMENT OF INTELLIGENT SYSTEMS E-9

The Department of Intelligent Systems develops new methods and techniques for intelligent computer systems, with applications in the areas of the information society, computer science and informatics, and network communication systems. The main research areas are ambient intelligence, computational intelligence, agent modelling, language and speech technologies, and search algorithms. The department collaborates closely with the Faculty of Computer and Information Science of the University of Ljubljana on the joint research program "Artificial Intelligence and Intelligent Systems", led by Prof. Ivan Bratko.

Head:
Prof. Matjaž Gams

Intelligent systems simulate intelligence so that a typical user seemingly perceives them as truly intelligent. In reality, these systems use complex mechanisms and implement them on digital computers to imitate human behaviour as well as possible, and combine them with raw, exponentially growing, computer power.

Ambient intelligence is a quickly developing research area. It aims to introduce the technology into our everyday environment in a friendly way that is undemanding for the user. Due to the rapid aging of the population, one of the area's main goals is care for the elderly. We addressed it in the 7th Framework Program project **Confidence**. The project intends to extend the independent living of the elderly by improved care in their homes. Confidence users wear a number of tags on their bodies, whose locations are detected by radio sensors. From these locations, the posture and movement of the user is reconstructed. This makes it possible to detect falls and changes in behaviour that may indicate a health problem. In the past year the emphasis was on the automatic adjustment of the system to individual users and a variable number of tags. In the project we combined machine learning, expert knowledge and agent technologies. The final prototype was successfully demonstrated at several locations across Europe. One of them was the "Europe's ICT 2010: Digitally Driven" conference in Brussels, where the best 7th Framework Program projects from the area of information and communication technology were presented. The prototype was among those that attracted the most visitors, because it enabled live testing and thus demonstrated the advantages. We also extended the research on human-behaviour monitoring and analysis to other areas. In the European project **Chiron** we work on monitoring chronic heart-disease patients at home. Our goal is the interpretation of sensor data in a way that is usable for physicians. We also plan to automatically detect events dangerous to the patients' health. In the **iLab** project, the Lotrič company and we used sensors to monitor a laboratory that is storing sensitive substances. We raised warnings in cases of environmental changes that could adversely affect these substances. In the **Uvid** project, an intelligent natural-language assistant was designed with Amebis to help users communicate and control a TV based on the Net-Top-Box communicator by Iskratel.

- **The 7th Framework Program project Confidence intends to extend the independent living of the elderly by introducing a personal intelligent system that makes it possible to detect falls and changes in behaviour that may indicate a health problem.**
- **In the 7th Framework Program project MIRACLE we developed a computer infrastructure to efficiently balance between the generation and consumption of electrical energy with an increased amount of energy from renewable sources.**

Computational intelligence is a study of stochastic search, optimization and learning methods, inspired by physical and biological systems. Research in this area at the Department of Intelligent Systems focuses on evolutionary computation methods. We develop and analyze evolutionary algorithms, study their multi-objective optimization extensions and parallelization, and apply them in engineering design and optimization problems. A substantial part of our applied research is devoted to energy efficiency. In collaboration with partners from five European countries, we started the 7th Framework Program project **MIRACLE** in 2010. Its goal is to develop a computer infrastructure to efficiently balance between the generation and consumption of electrical energy with an increased amount of energy from renewable sources. It will rely on micro-requests for energy generation and consumption, their aggregation and scheduling. In addition, we extended our algorithm for energy-flow optimization in the distribution network that is a building block for an e-service developed in collaboration with the INEA company and other

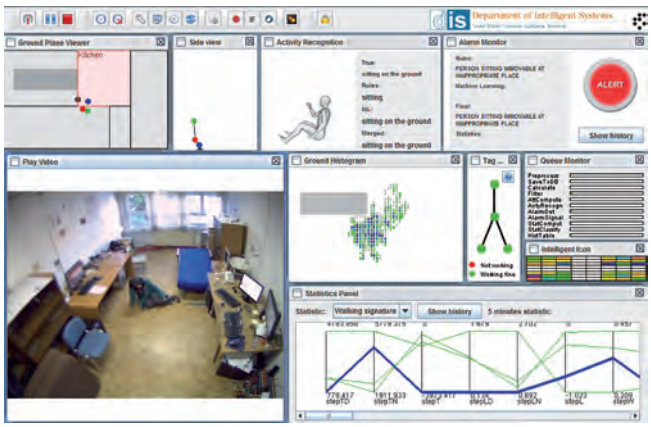

Figure 1: Project Confidence: detecting falls and changes in behavior

Figure 2: Computer-aided arranging of wall painting fragments with the Pedius program

academic and industrial partners. For the Restoration Center in Ljubljana, which is part of Institute for the Protection of Cultural Heritage of Slovenia, we developed the **Pedius** computer package aimed at keeping records of, and arranging, wall-painting fragments. The program is used in the restoration of antique frescos based on thousands of fragments obtained in archaeological excavations in the region of Celje, Slovenia.

Research in the field of **agent modelling** is focused on the behaviour analysis of individuals and groups. Most of the work is performed for the **EUSAS** (European Defense Agency) project. The scope of this project is to develop methods for multi-agent modelling of asymmetric conflicts. The aim is to develop a new approach to mission analysis and training for low-level units facing asymmetric threats in an urban environment. Our task is to discover the common agent strategy by knowing only low-level agent behaviour and basic domain knowledge. Moreover, the objective is to transfer some of the observed behaviour patterns into highly realistic and reusable models of human behaviour in riots. The constructed models will later be used in simulations to provide a more realistic behaviour for training peace-keeping personnel.

In the field of **speech and language technologies** we dealt with speech synthesis, forensic speaker recognition, syntactic parsing and question answering. Together with the Amebis company we develop a new speech synthesizer for Slovene. In cooperation with the national television and radio, RTV Slovenia, a phonetically rich and balanced speech database for corpus-based speech synthesis has been designed and recorded. In speaker recognition, the influence of the sound quality transmitted over phone lines on the biometric/forensic speaker recognition has been studied. In syntactic parsing, further experiments using the extended version of the JOS Treebank (6150 sentences) were conducted. Better parsing accuracy was achieved, compared to the results on the SDT Treebank.

The main goal of the EUSAS project is to develop a new approach to mission analysis and training for low-level units facing asymmetric threats in an urban environment.

We study **search algorithms** for path-finding and other applications. We explained many cases of pathological behavior of these algorithms, i.e., achieving worse results at greater search depth. We investigated the interplay of factors known to influence the benefits of deeper search, and identified some new such factors.

We co-organized the Fourth International Conference on Bioinspired Optimization Methods and their Applications – **BIOMA 2010**. The conference was dedicated to the theoretical and practical aspects of computer-optimization methods based on the models of biological processes and populations. The invited speaker was dr. Christian Blum, a research fellow at the Technical University of Catalonia, Barcelona, Spain, and a leading researcher in the fields of ant-colony optimization and the hybridization of metaheuristics.

From 11th to 15th October 2010, the 13th International Multiconference **Information Society** – IS 2010 took place at the Jožef Stefan Institute. It consisted of ten independent conferences with 203 papers, contributed by 326 (co)authors from 20 countries. The official speaker was dr. Pavel Gantar, the president of the National Assembly of the Republic of Slovenia. Two conference recognitions were awarded: for an exceptional contribution to the development and promotion of the information society, and for current achievements in the field of information society.

Figure 3: In the EUSAS project we develop methods for the multi-agent modeling of asymmetric conflicts to serve the needs of peace-keeping missions.

Some outstanding publications in the past year

1. I. Fister, M. Mernik, B. Filipič, A hybrid self-adaptive evolutionary algorithm for marker optimization in the clothing industry. Applied soft computing, 10 (2010), 409–422.
2. D. S. Nau, M. Luštrek, A. Parker, I. Bratko, M. Gams, When is it better not to look ahead?, Artificial Intelligence, 174 (2010), 1323–1338.
3. M. Gams, M. Ožek, Model order reduction for large LTI control systems, Journal of Computer and Systems Sciences International, 49 (2010), 696–701.

Awards and appointments

1. Erik Dovgan: Best paper award on study programme Information and Communication Technologies at the 2nd Jožef Stefan International Postgraduate School Students Conference, Ljubljana, 27. 5. 2010, paper title "Multiobjective genetic discovery of driving strategies"

2. Boštjan Kaluža, Matjaž Gams: Best student paper award at the International Conference on Machine Learning and Data Analysis (ICMLDA'10), San Francisco, California, USA, 20.–22. 10. 2010, paper title "Approach to analysis of daily living dynamics"

Organization of conferences, congress and meetings

1. The Fourth International Conference on Bioinspired Optimization Methods and their Applications, BIOMA 2010, Jožef Stefan Institute, Ljubljana, 20.–21. 5. 2010
2. 2nd Jožef Stefan International Postgraduate School Students Conference, Jožef Stefan Institute, Ljubljana, 27. 5. 2010
3. 16th Workshop on Nature-Inspired Algorithms, AVN, Jožef Stefan Institute, Ljubljana, 16. 6. 2010
4. 13th International Multiconference Information Society, IS 2010; independent conferences:

– Intelligent Systems,
– Collaboration, Software and Services in Information Society,
– Data Mining and Data Warehouses (SiKDD 2010),
– Education in Information Society,
– Facing Demographic Challenges,
– Cognitive Sciences,
– Robotics,
– Language Technologies,
– MATCOS 2010, Mini-Conference on Applied Theoretical Computer Science, Jožef Stefan Institute, Ljubljana, 11.–15. 10. 2010

5. SAME 2010, 3rd International Workshop on Semantic Ambient Media Experience (NAMU Series) in conjunction with First International Joint Conference on Ambient Intelligence (AmI-10), Malaga, Spain, 10.–12. 11. 2010

- **We developed a new speech synthesizer for Slovene, for which a phonetically rich and balanced speech database for corpus-based speech synthesis has been designed and recorded in cooperation with the national television and radio, RTV Slovenia.**
- **The department staff organized the Fourth International Conference on Bioinspired Optimization Methods and their Applications– BIOMA 2010, and the 13th International Multiconference Information Society – IS 2010.**

Figure 4: The Information Society 2010 multiconference recognition for the exceptional contribution to the development and promotion of the information society was awarded to Prof. Tomaž Kalin.

INTERNATIONAL PROJECTS

1. Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution
   MIRACLE
   7. FP, 248195
   EC; Sofía Martínez-Schmitt, Dr. Henrike Berthold, SAP AG, Walldorf, Germany
   Prof. Bogdan Filipič
2. Ubiquitous Care System to Support Independent Living
   CONFIDENCE
   7. FP, 214986
   EC; Centro de Estudios e Investigaciones Tecnicas de Guipuzcoa, San Sebastian, Spain
   Prof. Matjaž Gams, Prof. Leon Žlajpah
3. European Urban Simulation for Asymmetric Scenarios
   EUSAS
   Contract EADS DC
   EADS N.V., Defense and Security Systems, Elancourt, France
   Prof. Matjaž Gams
4. Intelligent Information System for Health Laboratory Service: I-LAB
   E-contents and E-services
   3211-09-000535
   Marko Lotrič, LOTRIČ d.o.o, Selca, Slovenia
   Dr. Mitja Luštrek
5. Universal Interface for Intelligent Home: UVID
   E-contents and E-services
   3211-09-000524
   Tone Stanovnik, Podjetje Špica International d.o.o., Ljubljana-Črnuče, Slovenia
   Prof. Matjaž Gams
6. Cyclic and Person-Centric Health Management: Integrated Approach for Home, Mobile and Clinical Environments
   CHIRON, ARTEMIS
   3211-10-000214
   Dr. Mitja Luštrek

R & D GRANTS AND CONTRACTS

1. Simulation and Optimization of Casting, Rolling and Heat Treatment Processes for Competitive Production of Topmost Steels
   Prof. Bogdan Filipič

RESEARCH PROGRAM

1. Artificial Intelligence and Inteligent Systems
   Prof. Matjaž Gams

MENTORING

Ph. D. Thesis

1. Matjaž Depolli, *Parallelization of an evolutionary algorithm for multiobjective optimization* (mentor Bogdan Filipič; co-mentor Roman Trobec)

VISITORS FROM ABROAD

1. Jan Marincek, Skopje, Republic of Macedonia, 1. 3.–30. 4. 2010
2. mag. Peter Dueholm Justesen, Aarhus University, Department of Computer Science, Aarhus, Denmark, 20. 5.–21. 5. 2010
3. dr. Rasmus Kjaer Ursem, Grundfos Management A/S, Bjerringbro, Denmark, 20.–21. 5. 2010
4. Hristijan Gjoreski, Faculty of Electrical Engineering and Information Technologies, Ss Cyril and Methodius University, Skopje, Republic of Macedonia, 4. 6.–31. 7. 2010
5. dr. Dmitry Gimon, Moscow, Russia, 9. 6.–31. 7. 2010

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3. **Prof. Matjaž Gams, Head**
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21. *Matej Ožek, M. Sc., left 07.07.10*
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32. Lana Jelenković
33. Mitja Lasič
34. Liljana Lasič

Note:
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Original Articles

1. Matea Curkova, Vladislav Rajkovič, "Izbira šolskih in obšolskih dejavnosti otrok s pomočjo odločitvenega modela", In: *Education in information society*, (Organizacija, vol. 43, 2010, no. 1), Vladislav Rajkovič, ed., Mojca Bernik, ed., Eva Jereb, ed., Tanja Urbančič, ed., Kranj, Moderna organizacija, 2010, pp. A23-A34.
2. Erik Dovgan, Boštjan Kaluža, Tea Tušar, Matjaž Gams, "Improving user verification by implementing an agent-based security system", *Journal of ambient intelligence and smart environments*, vol. 2, no. 1, pp. 21-30, 2010.
3. Iztok Fister, Marjan Mernik, Bogdan Filipič, "A hybrid self-adaptive evolutionary algorithm for marker optimization in the clothing industry", *Applied soft computing*, vol. 10, no. 2, pp. 409-422, 2010.
4. Matjaž Gams, Matej Ožek, "Model order reduction for large LTI control systems", *J. comput. syst. sci. int.*, vol. 49, no. 5, pp. 696-701, 2010.
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6. Domen Marinčič, "Parsing with intraclausal coordination and clause detection", *Informatica (Ljubl.j.)*, vol. 34, no. 2, pp. 263-264, 2010.
7. Dana S. Nau, Mitja Luštrek, Austin Parker, Ivan Bratko, Matjaž Gams, "When is it better not to look ahead?", *Artif. intell.*, vol. 174, no. 16/17, pp. 1323-1338, 2010.

