

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, multiferroics and conductive oxides. The emphasis is on the creation of the properties by the synthesis and structure on the nano-, micro- and macro-levels. The group also works on the principles of basic technologies of ceramic pressure sensors, ceramic MEMS and flexible electronics.

Activities in 2015

In the framework of lead-free piezoelectric materials we were particularly interested in alkali-niobate-based ceramics, which are considered as candidates for the replacement of lead-based perovskites in piezoelectric applications. The equilibrium vapour pressures of sodium and potassium over a $K_xNa_{1-x}NbO_3$ solid solution within its whole compositional range at temperatures between 1173 K and 1303 K were determined by Knudsen Effusion Mass Spectrometry in collaboration Eötvös Loránd University, Hungary. The equilibrium vapour pressure of potassium over $K_{0.5}Na_{0.5}NbO_3$ (KNN) is a few times larger than that of sodium, i.e., $8 \cdot 10^{-3}$ Pa as compared to $3 \cdot 10^{-3}$ Pa at 1263 K. The comparison of the obtained results with the well-established lead-based piezoelectric systems revealed that the vapour pressure of alkalis over the respective niobates at 1200 K is almost three orders of magnitude lower than the values reported for lead oxide over $Pb(Zr,Ti)O_3$.

Within the activities on lead-based piezoelectric ceramics, in the frame of the 7th OP EU CERAMPOL project, and in collaboration with our research partner HIPOT-RR, we modelled and fabricated a vibrating system for waste-water purification applications. The vibrating system consisted of electrical wiring and a protective layer that was screen printed on a porous ceramic substrate (20 cm × 20 cm) and a piezoelectric $Pb(Zr,Ti)O_3$ actuator. The tests performed by the project partners showed that the efficiency of water purification achieved with the vibrating system is higher than in conventional systems.

With co-workers from Austria, France, USA, the National Institute of Chemistry, Ljubljana and the Department for Condensed Matter Physics, JSI, we demonstrated the important effect of processing on the B-site ordering in $Pb(Sc_{0.5}Nb_{0.5})O_3$ ceramics. In contrast to previous observations on the ceramics prepared from solid-state synthesised powders, which show a distinctive B-site cation ordering when annealed below 1200 °C, we do not observe such ordering in the mechanochemically derived ceramics, regardless of the conditions of thermal post-annealing. (Figure 1)

Studies on multiferroic bismuth ferrite ($BiFeO_3$) were focused on the complex relationship between the local properties, such as the electrical conductivity at the domain walls and grain boundaries, and the macroscopic electromechanical response. Through a combination of local and macroscopic measurements of the electrical and electromechanical properties we showed evidence of a nonlinear piezoelectric Maxwell-Wagner effect as a new mechanism for explaining the relationship between the local domain-wall conductivity and the macroscopic piezoelectricity in $BiFeO_3$. (Figure 2). In-situ high-energy X-ray diffraction studies revealed a strong post-poling relaxation of the switched non-180° domain walls in $BiFeO_3$ where the conductive nature of the domain walls most probably plays a role. We reported on the development of an efficient and reproducible synthesis technique based on the mechanochemical activation of rare-earth (RE=Sm, Gd, Dy) modified $BiFeO_3$ (RE-BFO) ceramics, and explained the mechanisms involved in the improvement of the perovskite phase formation in RE-BFO relative to the unmodified $BiFeO_3$.

In collaboration with the Condensed Matter Physics Department, JSI, we continued our research on the electrocaloric (EC) effect, i.e., the adiabatic and reversible temperature change that occurs in a polar material upon the



Head:

Prof. Barbara Malič

We published a paper “Mobile Domain Walls as a Bridge between Nanoscale Conductivity and Macroscopic Electromechanical Response” in the journal Advanced Functional Materials in collaboration with the Swiss Federal Institute of Technology. Our results link the local conductivity and the macroscopic piezoelectricity via the domain-wall dynamics, revealing that the domain-wall conductivity should be considered when interpreting and controlling the macroscopic electro-mechanical response of piezoelectric ceramics.