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1. Matjaž Gams, Andraž Bežek, "Multi-agent strategic modeling in a specific environment", In: *Handbook of ambient intelligence and smart environments*, Hideyuki Nakashima, ed., Hamid K. Aghajan, ed., Juan Carlos Augusto, ed., New York [etc.], Springer, cop. 2010, pp. 731-750.
2. Matjaž Gams, Matej Ožek, "Use of data mining techniques for process analysis on small databases", In: *Dynamic and advanced data mining for progressing technological development: innovations and systemic approaches*, A. B. M. Shawkat Ali, ed., Yang Xiang, ed., Hershey, Information Science Reference, cop. 2010, pp. 422-436.
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1. Vladislav Rajkovič, "Group decision making and leveraging of interests", In: *Človek in organizacija: zbornik vabljenih predavanj in povzetkov referatov: conference proceedings of invited lectures and abstracts*, Tomaž Kern, ed., Marko Ferjan, ed., Vladislav Rajkovič, ed., Björn Paape, ed., Kranj, Moderna organizacija, 2010, pp. 66-41.

Regular papers

1. Peter Benedik, Vladislav Rajkovič, Andraž Jakelj, Mirjana Kljajić Borštnar, Marjana Pikec, Peter Benedik, "Prenova podatkovne baze registra za tuberkulozo", In: *Človek in organizacija: zbornik 29. mednarodne konference o razvoju organizacijskih znanosti: proceedings of the 29th International Conference on Organizational Science Development*, 29. mednarodna konferenca o razvoju organizacijskih znanosti, 24.-26. marec 2010, Portorož, Slovenija = 29th International Conference on Organizational Science Development, 24-26 March 2010, Portorož, Slovenia, Tomaž Kern, ed., Vladislav Rajkovič, ed., Björn Paape, ed., Marko Ferjan, ed., Kranj, Moderna organizacija, 2010, pp. 100-107.
2. Robert Blatnik, Tomaž Šef, "Meritve vpliva kakovosti govora v VoWLAN na samodejno razpoznavanje govorcev", In: *Zbornik 13. mednarodne multikonference Informacijska družba - IS 2010, 11.-15. oktober 2010: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 59-62.
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5. Božidara Cvetković, Boštjan Kaluža, Matjaž Gams, "Prilagajanje modela za razpoznavanje aktvnosti človeka z aktivnim delno nadzorovanim učenjen", In: *Zbornik 13. mednarodne multikonference Informacijska družba - IS 2010, 11.-15. oktober 2010: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2010, pp. 63-66.
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THESES

Ph. D. Thesis

1. Matej Guid*, Search and knowledge for human and machine problem solving: doctoral dissertation*, Ljubljana, [M. Guid], 2010.

B. Sc. Theses

1. Simon Kozina*, Development of a system for monitoring changes in human gait: undergraduate thesis*, Ljubljana, [S. Kozina], 2010.
2. Miha Mlakar, *Accuracy of cancer diagnosis models inferred by machine learning from gene expression data sets: undergraduate thesis*, Ljubljana, [M. Mlakar], 2010.

DEPARTMENT OF REACTOR ENGINEERING

R-4

The Department of Reactor Engineering is involved in basic and applied research in the fields of nuclear engineering and safety. Topics include modeling of basic thermal-hydrodynamic phenomena, thermal-hydraulic safety analyses of design-basis and severe accidents, structural safety analyses and probabilistic safety assessments. Most research activities are part of international cooperation programs. Research results are incorporated into projects for industry and for the regulatory authorities, as well as in undergraduate and doctoral studies programmes.

Head:
Prof. Leon Cizelj

Modeling of basic thermal-hydrodynamic phenomena

Within the research of convective boiling phenomena, simulations of boiling experiments in a vertical rectangular channel were performed. Important measurements of velocity distributions and turbulent fluctuations in the boundary layer close to the heated plate were performed using Particle Tracking Velocimetry (PTV) at Texas A & M University (USA). The precise measurements in the boundary layer were used to assess the turbulence models and wall functions of the two-fluid (gas-liquid) model. The work was carried out within the 7th EU Framework Programme (FP) project NURISP.

The modeling of turbulent flow is being used in research related to the development of future fission and fusion reactor systems. We perform a direct numerical simulation of turbulent heat transfer in channels at the Prandtl number 0.01. These simulations, carried out within the 7th EU FP project THINS, are relevant for the next-generation nuclear reactors that will be cooled with liquid sodium. Within the frame of the DEMO fusion reactor conceptual studies, we continued the investigations of the efficiency of heat removal in a divertor cooled by helium jets. A numerical model for single-jet impingement cooling was developed and simulation results were compared to the experimental data. The verified model was then used to analyze the distribution of the cooling jets in the real divertor's geometry. These activities were carried out in cooperation with the Karlsruhe Institute of Technology (Germany) within the European Fusion Development Association (EFDA).

A numerical model for turbulent jet impingement cooling was developed.

Various transients in single- or two-phase (gas-liquid) flow may occur in the piping systems of nuclear plants during design-basis accidents. In the field of transient modelling, the one-dimensional WAHA computer code is being further developed: a new version is being improved with new models of two-phase stratified and slug flow. The WAHA code is also being tested at supercritical temperatures and pressures, at which some of the next-generation nuclear reactors, cooled with supercritical water, are designed to operate. In the field of two-phase stratified flow modelling, we have completed the research and development of new numerical schemes, based on the conservative level-set method. These activities were part of the 7th EU FP project NURISP.

A steam explosion might occur during a hypothetical severe accident in a nuclear power plant if the molten reactor core were to pour into the water in the reactor cavity. Within the OECD project SERENA, we simulated and analyzed, using the European code MC3D, steam explosion experiments that were performed on the complementary KROTOS (Commissariat à l' Energie Atomique - CEA, France) and TROI (Korea Atomic Energy Research Institute) facilities. The developed, improved, melt droplets solidification model and the established melt droplets fragmentation criteria were implemented in the MC3D code and validated on experimental data. We also analyzed the influence of premixing conditions on melt droplets solidification. These activities are being carried out within the SARNET-2 Network of Excellence (7th EU FP) as well.

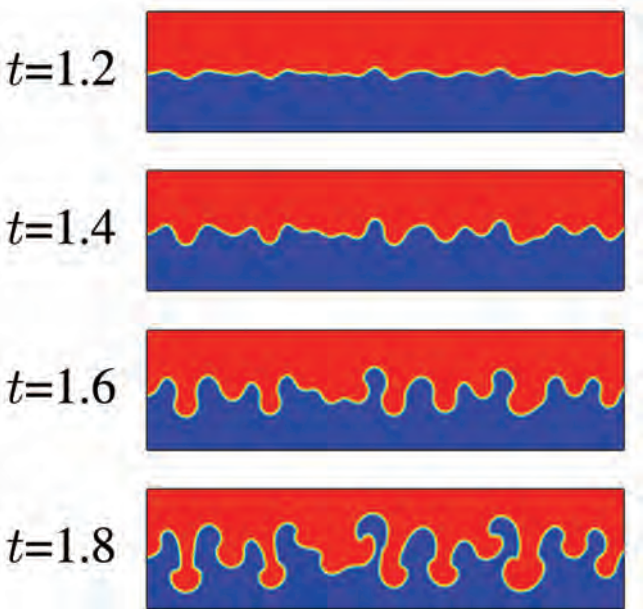

Figure 1: Simulation of the Rayleigh-Taylor instability with a conservative level-set method.

Thermal-hydraulic safety analyses

The influence of measurement delay on over-temperature trip protection during the loss of an external load in the Krško nuclear power plant (NPP) was analyzed with the RELAP5/MOD3.3 thermal-hydraulic computer code. The study demonstrated that the trends for departure from nuclear boiling can be evaluated with RELAP5/MOD3.3 using the critical heat-flux ratio for the average core conditions. However, for licensing calculations of the minimum departure from nucleate boiling (DNBR), the coupling of the RELAP5 code with a code with the capability to calculate transient DNBR for a hot rod, taking into account local mass flux and local steam quality, would be necessary.

For simulations of transients in experimental facilities of pressurized-water-reactor primary systems, we have started to use the TRACE thermal-hydraulic computer code, which is supposed to replace the RELAP code in the future.

In the field of modeling of containment phenomena, we have simulated with the European ASTEC severe accident code, in the frame of the OECD SETH-2 project, experiments on air-helium atmosphere stratification breakup, which were performed in the MISTRA facility at CEA Saclay (France). The atmosphere stratification was broken up in two ways: by injecting a steam jet, and by initiating natural circulation through the heating of the vessel walls. We have also simulated with the CONTAIN code, in the frame of the OECD International standard problem no.49, an experiment on hydrogen deflagration, which was performed in the ENACCEF facility in the ICARE centre at the Centre National de la Recherche Scientifique in Orléans (France).

Structural safety analyses

The long-term research spotlight is the development of multi-scale computational simulation tools for polycrystalline metallic materials. An advanced, constitutive model of crystal plasticity is combined with random grain sizes and shapes, based either on experimental data or Voronoi tessellations. The microscopic stress fields in randomly oriented and shaped grains are then obtained using the finite-element solver ABAQUS.

In 2010, we continued the development of physical grain structures, based on experimental data. The purpose of the research is the development of computer models and codes for the prediction of intergranular crack initialization and growth. The spatial structure of the grains is obtained using the diffraction-contrast tomography method, which has been developed together with the University of Manchester (UK) and the European Synchrotron Radiation Facility. Grain shapes are first reconstructed from experimental data. The influence of the grain structure on the behaviour of the material is then estimated using the finite-element method. The crystallographic orientation and anisotropic behaviour of the grains are taken into account, resulting in rather inhomogeneous stress and strain fields.

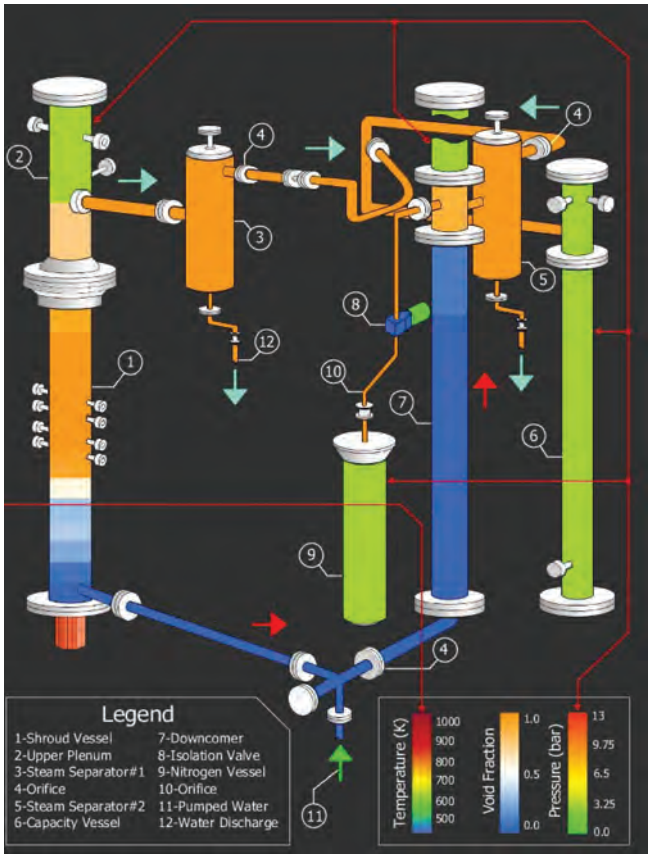

Figure 2: Simulation of a transient in the Achilles experimental facility (UKAEA Winfrith, UK) with the TRACE thermal-hydraulic computer code.

We have also started the development of a thermo-mechanical model of a divertor cooling finger for the upcoming DEMO fusion reactor. The work is carried out in collaboration with the Karlsruhe Institute of Technology (Germany). The research is oriented towards the development of a design that will ensure sufficient heat-removal capability and safe operation of the divertor.

The list of research partners also includes the EU Joint Research Center - JRC in Petten (Netherlands), CEA (France) and AIB-Vinçotte Nucléaire (Belgium). We are also members of the European network of excellence on nuclear plant lifetime prediction NULIFE, which in 2010 started a transition towards being a non-profit professional association.

Probabilistic safety assessment

Methods for the optimization of testing and maintenance of stand-by safety systems in a nuclear power plant have been developed by using probabilistic safety-assessment models with their results. The models were upgraded with the inclusion of parameters for ageing. The work was performed in cooperation with the Institute for Energy (JRC Petten).

Improved genetic optimization algorithms were developed. An improved method was applied for the optimization of the daily load diagram of electric energy consumption of a power system including hydro power plants, thermal power plants and nuclear power plants.

The uncertainty in the probabilistic safety assessment was investigated. New probability distributions encompassing the ageing rates available in the considered data set were developed. The obtained results indicate the extent to which the uncertainty of the considered ageing data set, given the inherently assigned probability distribution, influences the performed calculations of the unavailability.

Technical cooperation, consulting services and education

In 2010, the Reactor Engineering Department researchers also cooperated in projects for industry and the state administration. The Jožef Stefan Institute issues permissions for recriticality and regular operation of the Krško NPP after each regular outage.

An improved melt droplets solidification model was implemented in the European steam-explosion code MC3D.

We have performed a study of the safety characteristics of four generation III reactors for the company "GEN energija", which is a potential investor in the Krško NPP 2nd unit. The study will be used as a basis for a decision about the eventual reactor type for the projected unit.

Members of the department are also actively involved in the Nuclear Engineering undergraduate and doctoral studies programmes at the Faculty of Mathematics and Physics at the University of Ljubljana. The programmes are associated with the European Nuclear Education Network (ENEN) and the European project ENEN-III.

Some outstanding publications in the past year

1. L. Cizelj, I. Simonovski, Microstructurally Short Cracks in Polycrystals Described by Crystal Plasticity, ISBN: 978-1-61668-811-0, Nova Science Publishers, New York, 2010.
2. I. Simonovski, B. Končar, L. Cizelj, Thermo-mechanical analysis of a DEMO divertor cooling finger under the EFREMOV test conditions, Fusion Engineering and Design, 85, 130-137, 2010.
3. L. Štrubelj, G. Ézsöl, I. Tiselj, Direct contact condensation induced transition from stratified to slug flow, Nuclear Engineering and Design, 240, 266-274, 2010.
4. M. Uršič, M. Leskovar, B. Mavko, Material properties' influence in fuel-coolant interaction codes, Journal of Engineering for Gas Turbines and Power, 132, 072901/1-072901/7, 2010.

Organization of conferences, congress and meetings

1. 13th Board meeting, ENEN Special Event 2010: »Needs and strategies on education & training for increasing nuclear power production« and 8th General Assembly meeting of the European Nuclear Education Network Association, June 4 – 6, 2010.

INTERNATIONAL PROJECTS

1. Training Scheme on Nuclear Safety Culture
   TRASNUSAFE
   7. FP – EURATOM, 249674
   EC; Giuseppe Esposito, Universite Catholique de Louvain, Louvain-la-Neuve, Belgium
   Prof. Borut Mavko
2. Thermal-hydraulics of Innovative Nuclear Systems
   THINS
   7. FP – EURATOM, 249337
   EC; Dr. Xu Cheng, Karlsruher Institut für Technologie (KIT), Institute for Neutron Physics and Reactor Technology, Eggenstein-Leopoldshafen, Germany
   Prof. Iztok Tiselj
3. European Nuclear Education Network Training Schemes
   ENEN-III
   7. FP – EURATOM, 232629
   EC; Dr. Peter De Regge, ENEN Association, European Nuclear Education Network Association p/a Centre CEA de Saclay, Gif-sur-Yvette, France
   Prof. Leon Cizelj
4. Network of Excellence for a Sustainable Integration of European Research on Severe Accident Phenomenology and Management - Phase 2
   SARNET 2
   7. FP – EURATOM, 231747
   EC; IRSN, France
   Dr. Matjaž Leskovar
5. Nuclear Reactor Integrated Simulation Project
   NURISP
   7. FP – EURATOM, 232124
   EC; Commissariat a l'Energie Atomique (CEA), Paris, France
   Prof. Iztok Tiselj
6. Modelling of High Flux Helium Cooling - Divertor Design - 4.5.1.
   EURATOM – MHEST
   7. FP - EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Dr. Boštjan Končar
7. Nuclear Plant Life Prediction
   NULIFE
   6. FP, 036412
   EC; Valton Teknillinen Tutkimuskeskus (VTT), Espoo, VTT, Finland
   Prof. Leon Cizelj
8. Steam Explosion Resolution for Nuclear Applications
   SERENA, OECD/NEA
   Jean Gauvain, OECD Nuclear Energy Agency, Agence de l'OECD pour l'Energie Nucleaire, Issy-les-Moulineaux, France
   Dr. Matjaž Leskovar
9. SETH-2 Project to Resolve Key Computational Issues for the Simulation of Thermal-Haydraulic Conditions in Water Reactor Containments
   SETH-2, OECD/NEA
   Jean Gauvain, OECD Nuclear Energy Agency, Agence de l'OCDE pour l'Énergie Nucléaire, Issy-les-Moulineaux, France
   Prof. Borut Mavko, Dr. Ivo Kljenak
10. Code Applications and Maintenance Program (CAMP)
    Thermal-Hydraulic Code Applications and Maintenance International Research Project
    Dr. Andrew J. Szukiewicz, Reactor and Plant Systems Branch, Division of Systems Technology, Office of Nuclear Regulatory Research; Dr. Ashok C. Thadani, Director, Donna-Maria Perez, Office of Nuclear Regulatory Research, United States Nuclear Regulatory Commission (US NRC), Washington, D. C., USA
    Prof. Borut Mavko
11. Calibration of a Crystal Plasticity Based Model using Monocrystal Samples
    BI-CZ/09-10-009
    Dr. Jaromir Kopeček, Institute of Physics, Academy of Sciences CR, Prague, Czech Republic
    Dr. Igor Simonovski
12. Fluid-fluid Transition and Related Phenomena in Flowing Systems
    601
    Dr. Imre Attila, MTA KFKI Atomic Energy Research Institute, Budapest, Hungary
    Prof. Iztok Tiselj

R & D GRANTS AND CONTRACTS

1. Improvement of Safety for Existing and New Nuclear Power Plants with Probabilistic Safety Assessment
   Prof. Marko Tomaž Čepin
2. Direct Contact Condensation in Stratified Two-phase Flow
   Prof. Iztok Tiselj
3. Modelling of Fluid Transport in Nanotubes
   Asst. Prof. Ivo Kljenak
4. Modelling of Material Influence on Steam Explosion
   Dr. Matjaž Leskovar
5. Development of Knowledge, Indispensable for Evaluation, Assessment and Surveillance of Ageing Management in Nuclear Facilities
   Prof. Leon Cizelj
6. Strategic Role of Nuclear Power Production in Comparison to Other Sources and Impact of the Slovenian Economy
   Prof. Borut Mavko

RESEARCH PROGRAM

1. Nuclear engineering
   Prof. Borut Mavko

NEW CONTRACTS

1. Expert opinion on Krško NPP tests and repairs during refueling at the end of fuel cycle 24.
   Milan Vidmar Electroinstitute, Ljubljana
   Ljubo Fabjan, M. Sc.
2. Description of safety characteristics of potential reactors for NEK II NPP
   GEN energija, d.o.o., Krško
   Ljubo Fabjan, M. Sc.
3. Cooperation with the International Research Program CAMP (Code Applications and Maintenance Program)
   Ministry of Environmental and Spatial Planning, Slovenian Nuclear Safety Administration, Ljubljana
   Dr. Andrej Prošek
4. Simulation of hydrogen combustion experiments in the ENACCEF experimental facility
   Commissariat a l'Energie Atomique (CEA), Paris, France
   Asst. Prof. Ivo Kljenak
5. Modelling of condensation induced water hammer and boilin g crisis in subcooled boiling flow)
   Commissariat a l'Energie Atomique (CEA), Grenoble, France
   dr. Boštjan Končar
6. Influence of melt droplets solidification on steam explosion
   CEA Cadarache, Laboratoire d'essais pour la Maitrise des Accidents graves, DEN/DTN/STRI/LMA, St. Paul lez Durance, France.
   dr. Matjaž Leskovar
7. Analysis of ex-vessel molten fuel coolant interaction
   CEA Cadarache, Commisariat á l'é atomique et aux énergies alternatives, Saint Paul lez Durance Cédex, France.
   dr. Matjaž Leskovar

MENTORING

Master's thesis

1. Matjaž Ferjančič, *Effects of Snubber Modeling Assumptions on the Earthquake Induced Stresses in Pipe* (mentor prof. Leon Cizelj)

VISITORS FROM ABROAD

1. Mr. Stefan Haussner, Dipl.Ing., AREVA NP GmbH, Erlangen, Germany, June 7 - 11, 2010
2. Mr. Alexandre Vigouroux, Institut Catholique d'Arts et Metiers (ICAM), Nantes, France, July 6 2010 - January 31, 2011
3. Mr. Nicolas Gary, Institut Catholique d'Arts et Metiers (ICAM), Nantes, France, December 3, 2010
4. Mr. Dinesh Singh, dipl.ing., Indian Institute of Technology (ITT), Mumbai, India, December 6, 2010 - January 10, 2011

Visitors students by the International Association for the Exchage of Students for Technical Experience (IAESTE):
1. Mr. Anthony James Cornwell, University of North Parramatta, Australia, July 16 – November 30, 2010
2. Ms. Clare Goddard, University of Nottingham, Nottingham, Great Britain, August 2 - September 17, 2010

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5. Dr. Boštjan Končar
6. Dr. Matjaž Leskovar
7. Prof. Borut Mavko
8. Dr. Andrej Prošek
9. *Dr. Igor Simonovski, left 01.08.10*
10. Prof. Iztok Tiselj

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11. Dr. Mihaela Irina Uplaznik
12. Dr. Andrija Volkanovski

Postgraduates
13. Ovidiu Adrian Berar, B. Sc.
14. Oriol Costa Garrido, B. Sc.
15. Martin Draksler, B. Sc.
16. Blaže Gjorgiev, M. Sc.
17. Duško Kančev, B. Sc.
18. Zoran Petrič, B. Sc.
19. Mitja Uršič, M. Sc.

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20. Armando Francisco Quiles Agustin, B. Sc., left 01.12.10
21. Andrej Sušnik, B. Sc.

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22. Tanja Klopčič
23. Zlata Vrhovec Mikolič

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

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B. Sc. Thesis

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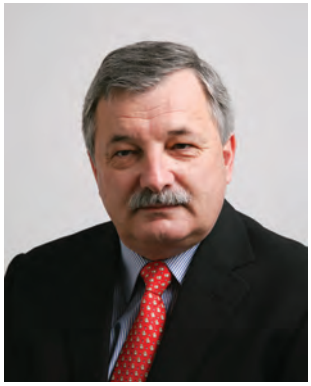
REACTOR INFRASTRUCTURE CENTRE RIC

The Reactor Infrastructure Center incorporates the research reactor TRIGA Mark II Reactor and the Hot Cells Laboratory. Reactor, operating since 1966, is used for neutron research, training and for producing radioactive isotopes. A detailed technical description of the reactor is available at http://www.rcp.ijs.si/˜ric/.



Head:
Asst. Prof. Borut Smodiš

The Hot Cells Laboratory is used for handling radioactive materials for the needs of research and development programs as well as for commercial activities. In addition, it is used for regular radiation monitoring of the TRIGA reactor.

Besides operating and maintaining the reactor, the members of the Reactor staff also cooperate in other activities requiring specialists skilled in the work with sources of radiation and in reactor technology, such as the servicing of industrial radioactive sources and the surveillance of the fuel management in NPP Krško.

In 2010, Reactor operated for 106 days. A total of 792 samples were irradiated, 624 of them in the rotary specimen rack and 168 in the pneumatic post system.

It mainly operated in steady-state mode. There have been no serious operational problems or events influencing nuclear or radiological safety. The reactor's operators were performing regular maintenance inspections and works according to the annual plan.

In the Hot Cell Laboratories, mainly used for work with strong radioactive sources, the actvities were performed by the Department of Environmental Sciences and the Radiation Protection Unit. In 2010, the IJS stuff performed training in the field of radiochemistry and measurements of radioactivity for specialists from countries that are joined in the EU Research Center. The training was performed in the Hot Cells Laboratory. In cooperation with the Slovenian Rad-waste Agency, the project "Conditioning of radioactive waste of small producers" was carried out.

Figure 1: Renovated control room of the TRIGA reactor

The reactor was mainly used for neutron activation analysis. The reactor operated mainly for the needs of the J. Stefan Institute's Milan Čopič Nuclear Training Center, for education, and for the following research departments: Environmental Science Department, Reactor Physics Department, Experimental Particle Physics Department and Department for Nanostructured Materials. The reactor was used in the following research:

- neutronics and reactor physics
- activation analysis
- neutron dosimetry and spectrometry
- neutron radiography
- activation of materials, nuclear waste and decommissioning
- irradiation of materials for fusion reactors.

Renovated control room of the TRIGA reactor

The reactor operators support the researchers by performing the operations and services for which the researchers are not qualified and authorized, such as operating the reactor, performing irradiations and manipulation with radioactive samples.

The results of this research were published in approximately 20 scientific papers. A total of 3 young researchers performed their research work at the reactor.

In 2010 some international courses in the field of the safety of research reactors were performed:

International Atomic Energy Agency

1. Technical Cooperation Regional Project RER4023 -Enhancing the Sustainability of Research Reactors and Their Safe Operation through Regional Cooperation, Networking, and Coalition Regional Meeting on Application of the Code of Conduct on the Safety of Research Reactors in Europe, Jožef Stefan Institute, Ljubljana, Slovenia, 2-5 November 2010, 20 participants

2. "Group Fellowship Training Programme on Research Reactors", Nuclear Training Centre "Milan Čopič", Jožef Stefan Institute, Ljubljana, Slovenia, 15–26 March 2010, 10 participants
3. Training in Radioactivity Measurements for Practitioners from Countries Eligible Under the JRS Enlargement & Integration Policy, 4 courses, 19 participants
4. Consultancy Meeting, Test of IAEA Field and Data Manuals, Jožef Stefan Institute, Ljubljana, Slovenia, 25–.-28. May 2010, 7 participants

Practical exercises in the field of reactor physics and kinetics for the students of physics at Ljubljana University were preformed. The post- graduate students of nuclear engineering attended some of these exercises as well. For these purposes the reactor operated for approximately 2 months. The reactor was also used also for practical exercises within the training program of the NPP Krško reactor operators. The exercises were prepared and carried out by the reactor personnel in co-operation with the Nuclear Training Center and the Department of Reactor Physics.

In 2010 , there were more than 50 short group visits toof the reactor. The visitors were mainly foreign scientists, students and more than 30 groups of school children. Their total number was more than 900.

INTERNATIONAL PROJECTS

1. Regional Meeting on the Application of the Code Conduct on the Safety of Research Reactors; Ljubljana, 2.-5.11.2010
   C1-RER/4/032901101
   IAEA - International Atomic Energy Agency, Vienna, Austria
   Asst. Prof. Borut Smodiš
2. Training in Radiochemistry and Radioactivity Measurements for Practitioners from Countries Eligible under the JRC Enlargement & Integration Policy
   54018
   Ivan Celen, European Commission, Joint Research Center JRC, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
   Asst. Prof. Borut Smodiš, Asst. Prof. Ljudmila Benedik

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CENTRE FOR NETWORKING INFRASTRUCTURE CNI

The basic function of the Centre for Network Infrastructure (CNI) is the management and maintenance of the JSI computer network, including planning, development, upgrades, maintaining contact with public networks, and providing security. The CNI also houses and supports the local SiGNET GRID cluster.

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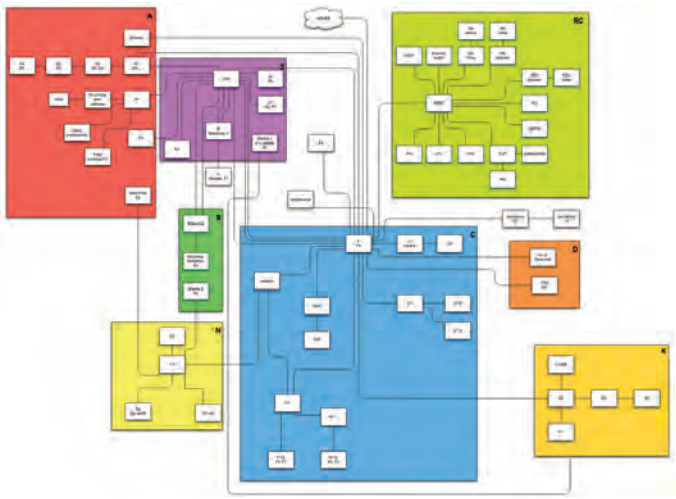

Figure 1: JSI connectivity structure

Figure 2: Layout of JSI communication network

**Photo by Sašo Rebolj Playboy*

SCIENCE INFORMATION CENTRE SIC

The Jožef Stefan Institute Science Information Centre is the central Slovenian physics library and one of the largest special libraries in Slovenia. Our main tasks are the acquisition, archiving, and loan of books and periodicals, and the input, update and control of bibliographic data of the Institute staff, as requested by the funding ministry.

Head:
Dr. Luka Šušteršič

Our collection covers the fields of physics, chemistry, biochemistry, electronics, information science, artificial intelligence, nuclear technology, energy management and environmental science. We are a full member of the Slovenian library cooperative, COBISS, and use their services to catalogue and loan our materials. You can check what is new in the library, browse our online catalogue, or send inter-library loan requests using our WWW site.

We supplement our comprehensive print collection of core journals with the electronic editions, offered through our WWW site. We subscribe to the electronic collections offered by ScienceDirect, Springer Link, IEEExplore, Stanford HighWire Press, ACS online editions, AIP electronic editions, IoP online journals, Wiley Interscience. We provide access to the SCOPUS, INSPEC, Crossfire Beilstein, and Web of Science databases, and the Dialog on-line database services.