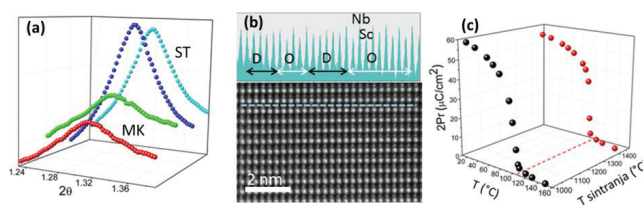


Figure 1: $Pb(Sc_{0.5}Nb_{0.5})O_3$ ceramics prepared from the mechanochemically (MA) activated powder: (a) Synchrotron X-ray diffraction pattern of superstructure peak ($\frac{1}{2} \frac{1}{2} \frac{1}{2}$). The pattern of solid-state (SS) ceramics is added for comparison. (b) HAADF-STEM image with the corresponding intensity profile of B site ions (O, D-ordered/disordered area) (c) Temperature dependence of remnant polarization of ceramics sintered at 1000 °C and 1420 °C.

application of an external electric field, in relaxor ferroelectric $0.9\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3-0.1\text{PbTiO}_3$ (PMN-10PT) bulk ceramics. We showed that a substantial enhancement of the EC effect is achieved with a properly engineered ceramic microstructure. Highly dense bulk ceramics with grain sizes in the micron range ($\approx 2\text{ }\mu\text{m}$ to $\approx 10\text{ }\mu\text{m}$)

A USA patent entitled “Amorphous multicomponent dielectric based on the mixture of high band gap and high K materials, respective devices and manufacture” was granted in 2015, and is the result of collaboration with University Nova, Lisbon, Portugal.

were prepared. The material with an $\approx 98\%$ relative density and 3.6-mm grains is characterized by a high breakdown strength exceeding 160 kV cm^{-1} , and a large EC temperature change (DT_{EC}) of 3.45°C . This value is the highest reported so far for Pb-based perovskites and is comparable to the best results obtained by multi-critical-point enhancement. Furthermore, in collaboration with the Faculty of Mechanical Engineering, University of Ljubljana, we explored the applicability of the PMN-10PT ceramics as active elements for the heat regenerator in an EC cooling device. The experimental

testing of the cooling device demonstrates the efficient heat regeneration and the establishment of the temperature span between the hot and the cold sides of the regenerator, exceeding several times the electrocaloric temperature change within a single ceramic plate.

The EC effect of a lead-free relaxor ferroelectric $0.85\text{K}_{0.5}\text{Na}_{0.5}\text{NbO}_3-0.15\text{SrTiO}_3$ (KNN-STO) ceramic was investigated. A large DT_{EC} exceeding 1.2 K at 300 K and 1.9 K at 340 K at 159 kV/cm was observed, and in a broad temperature range of $\approx 80\text{ K}$. Such a high ECE response near room temperature is comparable to that found in lead-based ceramic materials, thus making KNN-STO a strong candidate to replace lead-based materials in future EC applications.

Within the studies of environment-friendly lead-free ferroelectric thin films we demonstrated the relationship between the microstructural details of $(\text{K}_{0.5}\text{Na}_{0.5})\text{NbO}_3$ thin films, synthesized from alkoxide-based solutions, and their leakage-current behaviours. The films deposited from the 10 and 5 mol % excess potassium-acetate solutions and annealed at 750°C possessed columnar or fine-grained microstructures, respectively. The latter exhibited a current density of $2.9 \times 10^{-7}\text{ A/cm}^2$ at 50 kV/cm , whereas the value increased by two orders of magnitude in the films with the columnar grains. Using conductive atomic force microscopy we obtained direct evidence that the current starts to flow initially along the boundaries of the columnar grains, because such grain boundaries provided a direct conduction path between the electrodes. (Figure 3)