We manage a bibliographic database of the Institute's production. The database contains about 80,000 records, going back to the Institute's inception in 1949. The records of last year's work are included as part of this report.

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ENERGY EFFICIENCY CENTRE

EEC

The basic activities of the Energy Efficiency Centre are in efficient energy use, long-term planning in energy and the reduction of greenhouse-gas emissions. The centre is a focal point for the collection and transfer of energy-efficiency technologies to energy users, the state, energy service and equipment providers, and other interested agencies. At the same time it covers the environmental effects of energy use and conversion. The most significant part of the EEC activities is thus its cooperation with state institutions in the preparation of strategic documents and legislation in the field of efficient energy use, energy planning, distributed electricity production, emission trading; nevertheless, it still remains strongly connected, by its consulting and training role in energy, with industrial companies and other institutions.

Head:
Stane Merše, M. Sc.

Energy and the environment

In 2010 the Energy Efficiency Centre, with its professional work, was intensively included in the preparation of key development strategic documents in the field of energy planning and greenhouse-gas emissions reduction.

An intensive preparation of **strategic studies for the new National Energy Programme (NEP)** continued, which represents the greatest professional task and challenge for the center's activities ever. The preparation of strategic studies and a quantitative analysis for the preparation and evaluation of sub-programmes in all key fields demanded a complete update of all the developed models and software tools, especially the Referential Energy Environment Model of Slovenia REES-SLO2, which was completely updated in the new MESAP environment.

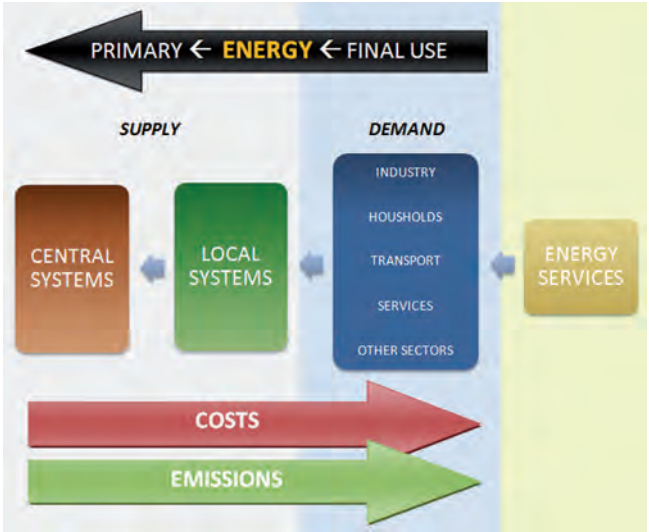
The accepted EU climate-energy package set for Slovenia's new ambitious goals regarding an increase of energy efficiency, the exploitation of renewables (RES) and a reduction of greenhouse-gas emissions. Achieving a 25% share of RES in the final energy use up to 2020 presents the greatest development challenge. The centre, with the Ministry of the Economy, carried out the Action plan of RES for the period 2010-2020 to achieve that share and it was presented to the European Commission by the Slovenian government.

The R&D work of the Energy Efficiency Centre is an important contribution to the preparation of key documents in Slovenia in the field of energy development, energy efficiency, renewables exploitation and the transition of Slovenia to a low-carbon society. With training activities and support to industry it significantly contributes to an increase in competitiveness and development restructuring.

In the field of greenhouse-gas emissions reduction, the centre carried out new projections of greenhouse-gas emissions and a report for reporting to the European Commission and new projections of pollutants' emissions from the NEC directive for the Ministry of the Environment. The centre also cooperated with the Governmental Office for Climate Changes during the preparation of negotiation starting points of Slovenia as regards the formation of new goals of the EU climate policy.

The Energy Efficiency Centre continues with activities of the state referential center for energy and in 2010 it refreshed and broadened the list of indicators for energy and environment.

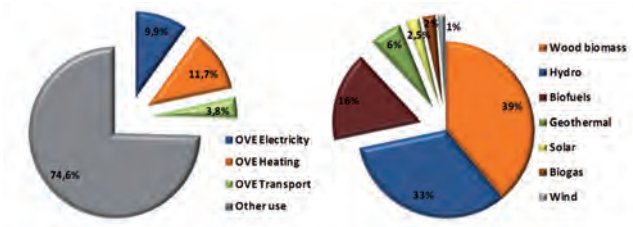
The directive on energy services and the accepted climate energy package also set Slovenia binding goals as regards an increase in energy efficiency up to 2016 and 2020. In 2010 the centre concluded the project for the preparation of evaluation methodologies for carrying out energy-efficiency measures, which will be a key instrument of the presentation of fulfilling the set goals. The preparation of the methodology is a part of a broader process of the preparation of harmonized evaluation methodologies in the EU where cooperation continued within the framework of "Concerted Action – Energy Service Directive (CA – ESD)".



Picture 1: Concept of the new Reference energy environment model of Slovenia REES-SLO2 in the MESAP environment

Promotion of efficient energy use and energy consulting

The Energy Efficiency Centre in 2010 in the field of the promotion of efficient energy use and energy consulting in industry and institutions continued with its training activities where the third cycle of energy managers' training was successfully concluded within the European programme EUREM. In the autumn, already the fourth cycle of training started. Due to



Picture 2: Action plan for RES for the period 2010-2020: achieving a 25% share of renewable sources in the final energy use

the very positive reaction of participants and their interest, it is clear that there is a great need for such training. High-quality knowledge in this field is of key importance for the execution of efficient solutions in practice. A great acknowledgement of our successful work is the award of diploma European Energy Manager of the Year for big enterprises to Mr. Dušan Novkovič from the company Acroni, in the category of small enterprises the award for the project "Optimization of the distribution pumps system for technological waters" went to Mr. Matija Tacer from the company Iskra Invest.

In 2010 the Center of Energy Efficiency carried out several consulting tasks in industry and performed a series of energy audits for enterprises and institutions to reduce the consumption and costs for energy and emissions. Among the larger clients are Luka Koper, the Municipality of Ljubljana, Borzen – Support Center, Municipality Domžale, Tanin Sevnica, etc.

The centre also prepared the programme and cooperated in the twelfth execution of the largest Slovenian conference of energy managers "Energy Managers Days", the annual meeting of energy managers with more than 200 participants, which confirms the quality and public profile of the EEC professional work. In 2010, the Energy Efficiency Centre prepared the electronic issuing of the Energy Efficiency Newsletter for the Ministry of the Economy. Individual EEC experts published numerous articles in magazines and public media as well as taking part in radio and television broadcasts.

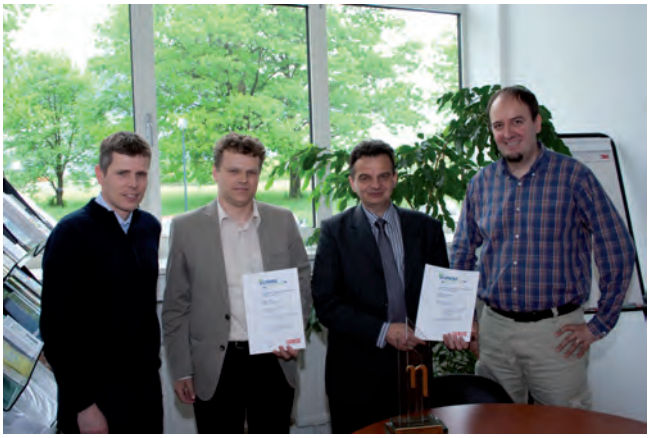
International cooperation

In 2010 the EEC carried out as many as 11 international projects, financed from the European Union resources as part of the programme "Intelligent Energy for Europe".

Projects cover activities in the fields of:

- Promotion and development of new energy services – project Good Practice Examples of Changes in Energy Services (ChangeBest),
- Development and carrying out of energy contracting and advanced energy services – project European Energy Service Initiative (EESI),
- Monitoring of execution of Directive on cogeneration – project Cogeneration Observatory and Dissemination Europe (CODE),
- compiling and elaboration of the current data on renewable energy sources use – EurObserv` ER Barometer,
- carrying out of EU directive on energy services and evaluation of energy efficiency measures – project Concerted Action – Energy Service Directive (CA-ESD),
- monitoring of indicators of energy use and energy efficiency in EU – project Monitoring of Energy Demand Trends and Energy Efficiency in the EU (ODYSSEE MURE EU-27)
- and others.

Projects include cooperation with R&D organisations from Europe with a strong emphasis on concrete applications and the promotion of energy efficiency. In the framework of each project the EEC staff took part in numerous foreign professional meetings and visits.



Picture 3: Receivers of awards for European Energy Manager 2010.

Some outstanding achievements in 2010

1. Preparation of several key support documents for the government of the Republic of Slovenia in the field of energy policy (Green paper and strategic studies for the National Energy Programme), energy efficiency (National Action Plan for Energy Efficiency), renewable energy sources (Action Plan for Renewable energy sources for the period 2010–2020) and climate policy (Operative programme of GHG emissions reduction up to 2012).
2. Establishment of energy managers training in the framework of the European project EUREM and professional support to industry and other institutions by carrying out energy audits, feasibility studies and other consulting (Goodyear, Cinkarna Celje, Litostroj, TE-TOL, Luka Koper ,etc.).
3. Cooperation in different international projects in the framework of European Commission programmes in the fields of energy efficiency, energy management, combined production of electricity and heat, promotion of energy efficient technologies, external costs in energy, exploitation of wood biomass and others.

Organization of conferences, congress and meetings

1. Energy Managers Days 2010 – 12th Meeting of Energy Managers of Slovenia, Portorož, 19.- 20.4.2010
2. Workshop on the project Cogeneration Observatory and Dissemination Europe (CODE), Budapest, Hungary, 5.-6.5.10
3. Expert workshop on methods of energy savings determination by measures for increasing energy efficiency and usage of renewables, Ljubljana, 13.5.2010
4. European Energy Manager Training, Ljubljana, 20.1.-22.1., 17.3.-19.3., 5.-7.5. in 17.6.10

INTERNATIONAL PROJECTS

1. Monitoring of EU and National Energy Efficiency Targets
   ODYSSEE MURE 2010
   IEE Programme
   IEE/09/801/SI2.558254
   EC; Didier Bosseboeuf, Agence De l'Environnement et de la Maitrise de l'Energie (ADEME), Angers, France
   Dr. Fouad Al-Mansour
2. The EurObser'ER Barometer Backs the New RES Directive
   EurObserv'ER 2020
   IEE Programme
   IEE/09/737/SI2.558317
   EC; Observatoire des Energies Renouvelables (Observ´ER), Paris, France
   Dr. Fouad Al-Mansour
3. European Energy Service Initiative
   EESI
   IEE Programme
   IEE/08/581/SI2.528408
   EC; Michael Geissler, Berliner Energiagentur GmbH (BEA), Berlin, Germany
   Damir Staničić, M. Sc.
4. Good Practice Examples of Changes in Energy Service Business, Strategies and Supportive Policies and Measures in the Course of the Implementation of Directive 2006/32/EC
   ChangeBest
   IEE Programme
   IEE/08/434/SI2.528383
   EC; Wuppertal Institut für Klima, Umwelt, Wuppertal, Germany
   Evald Kranjčevič, M. Sc.
5. EurObserv` ER Barometer
   EurObserv` ER
   IEE Programme
   EIE/07/056/SO2.466834
   EC; Observatoire des Energies Renouvelables (Observ´ER), Paris, France
   Polona Lah, B. Sc.
6. Cogeneration Observatory and Dissemination Europe
   C.O.D.E
   IEE Programme
   IEE/07/564/SI2.499462
   EC; COGEN EUROPE, Brussels, Belgium
   Stane Merše, M. Sc.
7. Concerted Action Supporting Transposition and Implementation of Directive 2006/32/EC of the Council
   CA ESD
   IEE Programme
   IEE/CA/08/001/SI2.503473
   EC; Rob Boeree, SenterNovem, Sittard, The Netherlands
   Damir Staničić, M. Sc.
8. Intelligent Information System for Monitoring and Verification of Energy Management in Cities
   ISEMIC
   SEE-ERA.NET Plus
   ERA 163/01
   EC; Prof. Željko Tomšić, University of Zagreb, Faculty of Electrical Engineering and Computing, Department of Power Systems, Zagreb, Hrvaška
   Boris Sučić, M. Sc.

R & D GRANTS AND CONTRACTS

1. Determination of the Applied Potential of Agricultural Biomass and Definition of Environmentally Friendly Technologies Used for its Exploitation
   Dr. Fouad Al-Mansour
2. Slovenia - Low Carbon Cociety
   Andreja Urbančič, M. Sc.

RESEARCH PROGRAM

1. Environment Impact - Modelling and Assessment
   Dr. Borut Smodiš, Dr. Fouad Al-Mansour

NEW CONTRACTS

1. Statistics of Energy and Fuel Consumption in Households
   Statistical Office of the Republic of Slovenia
   Matjaž Česen, B. Sc.
2. Energy Managers Days 2010
   Journal Finance d.o.o.
   Stane Merše, M. Sc.
3. Editing of Energy Efficiency Newsletter
   Ministry of the Economy
   Barbara Petelin Visočnik, M. Sc.
4. Completion of Strategic Studies for the National Energy Programme (NEP) with the Estimation of a Hypothetic Scenario of Energy Development when Closing Velenje Coal Mine and Stopping of Electricity Production from the Domestic Coal up to 2027
   Ministry of the Economy
   Andreja Urbančič, M. Sc.
5. Preparation of GHG Emissions Projections in Accordance with Requirements of the Decision 280/2004/ES on the Mechanism for Monitoring of Greenhouse Gases
   Ministry of the Environment and Spatial Planning
   Stane Merše, M. Sc.
6. Analysis of the Actual State of Policy and Mechanisms for Stimulation of Electricity Production from RSE and CHP in EU
   BORZEN d.o.o.
   Stane Merše, M. Sc.
7. Professional Opinion and Support to the Government in the Formation of the Viewpoint Regarding 30% Reduction of GHG Emissions up to 2020
   Government Office for Climate Change
   Matjaž Česen, B. Sc.
8. Energy Audit of Six Primary Schools in the Municipality of Domžale
   Civil Engineering Institute ZRMK
   Marko Pečkaj, B. Sc.
9. Professional consulting at the execution of the CLIMAPORT programme EU project
   LUKA KOPER d.d.
   Marko Pečkaj, B. Sc.

VISITORS FROM ABROAD

1. Antonia Colonna d` Istria, postgraduate student, L` ecole nationale superieure d` arts et metiers, Bastia, Corse, France, 15.4.2010 – 30.9.2010
2. Lazar Dečevski, director, Energy Agency of the Republic of Macedonia, Skopje, Macedonia, 12.4.2010
3. Tome Kostadinovski, director, Konstruktor, Skopje, Macedonia, 12.4.2010
4. Joe Bolkcom, Director for Education, University of Iowa, Green Bike Tour, Iowa, USA, 11.6.2010
5. Edward Woolsey, director and lobbyist, Izaak Walton League, Green Bike Tour, Iowa, USA, 11.6.2010
6. John Moreland, senate Tom Harkin, Green Bike Tour, Iowa, USA, 11.6.2010
7. Audrey Seon, in charge of studies, Institut de la Mediterranee, Marseille, France, 19.10.2010

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14. Igor Ribič
15. Milan Simončič, B. Sc.

BIBLIOGRAPHY

Original Article

1. Fouad Al-Mansour, Jaroslaw Zuwala, "An evaluation of biomass co-firing in Europe", *Biomass bioenergy*, iss. 5, vol. 34, pp. 620-629, 2010.

Published Conference Papers

Regular papers

1. Fouad Al-Mansour, "Sistemi za izkoriščanje kmetijske biomase za energetske namene in možnosti zmanjševanja porabe energije v kmetijstvu", In: *Kmetijska biomasa za energetske namene: Zbornik seminarja, Ljubljana, Kmetijski inštitut Slovenije, 31. 08. 2010*, Viktor Ejčič, ed., Ljubljana, Kmetijski inštitut Slovenije, 2010, pp. 23-48, 2010.
2. Zoran Morvaj, Boris Sučić, Vesna Bukarica, "Uspješna implementacija programa energetske efikasnosti u javnom sektoru u Hrvatskoj", In: *[Energetika na razvojnem prelomu]: zbornik*, Aleš Podgornik, ed., Stane Merše, ed., Igor Ribič, ed., Ljubljana, Časnik Finance, 2010, 17 pp.
3. Zoran Morvaj, Boris Sučić, Vesna Bukarica, "Uspješna implementacija programa energetske efikasnosti u javnom sektoru u Hrvatskoj", In: *[Energetika na razvojnem prelomu]: zbornik*, Aleš Podgornik, ed., Stane Merše, ed., Igor Ribič, ed., Ljubljana, Časnik Finance, 2010, pp. 4.2/1-4.2/17.
4. Boris Sučić, Andreja Urbančič, Stane Merše, Damir Staničić, Matjaž Česen, "Integration od sustainability into overall energy policy: new slovenian national energy program", In: *EEM 10*, 7th International Conference on the European Energy Market, EEM 10, June 23-25 2010, Madrid, Spain, [Madrid, Universidad Pontificia Comillas], cop. 2010, 5 pp., 2010.

CENTRE FOR ELECTRON MICROSCOPY

CEM

The Center for Electron Microscopy (CEM) has the function of a supporting infrastructure center at the JSI that comprises the equipment for electron microscopy that is necessary for the research work of the departments K5, K6, K7, K8 and K9. Other JSI departments, research institutes, universities and industry also have access to the equipment. The users of the CEM equipment are the researchers in the field of materials science that are involved in the chemical and structural analysis of materials on the micro and atomic scales. The major equipment of the CEM represents two scanning electron microscopes (JSM-840A and JSM-5800) and two transmission electron microscopes (JEM-2000FX and JEM-2010F). CEM coworkers also manage the transmission electron microscope JEM-2100 that belongs to the Center of Excellence NiN, and in 2009 a newly installed field-emission scanning electron microscope JSM-7600F that was a joint purchase by ten JSI departments and also the faculties NTF and FKKT of the University Ljubljana. In 2010 the electron microscopes were upgraded with the following analytical attachments that were purchased by the Centre of Excellence NAMASTE: CCD camera on the JEM-2010F, ADF detector on the JEM-2010F and EBSD system on the JSM-7600F.

Head:
Prof. Miran Čeh

Scanning electron microscopy (SEM) is used for the morphological studies of either fractured or polished surfaces. Since both scanning electron microscopes are equipped with X-ray spectroscopy (EDXS, WDXS), qualitative and quantitative chemical analyses on the micro-scale is also possible. Since only a few μm^3 of the material are nondestructively analyzed, the term electron-probe microanalysis (EPMA) is used for such analytical work. Apart from EDXS and WDXS, the new FEG-SEM JSM-7600F is also equipped with electron lithography.

When the structural features on the nano-scale are investigated, however, various techniques of transmission electron microscopy (TEM) are used. In particular, the JEM-2010F is a state-of-the-art TEM/STEM microscope with a FEG (field-emission gun) electron source and with a point-to-point resolution below 0.19 nm, which is more than sufficient to observe the atomic columns in crystalline materials. The JEM-2010F is also equipped with an annular dark-field detector (HAADF-STEM) for so-called Z-contrast imaging, which enables chemical analysis of a single atomic column on the basis of the measured intensities. Both transmission electron microscopes are additionally equipped with analytical systems for chemical analyses (EDS, EELS). The CEM also comprises the equipment for SEM and TEM specimen preparation, which is the first starting step for all electron-microscopy observation procedures. Especially important are high- and low-energy ion-millers, which enable the preparation of thin foils that are transparent for high-energy electrons.

The analytical work that is performed on the CEM equipment varies with regard to both the investigated materials and/or the electron microscopy techniques used. While scanning electron microscopy is used mainly for the microstructural characterization and chemical analysis of polycrystalline ceramic materials (functional ceramics, engineering ceramics, bio-ceramics, and composites), magnetic materials, glasses, metals, alloys, etc., transmission electron microscopy is used for structural and chemical investigations of grain boundaries, planar faults, dislocations and precipitates within the same materials. The structural and chemical analysis of grain boundaries is especially important since it is known that the final physical properties to a great extent depend on the structure and chemistry of grain boundaries.

In order to be able to perform electron microscopy investigations it is imperative that the equipment in the CEM is well maintained. In view of this, one on the main tasks is to attain the maximum possible operational time of the microscopes. This complex and expensive equipment needs regular daily maintenance apart from servicing. Other activities of the CEM are the organization of training courses for operators and the implementation of new analytical methods, which is realized with the help of CEM co-workers.

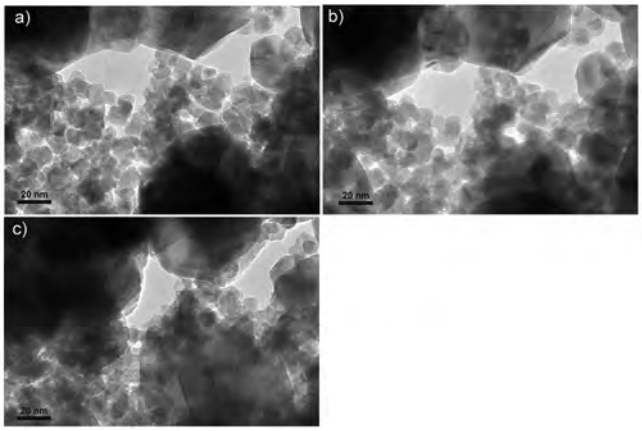

Figure 1: Sintering of nano and micro ZrO_2 particles during heating in transmission electron microscope. a) before heating, b) 0.5 h - 800°C, c) 0.5 h - 1000°C
Dept. of. Engineering Ceramics: I. Pribošič

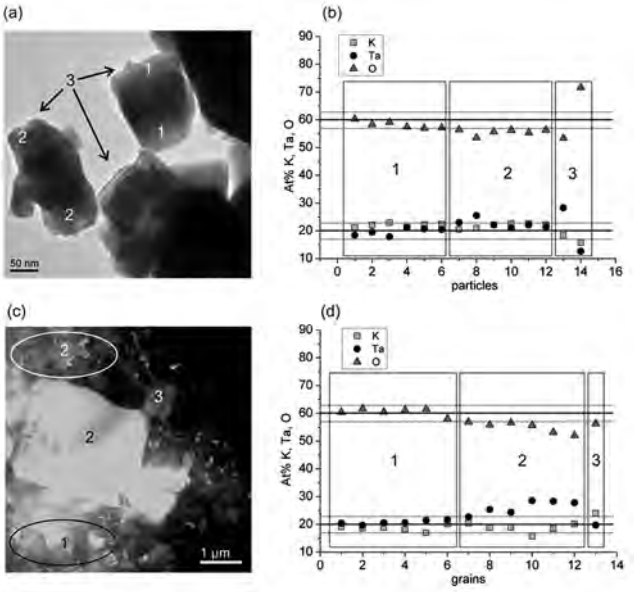

Figure 2: Quantitative TEM-EDXS analysis of the $KTaO_3$ powder gives precise information on the powder's chemical composition and the possible sources of compositional inhomogenieties in the subsequently processed ceramic. During the conventional TEM analysis of the powder, the incomplete perovskite crystallization along with the existence of nanoparticles attached to the powder particles were discovered (Fig. a). The area (1) represents well-crystallized cubic-shaped particles, the area (2) represents particles with disturbed edges, and the area (3) represents small poorly crystalline or amorphous particles attached to large ones. The chemical composition of the powder shown in Fig. b revealed the presence of both K- and Ta-rich fractions. Nevertheless, the majority of the well-crystallized particles had a perovskite composition with a slight shift onto the K-rich side due to the presence of the remaining K-rich amorphous phase. The hot-pressed ceramic, in its turn, exhibited abnormal grain growth phenomenon (Fig. c) accompanied by a compositional inhomogeneity (Fig. d). The area (1) corresponds to the areas of matrix grains, the area (2) corresponds to the Ta-rich matrix grains in the vicinity, and the area (3) corresponds to the K-rich grains, a small amount of which was detected in the specimen. The majority of matrix grains showed a perovskite composition with a slight Ta-rich tendency, however, both K- and Ta rich grains were also encountered (Fig. d). In both plots, the solid line represents the nominal composition; the standard deviation of ±2s for each element is shown in dotted lines.
Dept. of Electronic Ceramics: E. Tchernychova
Reference: E. Tchernychova, S. Glinšek, B. Malič and M. Kosec, J. Am. Ceram. Soc., doi: 10.1111/j.1551-2916.2010.04288.x .

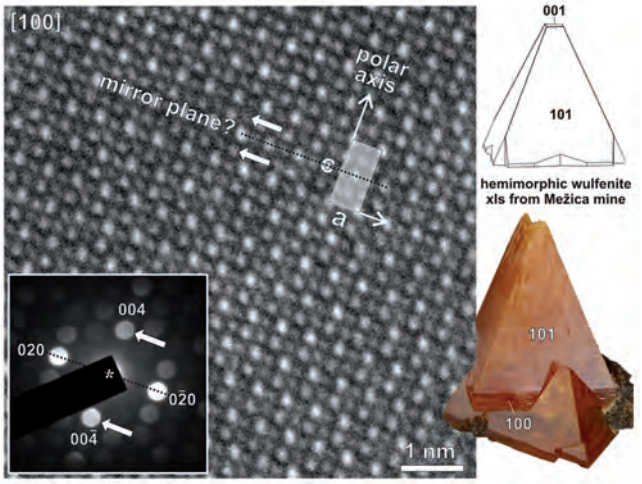

Figure 3: Hemimorphy of the wulfenite crystals from the lead-zinc ore deposit Mežica (Slovenia). Wulfenites from Mežica possess peculiar morphological features that are not observed on wulfenites from other localities. In addition to the regular I4/m symmetry (tetragonal bipyramidal) we frequently encounter hemimorphic crystals with a unique I4 symmetry (tetragonal pyramidal) with one of the basal terminations flat, and the other pyramidal. Micro-diffraction analysis showed a slight difference in the intensity of +g and -g pairs of reflections related to the polar c-axis. Similar asymmetry is observed in the fine contrast features on phase-contrast images.
Figure: HRTEM image with superimposed micro-diffraction pattern of hemimorphic wulfenite suggest a possible noncentrosymmetricity of wulfenite along the c-axis. The breakdown of Friedel's law is visible by the difference in the intensity of reflection pairs and by the differences in HRTEM image contrast.
Dept. for Nanostructured Materials: A. Rečnik
Reference: J. Zavašnik, A. Rečnik, Z. Samardžija, A. Meden, I. Dódony, Hemimorphic wulfenite crystals from lead-zinc ore deposit Mežica (Slovenia). [20th General Meeting of the International Mineralogical Association 21-27 August, 2010, Budapest, Hungary]. Acta Univ. Szeged. 6 (2010) 727.

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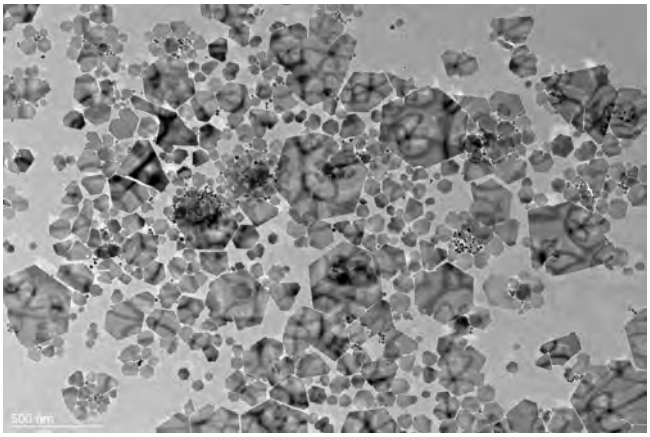

Figure 4: Thin platelets of hydrothermally synthesized barium ferrite.
Dept. of Materials Synthesis: D. Lisjak (material: S. Ovtar)

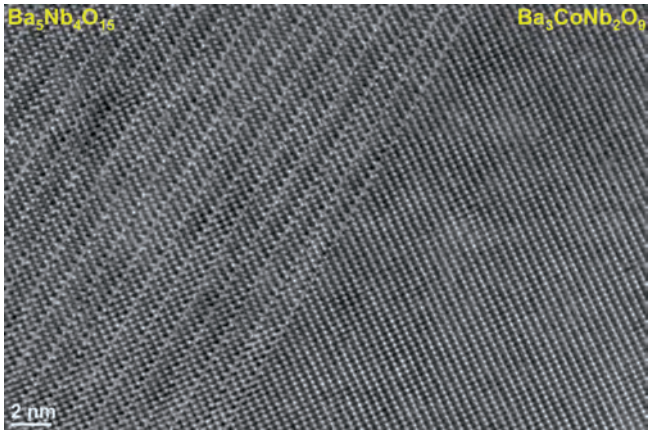

Figure 5: Coherent intergrowth of hexagonal perovskite with ordered cation vacancies $Ba_5Nb_4O_{15}$ and cubic perovskite with ordered B-site cations $Ba_3CoNb_2O_9$.
Dept. of Advanced Materials: B. Jančar

CENTRE FOR KNOWLEDGE TRANSFER IN INFORMATION TECHNOLOGIES CT-3

The Centre for Knowledge Transfer in Information Technologies performs educational, promotional and infrastructural activities and provides the direct exchange of information and experience between researchers and the users of their research results.

Head:
Mitja Jermol, M. Sc.

By partnering and active engagement in different European research projects the centre successfully extends its activities to research and development. Most of the research is performed in the area of knowledge management for traditional and emerging forms of organizations, like networked and virtual organizations. In 2010 the centre was active in several European projects, from FP6 NEON (**Lifecycle Support for Networked Ontologies**) and SWING (**Semantic Web Services Interoperability for Geospatial Decision Making**). And from FP7 PASCAL2 (**Pattern Analysis, Statistical Modelling and Computational Learning 2**), ACTIVE (**Enabling the Knowledge Powered Enterprise**), COIN (**COllaboration and INteroperability for networked enterprises**) and EURIDICE (**European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics**), METANET (**Multilingual Europe: a Technology Alliance**), ENVISION (**ENVIronmental Services Infrastructure with Ontologies**), GENDERA (**Gender Debate in the European Research Area**), RENDER (**Reflecting Knowledge Diversity**), ALERT (**Active support and Real-time Coordination based on Event Processing in Open Source Software Development**), PLANETDATA (**A European Network of Excellence on Large-Scale Data Management**) and e-LICO (**An e-Laboratory for Interdisciplinary Collaborative Research in Data Mining and Data-Intensive Science**).

The Centre for Knowledge Transfer includes a financial subunit, Communication and Technology Transfer (KTT). Its core business is to help transfer technology and know-how with the JSI in the economy and educational system (building conditions, links, ensuring the performance of contract research with industry, licensing and the establishment of new enterprises) and research in the field of innovation and innovation management.

The Centre is operating two web portals. The first one is http://videolectures.net/ , which is now becoming a reference portal, presnting high-quality scientific lectues; and the http://www.ist-world.org, which offers services for automatic data collection and the analysis of the European research.

The centre prepares and organizes carefully designed educational events, such as: conferences, seminars, workshops, and summer schools. They are targeted at experts who would like to apply the latest knowledge and achievements from intelligent data analysis, knowledge technologies, data mining, text mining and decision support to the areas of the network organizations, business decisions, finance, marketing, automatization and process control. A special consideration is put on the managers and decision makers who are aware of the strengths and benefits of the success of their business.

All the educational events are designed to transfer basic, additional and the latest expert knowledge to companies, research and educational organizations. In order to make the knowledge transfer efficient we are combining traditional and ICT-supported training methods. For this purpose we are operating a number of training web portals. The most popular one is http://videolectures.net/. This now offers 12,657 recorded tutorials from different scientific events and is visited daily by an average of 7500 visitors from around the world. The main purpose of the portal is to provide free and open access to high-quality video lectures presented by distinguished scholars and scientists at the most important and prominent events. For the third year we have successfully collaborated within the Videolectures.net portal with some of the top ten American universities – MIT (Massachusetts Institute of Technology), University of California - Berkeley, YALE and CMU – as well as with the European CERN and ETH from Zurich.

The centre also operates a web portal http://www.ist-world.org that offers services for automatic data collection and the analysis of European research. The user can perform several simple and complex analyses, predictions and detect trends in research. The database currently contains data on

Figure 1: Visit of young researchers (in enterprise Talum)

Figure 2: 3rd International Technology Transfer Conference

about 100,000 research organizations, 42,500 research projects and around 2 million experts from Europe. This is an exceptional web service that is being visited daily by an average of 5,000 unique visitors.

In 2010 we organized the 5th Student Competition in Computer Science, attended by 137 students from Slovenian secondary schools and three seminars for participants from industry. We have also organized three project meetings for different EU projects. In the autumn we organized the 2nd Summer School on Advanced Technologies for Knowledge Intensive Networked Organisations, attended by 34 experts. For the education and integration of domestic and foreign scientists, the Laboratory for Communication and Technology Transfer organized several seminars, workshops and round-table discussions and lectures and participated in them actively. The most important were: (a) the workshop entitled "Selling technology in the global market", (b) the Workshop on Entrepreneurship for Young Researchers, (c) the "3rd International Technology Transfer Conference", (d) a workshop about spin-offs under this conference, (e) the conference "Options and opportunities for TT", and (f) the Workshop Young Hopes. We were also invited as guest lecturers at different lectures, panel discussions, etc..: (a) PODIM 2010: "The market potential of public research and development activities in the field of science - the study of practical examples of assessment and suggestions for improvement", (b) University of Primorska, Faculty of Management, Koper (April 2010), "Transfer of knowledge and technologies: opportunities, pitfalls, path", (c) SFI 2010: Round table "Is for a successful global commercialization of intellectual property its protection is needed?" (d) roundtable "Instruments of the State for the Transfer of Knowledge", and (e) round table "Development of the supportive environment for entrepreneurs in Slovenia and Europe. "

For the third year http://videolectures.net/ collaborates with the Massachusetts Institute of Technology (MIT), YALE, the University of California - Berkeley, the University of Ljubljana, and with European Organization for Nuclear Research - CERN.

Our role in the FP7 integrated projects COIN - COllaboration and INteroperability for networked enterprises, EURIDICE - European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics, ACTIVE - Enabling the Knowledge Powered Enterprise and in one network of excellence PASCAL2 – Pattern Analysis, Statistical Modelling and Computational learning is to coordinate all the educational and dissemination activities as well as the knowledge transfer.

KTT is a financial sub-unit within CT3, established on 07/01/2009, when some of the projects were transferred from the Office of the Transfer (U9) to KTT (at CT3).

In 2010, KTT was involved in a total of 14 projects. In the 6. and 7. OP, this was ICT RTD (Technological Audit for Slovenia), Medossic 1, Medossic 2, Medossic 3, KidsINNscience, Cosmos and MaPEer. The national projects were JRO TT 2 (Technology transfer from public research organizations in the industry, TIA), KTT (Communications and Technology Transfer, MVZT), ZS (SRA) and PROINCOR TP (Technology Park LJ); internal projects at the Institute Jožef Stefan were IJS Tehnološki transfer (technology transfer), Komunikacija tehnologije (communication technology) and JSI Cyclotron.

Through research, together with many Slovenian and foreign organizations, we try to improve knowledge about the needs of the economy and work on creating innovation and development policies.

Performed research: (a) Analysis of the commercial potential of technology-transfer activities - case study with suggestions for improvement [International Conference PODIM10], (b) Study of the research community in the field of information and communication technologies in FP6/FP7 [projectICT Audit] (c) The study of eco-technologies and eco-innovation [Project Medossic 2 and 3], (d) The methodology for assessing the effectiveness of technology transfer [project JRO TT 2, CERN TT], (e) The assessment of the innovation environment in Slovenia [for the Working Group MHEST].

Figure 3: Founding of the Association of Professionals for Technology Transfer Slovenia

We maintain an online entry point with a set of IJS skills to communicate with the economy and the public, http://tehnologije.ijs.si. We have obtained funding for patent applications in Slovenia and the PCT applications, which allows assessments of the commercialization and search strategies for the commercialization of intellectual property, in cooperation with the industrial property. We participated in five cases of the establishment of new JSI enterprises and in more than 10 advisory sessions on patent applications. In 2010 they were four patent applications, four granted patents, one patent application abroad and a granted patent abroad.

To assist in the commercialization of R&D results, the inventors, researchers and entrepreneurs from Slovenia are turning to us - in 2010 we helped at least three of them to carry out contract research. To increase the active cooperation between researchers and industry we have participated in the writing of more interdisciplinary projects, innovation vouchers (JAPTI) and helped several sections at the JSI in the preparation and submission of EU projects.

Together with the section F2, coordination meetings for the project proposal Cyclotron JSI were carried out with representatives of the Department of Nuclear Medicine from the University Medical Centre Ljubljana.

In one year, a total of 350 presentations of the JSI sections were made. Due to the great interest to participate at the traditional "JSI Open doors" in March, we have turned the Open day into a "Week of open doors". In this week, 200 visitors were at the Reactor Center and 500 at the Institute on Jamova road. Altogether, in 2010 the Institute was visited by around 2000 visitors: companies / institutions (15) have met with researchers through workshops and/or laboratory visits at the JSI, we were visited by schoolchildren, students (40 kindergarten, elementary and secondary schools and colleges), teachers in secondary schools (around 50), foreign researchers and the various delegations and visits from various public services (for example, the Japanese Office for Metrology, NASA, LakesideLabs, TRC Carinthia, etc..).

Figure 4: 5th Student competition in computer science

We also perform the editing and production of our information center for journalists, the online newsletter IJSplet, which at least five times annually is received by more than 140 journalists. We have been active as foreign reviewers of the Austrian Ministry of Science on the new scientific program "Sparkling Science" and as reviewers for JAPTI projects.

In 2010, on the basis of 2009, we established an informal association, the Association of Professionals for Technology Transfer Slovenia (SI-TT). The president of SI-TT is Dr. Špela Stres.

KTT works in the field of technology and knowledge transfer with the JSI in the economy and education system. Innovation, innovation management and concrete technological solutions are also the subject of our research work in collaboration with CERN, MIT, KU Leuven, EPFL, ASTP, YEAR and others.

Some outstanding publications in the past three years

1. Michael J. Witbrock, Marko Grobelnik, Mitja Jermol, Jaro Berce, Peter Papler, Vlado Dimovski. An integrated analytical environment for irregular warfare using advanced semantic, knowledge and context technologies. V: RTO-MP-SAS-071 Analytical Tools for Irregular Warfare. [S. l.]: NATO Research and Technology Organisation, 2009-, 20 str. http://www.rto.nato.int/Pubs/RDP.asp?RDP=RTO-MP-SAS-071
2. Jaro Berce, Darko Štamfelj, Vlado Dimovski, Sandra Penger, Judita Peterlin, Marko Grobelnik, Mitja Jermol, Dunja Mladenić. "Razvoj sistema upravljanja z znanji v Slovenski vojski" : poročilo. Ljubljana: Univerza v Ljubljani, Fakulteta za družbene vede, Center za metodologijo in informatiko: Institut "Jožef Stefan": Univerza v Ljubljani, Ekonomska fakulteta, 2009. 105 f., ilustr.
3. Špela Stres. Public R&D in natural sciences as a market potential : an study of examples with assessment of situation and practical proposals for solutions. V: REBERNIK, Miroslav (ur.), BRADAČ, Barbara (ur.), RUS, Matej (ur.). Selling innovative ideas : proceedings of the 30th Conference on Entrepreneurship and Innovation Maribor - PODIM, Maribor, 14th-15th April 2010.
4. Špela Stres. Innovative practices in science education - are they transferrable?. V: Borut Lazar (ur.), Slavko Dolinšek (ur.), Terry J. Lyons (ur.). XIV. IOSTE Symposium, June 13.-18. 2010, Bled, Slovenia. Socio-cultural and human values in science and technology education : conference program. Ljubljana: Institute for Innovation and Development of University, 2010, str. 10.
5. Špela Stres, Primož Kunaver, Alenka Pahor Žvanut. Existing situation analysis In MEDOSSIC regions, (MEDOSSIC, 1G-MED08-298). [S. l.: s. n.], 2010. 94 str., ilustr.

Organization of conferences, congress and meetings

1. 5th Student competition in computer science, Ljubljana, 27.3.2010
2. Summer School on Advanced Technologies for Knowledge Intensive Networked Organisations, Aachen, Germany, 18.10.–22.10.2010
3. Project meeting of the EU project ACTIVE, Ljubljana, 12.4.–16.4.2010
4. Project meeting of the EU project GENDERA, Bled, 22.11.–23.11.2010
5. Technical meeting of the EU project ENVISION, Portorož, 6.7.–7.7.2010

6. Technology transfer Conference, Ljubljana, 7.10.2010
7. Seminar “Modelling and simulation of control systems«, Ljubljana, 1.2.-5.2.2010
8. Seminar “Industrial regulation systems”, Ljubljana, 12.4.-16.4.2010
9. Seminar “Advanced control methods”, Ljubljana, 7.6.-11.6.2010
10. Workshop “Technology in the global marketplace”, 01/21/2010 - Ljubljana, IJS
11. Workshop on entrepreneurship for Young researchers “Intellectual Property, Patent care and academic entrepreneurship “, 03/12/2010 - Ljubljana. IJS
12. Conference on “Options and Opportunities for the TT”, 05/07/2010 - Ljubljana, GZS
13. A visit to the departments of electronics of JSI of Telekom, 02/06/2010 - Ljubljana, IJS
14. Workshop “Young hopes”, 08/06/2010 - Ljubljana, IJS
15. Workshop IJS - Telekom, October 2010 - Ljubljana, Telekom
16. 3rd International conference on technology transfer, 7 and 08.10.2010, Ljubljana, IJS and Maribor, University of Maribor
17. A short workshop IJS - Institut for pulp and paper, November 2010, Institut for pulp and paper
18. Visit of young researchers in ETI and Talum 22.12.2010 - ETI and Talum

INTERNATIONAL PROJECTS

1. Active Support and Real-time Coordination based on Event Processing in Open Source Software Development
   ALERT
   7. FP, 258098
   EC; Dr. Ljiljana Stojanovic, Forschungszentrum Informatik an der Universität Karlsruhe, Karlsruhe, Germany
   Mitja Jermol, M. Sc., Prof. Dunja Mladenić, Marko Grobelnik
2. PlanetData
   7. FP, 257641
   EC; Dieter Fensel, Universitaet Innsbruck, Innsbruck, Austria
   Mitja Jermol, M. Sc., Marko Grobelnik, Prof. Dunja Mladenić, Asst. Prof. Mihael Mohorčič
3. Reflecting Knowledge Diversity
   RENDER
   7. FP, 257790
   EC; Hartmut Schmeck, Karlsruhe Institute of Technology, Karlsruhe, Germany
   Mitja Jermol, M. Sc., Prof. Dunja Mladenić, Marko Grobelnik
4. Gender Debate in the European Research Area
   GENDERA
   7. FP, 244499
   EC; Dr. Dora Groo, Hungarian Science and Technology Foundation, Tudomanyos Es Technologiai Alapitvany, Budapest, Hungary
   Mitja Jermol, M. Sc., Prof. Dunja Mladenić
5. Technologies for the Multilingual European Information Society
   MetaNet
   7. FP, 249119
   EC; Dr. Stefhan Busemann, DFKI - German Research Center for Artificial Intelligence, Saarbrücken, Germany
   Mitja Jermol, M. Sc., Marko Grobelnik, Prof. Dunja Mladenić
6. Environmental Services Infrastructures with Ontologies
   ENVISION
   7. FP, 249120
   EC; Bjorn Skjellaug, Arne J. Berre, Stiftelsen Sintef, Trondheiim, Norway
   Mitja Jermol, M. Sc., Prof. Dunja Mladenić, Miha Grčar, B. Sc., Prof. Nada Lavrač
7. Cooperation of Space NCPs as a Means to Optimise Services
   COSMOS
   7. FP, 218813
   EC; Dr. Adrien Klein, Deutsches Zentrum für Luft und Raumfahrt e.v., (DLR), Köln, Germany
   Dr. Špela Stres, Dr. Boris Pukl, Prof. Spomenka Kobe
8. Innovation in Science Education - Turning Kids on to Science
   KidsINNscience
   7. FP, 244265
   EC; Nadia Prauhart, Markus Meissner, Austrian Institute of Ecology, Österreichisches Ökologie-Institut, Vienna, Austria
   Dr. Špela Stres, Tomaž Ogrin, M. Sc.
9. European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics
   EURIDICE
   7. FP, 216271
   EC; Dr. Paolo Paganelli, INSIEL - Informatica per il Sistema Degli Enti Locali s.p.a, Trieste, Italy
   Mitja Jermol, M. Sc., Marko Grobelnik, Prof. Dunja Mladenić
10. Enabling the Knowledge Powered Enterprise
    ACTIVE
    7. FP 215040
    EC; Dr. Paul Warren, British Telecommunications plc, London, Great Britain
    Mitja Jermol, M. Sc., Marko Grobelnik, Prof. Dunja Mladenić, Asst. Prof. Mihael Mohorčič
11. Pattern Analysis, Statistical Modelling and Computational Learning 2
    PASCAL 2
    7. FP, 216886
    EC; Prof. John Shawe-Taylor, University of Southampton, Southampton, Great Britain
    Mitja Jermol, M. Sc., Prof. Dunja Mladenić, Marko Grobelnik
12. Collaboration and INteroperability for networked enterprises
    COIN
    7. FP, 216256
    EC; Dr.Claudia Guglielmina, TXT e-Solutions Spa, Milano, Italy
    Mitja Jermol, M. Sc., Prof. Dunja Mladenić, Marko Grobelnik
13. Lifecycle Support for Networked Ontologies
    NEON
    6. FP, 027595
    EC; Prof. Enrico Motta, KMI, The Open University, Milton Keynes, Great Britain
    Mitja Jermol, M. Sc., Prof. Dunja Mladenić, Marko Grobelnik
14. Slovenia - RTD Technological Audit 2009/0030
    30-CE-0262075/00-96
    EC; Dr. Stephan Pascall, DG INFSO, Brussels, Belgium
    Dr. Špela Stres
15. Making Progress and Economic enhancement a Reality for SMEs
    MaPEer
    Viktor Stipta, Interactive Net Design Ltd., Miskolc, Hungary
    Dr. Špela Stres
16. Opencast Matterhorn Project
    00006855, Amendment no. 1, 00007260University of California, Berkeley, CA, USA
    Mitja Jermol, M. Sc.

NEW CONTRACTS

1. Preparation of project identification and indexing computerized speech to multimedia content and transfer of knowledge captured in existing conceptual prototype
   VIIDEA d.o.o.
   Mitja Jermol, M. Sc.
2. Translation and subtitling 74 shows "Fruits of knowledge"
   Slovenian Research Agency (ARRS)
   Marjana Plukavec, B. Sc.
3. Financing national system of innovations
   Public Agency for Technology of the Republic of Slovenia (TIA)
   Dr. Špela Stres
4. Strategic and operative plan to support (eco)innovation in SE Slovenia Region
   Development Centre Novo mesto Ltd.
   Dr. Špela Stres

5. Co-financing tech-transfer activities of public research organizations
   Ministry of Higher Education, Science and Technology
   Dr. Špela Stres
6. Innovation revisions of PROINCOR project
   Technology Park Ljubljana
   Dr. Špela Stres

VISITORS FROM ABROAD

1. Ugo Negretto, ENICMA, Italy, 11.1.–13.1.2010
2. Paul Warren, British Telecom, GB, 12.4. – 16.4.2010
3. John Davies, British Telecom, GB, 12.4. – 16.4.2010
4. Ugo Negretto, ENICMA, Italy, 30.8.–3.9.2010
5. Ugo Negretto, ENICMA, Italy, 11.10.–13.10.2010
6. Paul Warren, British Telecom, GB, 16.2.2009
7. Nazmin Alani, Development Bank, Canada; 7. and 8.10.2010
8. Andrea Di Anselmo, Meta Group, Italy; 7. and 8.10.2010
9. Thomas Bereuter, TTO, TU Graz, Austria; 7. and 8.10.2010
10. Iva Vukelja Blazina, EMC Boston, USA; 7. and 8.10.2010
11. Karen Laigaard, ASTP observer; 7. and 8.10.2010
12. Frits H. Von Meijenfeldt, Head of Division for International Affairs, Department for Innovation, Ministry of Economic, The Netherlands; 7. and 8.10.2010
13. Jon Wulff Petersen, TTO, Denmark; 7. and 8.10.2010
14. Jarno Salonen, YEAR observer; 7. and 8.10.2010
15. Jeff Skinner, London Business School, UK; 7. and 8.10.2010
16. Franziska Maria Stocker, Stadt Graz, Abteilung fur Wirtschaft- und Tourismusentwicklung, Graz, Austria; 7. and 8.10.2010
17. Yannis Tsakiris, European Investment Fund; 7. and 8.10.2010
18. Paul Van Dun, K.U. Leuven R&D, Belgium; 7. and 8.10.2010
19. Representatives of KBB from Austria, 28.9.2010
20. Representatives of Japan office for Metrology and NASA, 28.5.2010
21. Patent agent, Stan Antolin, USA, 24.5.2010

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Note:
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1. Tina Anžič, Marjan Jenko, Tatjana Rijavec, "Vključenost Slovenije v raziskovalne projekte na področju inteligentnih tekstilij v Evropski uniji, stanje in možnosti", *Tekstilec*, vol. 53, no. 1/3, pp. 59-73, 2010.
2. Špela Stres, "Ven, stran in navzgor", *IRT 3000*, vol. 5, no. 25, pp. 18-19, 2010.

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Regular papers

1. Špela Stres, "Public R&D in natural sciences as a market potential: an study of examples with assessment of situation and practical proposals for solutions", In: *Selling innovative ideas: proceedings of the 30th Conference on Entrepreneurship and Innovation Maribor - PODIM, Maribor, 14th-15th April 2010*, Miroslav Rebernik, ed., Barbara Bradač, ed., Matej Rus, ed., Maribor, IRP Institute for Entrepreneurship Research, 2010, pp. 257-267.

Textbooks and Lecture Notes

1. Davor Orlič, Mitja Jermol, *D2.3.2. KSC ICT infrastructure*, Ljubljana, Jožef Stefan Institute, 2010.

MILAN ČOPIČ NUCLEAR TRAINING CENTRE ICJT

The mission of our centre is training in the field of nuclear technologies and radiation protection. In addition, we are actively informing the public about these technologies.

Head:
Prof. Igor Jenčič

Training in the area of nuclear technologies is our primary mission. Due to the change of generations in NPP Krško and because of plans to build the second nuclear unit, this type of training has been very intensive in recent years. The most important is the Nuclear Technology course, which is the initial training of future control-room operators. There were two courses in the calendar year 2010; the first started in the fall of 2009 and ended in the spring of 2010, and the second started in the fall of 2010 and will end in the spring of 2011. Furthermore, a course Basics of Nuclear Technology, which is intended for the non-control-room personnel of NPP and participants from other organizations, was conducted.

There were 26 **radiological protection training** courses for medical, industrial and research use of radioactive sources. Among these, there were two courses for security workers during the transport of nuclear materials.

We have conducted 7 **international courses**, 3 in collaboration with the International Atomic Energy Agency (IAEA), 4 radiochemistry courses were financed by the EU for the participants from accession countries and the lecturers were researchers from the Environmental Sciences Division (O-2).

Public information remains a very important part of our activities. Groups of visitors (mainly schoolchildren, students and various societies) were regularly attending the lectures about electricity from nuclear energy, about radioactive waste, and about fusion. They have also visited the permanent exhibition on nuclear energy. Altogether, there were 174 groups or 7529 visitors this year. Since 1993 our information centre was visited by a total of 128,221 pupils, teachers and other visitors. At the end of the year, a new edition of the fuel-pellet mockup was produced. We have continued monitoring and analyzing media reports on nuclear energy. An important part of the information activity is the Fusion Expo project which is funded by the European Fusion Development Agreement and the financing was extended for additional two years. The travelling exhibition on fusion has been set up in Barcelona and Terrasa (Spain), Torino (Italy), Biddinghuizen (Netherlands) and Brussels (Belgium).

Due to the generation change in NPP Krško the Nuclear Training Centre has conducted very intensive training in the area of nuclear technologies.

Figure 1: A picture from the Fusion Expo

Figure 2: Test on the Nuclear Technology course (TJE11)

Figure 3: My mobile phone is not radioactive

Figure 4: TRIGA Research Reactor at the exhibition

Table of training activities at Nuclear Training Centre in 2010

Date	Title	Partici-pants	Lecturers	Weeks	Participant x weeks
(16.11.2009) – 9.4.	Nuclear technology, theory	20	21	14	280
25.1. - 27.1.	Radiation protection for RP department staff - refresher course	18	5	0.4	7.2
9.2. - 11.2.	Radiation protection for RP department staff - refresher course	5	3	0.6	3.0
15.3. - 26.3.	IAEA Group Fellowship Training Programme on Research Reactors	10	11	2.0	20
22.3. - 24.3.	Radiation protection for industrial and other practices (sealed sources)	24	4	0.6	14.4
22.3. - 24.3.	Radiation protection for industrial and other practices (unsealed sources)	7	5	0.6	4.2
22.3. - 26.3.	Radiation protection for medical and veterinary workers - Nuclear medicine workers	12	9	1.0	12
30.3.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	6	5	0.2	1.2
30.3.	Radiation protection for industrial and other practices (sealed sources)	8	4	0.2	1.6
30.3.	Radiation protection for industrial and other practices (measurement of roadway density and humidity) - Refresher Course	4	4	0.2	0.8
30.3.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	14	4	0.2	2.8
30.3.	Radiation protection for industrial and other practices (radiography) - Refresher Course	2	4	0.4	0.8
1.4.	Training Extension for RP Officers	7	2	0.2	1.4
12.4. - 14.5.	Basics of nuclear technology, theory	14	10	4.0	56.0
12.4. - 23.4.	Radiation Protection for Hidria Rotomatika Workers	14	2	0.6	8.4
5.5.	Radiation protection for industrial and other practices (sealed sources)	17	4	0.2	3.4
10.5. - 21.5.	Training in radiochemistry measurements for practioners from countries eligible under the JRC Enlargement & Integration Policy	6	5	2.0	12.0
17.5. - 11.6.	Basics of nuclear technology, systems	19	9	4.0	76.0
10.6.	Training Extension for RP Officers	9	2	0.2	1.8
21.6. - 24.6.	IAEA Technical Meeting on the Use of Nuclear Facilities and Simulators as Effective Tools for Education and Preserving Knowledge	9		0.8	7.2
2.7.	Security during transport of nuclear materials - refresher course	10	6	0.2	2.0
5.7. - 7.7.	Initial training for security of transport of nuclear materials	13	11	0.6	7.8
9.7.	Radiation protection for industrial and other practices (Ministry of Defence, Occasionally Exposed Workers)	33	2	0.2	6.6
13.9. - 24.9.	Training in radiochemistry measurements for practioners from countries eligible under the JRC Enlargement & Integration policy	5	5	2.0	10.0
24.9.	Radiation protection for industrial and other practices (Ministry of Defence, Occasionally Exposed Workers)	27	3	0.2	5.4
4.10. - 6.10.	Radiation protection for industrial and other practices (unsealed sources)	2	5	0.6	1.2
4.10. - 6.10.	Radiation protection for industrial and other practices (sealed sources)	23	4	0.6	13.8
12.10.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	9	4	0.2	1.8
12.10.	Radiation protection for industrial and other practices (measurement of roadway density and humidity) - Refresher Course	2	4	0.2	0.4
12.10. - 18.10.	Radiation protection for industrial and other practices (radiography) - Refresher Course	4	4	0.4	1.6

Date	Title	Partici-pants	Lecturers	Weeks	Participant x weeks
12.10.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	8	5	0.2	1.6
14.10.	Training Extension for RP Officers	3	2	0.2	0.6
18.10. - 29.10.	Training in radiochemistry measurements for practioners from countries eligible under the JRC Enlargement & Integration policy	4	5	2.0	8,0
15.11. - 26.11.	Training in radiochemistry measurements for practioners from countries eligible under the JRC Enlargement & Integration policy	5	5	2.0	10,0
15.11.–(8.4.2011)	Nuclear technology, theory	18	21	6	108.0
19.11.	Radiation protection for Nuclear Medicine Dpt. – Refresher Course	55	6	0.2	11.0
29.11. - 10.12.	International Train the Trainers Course on the Physical Protection of Nuclear Material and Facilities	18	10	2.0	36,0
TOTAL		464	215	50.2	740

INTERNATIONAL PROJECTS

1. Permanent Fusion Exhibition at JSI Nuclear Training Centre - 6.1.1-FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Prof. Igor Jenčič
2. Fusion Expo Support Action under EFDA Workprogramme
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; Republic of Slovenia, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Melita Lenošek Kavčič, B. Sc., Sabina Markelj, B. Sc., Asst. Prof. Igor Lengar, Asst. Prof. Saša Novak Krmpotič, Štefan Kolenko
3. IAEA Group Fellowship Training Programme on Research Reactors
   IAEERRI10
   Dr. Luka Snoj, Jožef Stefan Institute, F-8, Ljubljana, Slovenia
   Melita Lenošek Kavčič, B. Sc.
4. IAEA Technical Meeting on the Use of Nuclear Facilities and Simulators as Effective Tools for Education and Preserving Knowledge
   IASIMUL10
   Andrey Pryakhin, IAEA, Vienna, Austria
   Tomaž Skobe, B. Sc.
5. International Train the Trainers Course on the Physical Protection of Nuclear Material and Facilities
   IAPP10
   Vladimir Kryuchenkov, IAEA, Vienna, Austria
   Melita Lenošek Kavčič, B. Sc.
6. Production of Plasma Ball Support Structure, Appropriate for Transport
   SI2.
   O. Quintana Trias, European Commission, DG RTD J.1; CDMA, Brussels, Belgium
   Melita Lenošek Kavčič, B. Sc.

NEW CONTRACTS

1. Operation of the Nuclear Information Centre in 2010
   Agency for Radwaste Management
   Prof. Igor Jenčič
2. Inplementation of 2010 Training Program for Krško NPP
   Krško Nuclear Power Plant
   Prof. Igor Jenčič
3. Organization and implementation of two international workshops for foreign and national participants in the framework of IAEA 2010 Technical Cooperation Program
   Ministry of the Environment and Spatial Planning
   Prof. Igor Jenčič

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1. Bruno Cvikl, Matjaž Koželj, "On the violation of the Frenkel enhanced space charge limited current effect for Alq[sub]3 organic semiconductor", In: *Proceedings*, Denis Đonlagić, ed., Iztok Šorli, ed., Polona Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2010, pp. 107-111, 2010.
2. Radko Istenič, Igor Jenčič, "Public opinion about nuclear energy - year 2010 poll", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2010, Portorož, Slovenia, September 6-9, 2010, Andrej Trkov, ed., Igor Lengar, ed., Ljubljana, Nuclear Society of Slovenia, 2010, 4 pp.
3. Igor Jenčič, "Tangible results of Nuclear information centre in Slovenia", In: *Conference proceedings*, 8th International Conference on Nuclear Options in Countries with Small and Medium Electricity Grids, May 16-20, 2010, Dubrovnik, Dubrovnik, 2010, 7 pp.
4. Igor Jenčič, "Tangible results of Nuclear Information Centre Ljubljana", In: *Final proceedings*, WM2010, Improving the future by dealing with the past, March 7-11, 2010, Phoenix, Arizona, Phoenix, 2010, 8 pp.
5. Matjaž Koželj, "A brief history of Krško NPP radiation impact on environment", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2010, Portorož, Slovenia, September 6-9, 2010, Andrej Trkov, ed., Igor Lengar, ed., Ljubljana, Nuclear Society of Slovenia, 2010, 4 pp.

Textbooks and Lecture Notes

1. Igor Jenčič, *Osnove jedrske fizike*, Ljubljana, Izobraževalni center za jedrsko tehnologijo Milana Čopiča, 2010.
2. Igor Jenčič, Matjaž Koželj, *Osnove varstva pred sevanji*, Ljubljana, Izobraževalni center za jedrsko tehnologijo Milana Čopiča, 2010.

RADIATION PROTECTION UNIT SVPIS

The SVPIS has been involved in ionizing-radiation measurements and radiation protection since the commissioning of the TRIGA MARK II Reactor in 1966. The responsibility of SVPIS is the radiation control of all the activities at the Institute dealing with ionizing radiation. Our main task is the supervision of Reactor and the 17 laboratories that use sources of radiation in their research work. More than a hundred different sources are used, such as sealed sources, open sources, X-ray units and the accelerator TANDETRON, all of which need regulatory control.

The SVPIS is qualified to perform control in medical, industrial and research institutions dealing with open and sealed sources. In industry and research we are qualified to control X-ray units. Furthermore, we are involved in radioactive waste characterization.

The measurements of the dose rate and contamination are performed with an accredited method (EN ISO/IEC 17025). In this year we started the accreditation process for laboratory and field gamma spectroscopy.

Head:
Matjaž Stepišnik, M. Sc.

Personal dosimetry

Personal doses of 117 workers that regularly or occasionally deal with ionizing radiation were monitored with Thermo Luminescent Dosimeters (TLDs). The maximum individual yearly dose was 0.09 mSv. This is only 0.5 % of the regulatory limit for occupational workers (20 mSv per year) and 9 % of the limit for the general public (1 mSv per year). The collective dose at JSI in the year 2010 was 0.46 man mSv.

Supervision of reactor and laboratories

The controlled area of the Reactor, the Hot Cell Facility and the Department of Environmental Sciences, was monitored on a weekly basis. During some activities the constant presence of a radiation-protection worker was needed (i.e., for the opening of activated samples or radioactive-waste management).

On 17 October 2010 we had a small fire at the Hot Cell Facility. The fire was extinguished by the JSI staff. The investigation showed that most probably an electrical malfunction of the equipment used for drying radioactive waste was the cause of the fire. A local contamination was present in the facility. However, the room was successfully decontaminated. Measurements on the ventilation system and environmental measurements have proven that there were no discharges to the environment.

In 2010 we performed 23 inspections in other JSI laboratories. At present, 105 sources of radiation are used, which require regulatory control. Additionally, 361 low-activity sources are also used in different laboratories.

Measurements of dose rate, surface contamination (Figure 1), contamination of different objects and personal contamination were performed routinely. In most cases, no or very low contamination levels could be measured in the controlled areas. Gamma spectrometry was used to monitor the solid, liquid, aerosol, and gas samples as well as the radioactive waste.

Figure 1: Surface contamination measurements

Environmental measurements

Environmental monitoring of the Reactor Center was performed by measurements of external radiation levels, measurements of environmental samples and effluent measurements (gas discharges from the reactor operation and liquid discharges in the Sava River).

With environmental TLDs the radiation levels in the surroundings of the reactor and all the buildings on the site were monitored. Outside the controlled area only normal, natural background radiation levels could be measured.

Based on the effluent measurements and a conservative, environmental transfer model the effective dose to the reference group in the public was estimated to be less than one micro-Sievert per year. The public exposure in 2010 due to activities at the Reactor Center was insignificant.

Service for outside customers

The Radiation Protection Unit is qualified for supervision measurements and expert assessments in the field of radiation protection. In the past year 14 radiological control investigations were carried out in industrial, medical and research institutions. Our group has participated in

Figure 2: Radiological measurements during the transport of spent fuel.

the evaluation of radiological monitoring of Krško NPP, research reactor TRIGA and storage for low- and intermediate-level waste in Brinje.

In the scope of international projects we also collaborated in the organization and transport of spent fuel from the research reactor RA Vinča (Figure 2).

NEW CONTRACT

1. Radiation protection during the transport of spent fuel
   TRANSING d.o.o.
   Matjaž Stepišnik, M. Sc.

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Original Articles

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2. Matjaž Stepišnik, "Reka Sava", In: *Ovrednotenje rezultatov meritev radioaktivnosti v okolici Nuklearne elektrarne Krško: (poročilo za leto 2009)*, Benjamin Zorko, ed., Denis Glavič-Cindro, ed., 1. izd., Ljubljana, Institut Jožef Stefan, 2010, pp. 13-144-28-144.

TECHNOLOGY TRANSFER OFFICE U-9

The Technology Transfer Office's activities are focused on:

- ***increasing the number of applied-development projects at the Institute,***
- ***ensuring the best environment for the development and work for technologically demanding and entrepreneurial projects,***
- ***searching for and performing new ways of technology and knowledge transfer from the Institute to the business environment.***

The activities in 2010 were implemented through the following projects:

- ***Participation in the Enterprise Europe Network Project,***
- ***Work within the project SLO-INNO-BOOST,***
- ***Work within the project Act Clean,***
- ***Involvement in the UN (United Nations) and NATO (North Atlantic Treaty Organization) activities related to the legacy of U extraction and its impact on the environment in Central Asia,***
- ***Collaboration with the International Postgraduate School Jožef Stefan.***

Head:
Prof. Peter Stegnar

Enterprise Europe Network and Slo-Inno-Boost

Within the Enterprise Europe Network project, we supported research organisations, as well as enterprises, professional and sectorial associations, technological centres and all others to make the best use of the opportunities in the European Union. The Enterprise Europe Network was established at the beginning of 2008 by the European Commission, General Directorate for Enterprise and Industry. The biggest entrepreneurial support network is now active in over 40 countries. Six Slovenian partners, co-ordinated by our office, offer assistance in three areas: a) assistance in internationalisation activities, b) assistance in innovation, technology and knowledge transfer and c) assistance in applying for EU projects. The Technology Transfer Office was within this project assisting researchers and entrepreneurs mostly by establishing national and international contacts that led to discussions about concrete technology & development co-operation and with establishing partnerships for applications on EU calls. We visited over 60 researchers and entrepreneurs, answered over 100 individual questions about open calls, financing possibilities, possible development partnerships, etc. We identified and promoted through the network 18 Slovenian innovations. Based on these and other activities, 6 international agreements on research-technological co-operation were reached. Under Slo-Inno-Boost project the Enterprise Europe Network was established and created better connections with regional and local innovation actors in Slovenia. Good relationships between the network and these actors can be very beneficial for the successful help that we both give to Slovenian enterprises, researchers and others when including them in European partnerships.

- **We have organised an International Industry Workshop on Energy Efficiency in Buildings.**
- **At IFAT in Munich, we co-organised with a German partner the Ministry for Environment UBA a presentation of Slovenian technology offer and Professor Kunaver from the National Institute of Chemistry presented the technology of liquefied wood.**

Act Clean

EU directives and regulatives require enterprises to comply with environmental standards and ensure eco-efficient production processes. As a response, Central European countries have substantially increased their capacity in the field of environmental technologies and management systems in recent years. Still the problem remains that this capacity is not sufficiently applied throughout the area. On one site, many SMEs still struggle or even fail to respond to EU requirements, as they do not have access to the existing technological or managerial solutions developed in other parts of the region. On the other hand, those SMEs that offer eco-efficient technologies and management tools often have no access to the markets where demand for their products exists. To overcome this mismatch, Act Clean creates the first Central Europe-wide network for cleaner production. Act Clean connects

Figure 1: Co-organisation of individual meetings at the International technology matchmaking during the 5th Slovenian forum of innovation, December 2010

Figure 2: Act Clean international workshop on Energy Sustainable Construction, Ljubljana, 20.5.2010, CCIS

outstanding national institutions in the field of cleaner production from all over the region.

Project partners are: Federal Environmental Agency from Germany – lead partner, Cleaner Production Center Austria Ltd., Enviros – from Czech Republic, Hungarian Cleaner Production Centre/Corvinus University of Budapest, Jozef Stefan Institute (JSI) from Slovenia, Italian National Agency for New Technologies, Energy and Environment, Central Mining Institute Poland and Slovak Cleaner Production Centre/PROVENTUS.

In 2010 we have continued to work on the country report on technological needs of Slovenian SMEs and we have also prepared the report that combines the technological needs with the normative environment. This report will be milestone for a combined report. We have checked results on two workshops, one in May in Bologna and one in November in Prague. In Bologna, there was for first time present also an advisory board. From Slovenian side there was Janja Leban from the Chamber of Commerce of Slovenia.

United Nations and NATO

Within the framework of the NATO SfP (Science for Peace) programme, the project on Uranium Legacy and Environmental Security in the Central Asian countries of Kazakhstan, Kyrgyzstan, Uzbekistan and Tajikistan is in the final stage. A comprehensive final report is being prepared and is mainly dealing with the assessment of radiological situations in the areas, where extensive mining and the processing of uranium ore might have an impact on the environment and human health. The institutions participating in the project received analytical equipment for radioactivity measurements, and appropriate training of their scientists in the field missions and specialized training courses. The results obtained showed that ionizing radiation is low and no impact on the environment and human health has been observed. However, some specific situations have been found, where local resident populations might be exposed to elevated levels of ionizing radiation due to several reasons. In such cases, effective countermeasures are to be applied in order to minimize elevated exposure to ionizing radiation associated with the threat of physical danger in tectonically sensitive areas, where earthquakes, landslides and floods represent a higher risk than radioactivity.

Jožef Stefan International Postgraduate School

A doctoral thesis on Radon in Some Rural Areas of Western Balkans has been completed by Zora Žunić from the Institute of Nuclear Sciences Vinča, Belgrade, under the mentorship of the head of the office. A comparison of radon concentrations was made in the indoor and outdoor environment in the radon prone areas. Various analytical methods were applied for the retrospective determination of radon and consequently doses of ionizing radiation. A similar doctoral disseration was completed in Kosovo, in which Meleq Bahijari from the University of Pristina carried out comprehensive measurements of radon in schools, underground caves and in a lead mine in Trebča, where elevated concentrations of radon were detected. Both doctorates drew the attention of the international scientific community, the quality of doctoral theses were confirmed by numeorus publications in the peer-reviewed journals.

Organization of conferences, congress and meetings

1. Protection of Rights of Intellectual Property on FP7, Ljubljana, 16. 2. 2010
2. Energy Efficiency in Buildings, Transnational Industry Workshop, Ljubljana, 20. 5. 2010
3. International Technology Matchmaking and Technology Contact during the 5th Slovenian Forum of Innovation, Ljubljana, 2. 12. 2010 – 3. 12. 2010

INTERNATIONAL PROJECTS

1. Slovenian Innovation Boost
   SLO-INNO-BOOST
   CIP - Competitiveness and Innovation
   EEN/SPA/09/INO/257213
   European Commission, Executive Agency for Competitiveness and Innovation (EAIC), CIP Network Project Management Unit, Brussels, Belgium
   Marjeta Trobec, Spec. for International Affairs
2. EIC&IRC Services in Support of Business and Innovation
   EACI-EIC&IRC Slovenia 1
   CIP - Competitiveness and Innovation - Konkurenčnost in inovacije
   European Commission, Executive Agency for Competitiveness and Innovation (EAIC), CIP Network Project Management Unit, Brussels, Belgium
   Marjeta Trobec, Spec. for International Affairs
3. Access to Technology and Know-how in Cleaner Production in Central Europe
   ACT CLEAN
   Central Europe Programme
   EC; Jakob Gross, Horst Pohle, Federal Environment Agency, Dessau-Roßlau, Germany
   Andrej Gyergyek, B. Sc., Asst. Prof. Sonja Lojen, Dr. Andrej Stergaršek
4. Uranium Extraction and Environmental Security in the Central Asian Republics
   NATO SfP - Uranium Extraction Legacy
   ESP.EAP.SFPP 981742
   NATO Public Diplomacy Division, North Atlantic Treaty Organisation, Brussels, Belgium
   Prof. Peter Stegnar
5. Study Visits - Slovenian Groups Visiting Norway, Island and Lichtenstein
   NFM-NFM-94/09, SI-549/2010
   CMEPIUS, Ljubljana, Slovenia
   Marjeta Trobec, Spec. for International Affairs

MENTORING

Ph. D. Thesis

1. Zora S. Žunić, *Identification and assessment of high radon areas in some rural regions on the Balkans* (mentor James P. McLaughlin; co-mentor Peter Stegnar)

VISITORS FROM ABROAD

1. Prof. Nikolay Kovalev, Sevastopol National University of Nuclear Energy and Industry, Sevastopol, Ukraine, Viktor Palyvoda, Vitava d.o.o., Škofja Loka and Mr. Ivan Sodnik, Valter d.o.o., Radomlje, 11. 1. 2010
2. Nikola Tanevski, Agency for Promotion of Entrepreneurship of the Republic of Macedonia, Skopje, Macedonia and Mile Shoshevski, Foundation MIR (Management and Industrial Research), Skopje, Macedonia, 25. 2. 2010
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4. Dr. Štefan Vrátny, Roman Linczényi, BIC, Bratislava, Slovakia, 10. 3. 2010
5. Dr. Claudia Morsut, International Research Institute of Stavanger (IRIS), Stavanger, Norway, 7. 12. 2010

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PUBLISHED CONFERENCE PAPERS

Invited Paper

1. Radojko Jaćimović, Andrej Trkov, Peter Stegnar, "Temporal variation of the neutron flux in the carousel facility of the TRIGA Mark II reactor for diffrernt core set up", In: Book of abstracts, Fourth International Symposium on Nuclear Analytical Chemistry (NAC-IV), November 15-19, 2010, Mumbai, Mumbai, Department of Atomic Energy India, 2010, pp. 93-95.