In collaboration with the Faculty of Electrical Engineering, University of Ljubljana, Experimental Particle Physics Department, JSI, and the Centre of Excellence SPACE.SI we studied solution-derived tuneable ferroelectric $\text{Ba}_{0.5}\text{Sr}_{0.5}\text{TiO}_3$ (BST) thin films for microwave applications. The films deposited on polycrystalline alumina substrates with thicknesses in the range from 90 to 400 nm were rapid thermally annealed at 900°C . The microstructures of the films were uniform and dense, consisting predominantly of columnar grains. As the thickness increased from 90 nm to 240 nm , the dielectric permittivity, measured at 100 kHz , increased from 650 to 1250, respectively. Improved dielectric properties were explained by the grain size effect together with the effect of the increased film thickness. As the film thickness increased further to 400 nm , the dielectric permittivity dropped to around 900, which was explained by the existence of nano-cracks, formed via the relaxation of the tensile biaxial stress in thin films as a consequence of the thermal expansion mismatch. The dielectric properties also exhibited similar thickness and grain-size dependences in the GHz frequency range. The influence of neutron and gamma-ray irradiation on the kilohertz- and microwave-range dielectric properties of $\text{Ba}_{0.5}\text{Sr}_{0.5}\text{TiO}_3$ thin films was also investigated. We observed that microstructural features, such as grain boundaries, pores and cracks, as well as crystal-lattice defects have an effect

on the irradiation-damage accumulation rate, and we concluded that the microstructure of the pristine films is decisive for the irradiation hardness of ferroelectric thin films used for microwave applications.

The $\text{Pb}(\text{Zr,Ti})\text{O}_3$ (PZT) thick films were processed by electrophoretic deposition (EPD). Numerical analyses predicted a non-uniform current-density distribution on the electrodes, which was higher at the edges, which was in agreement with the experiments. We found that the thickness uniformity of the deposit could be improved by extending the deposition times and reducing the conductivity of the suspensions. Homogeneous and uniform layers were prepared from ethanol-butanol-based suspensions with a conductivity of $20\text{ }\mu\text{S/cm}$ (Figure 4).

In collaboration with François-Rabelais University, Tours, France, the electromechanical properties of PZT thick films with a thickness of $20\text{ }\mu\text{m}$ and relative density of 85% were measured. The films with a thickness

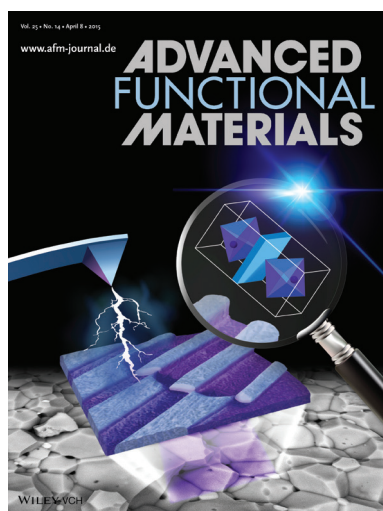


Figure 2: We published a paper entitled “Mobile domain walls as a bridge between nanoscale conductivity and macroscopic electromechanical response” in the high-impact-factor journal *Advanced Functional Materials*, (IF 11.805). The paper was accompanied with an inside front cover authored by the researchers from K-5.

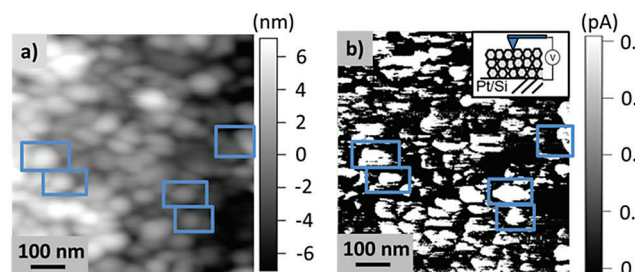


Figure 3: Direct imaging of the leakage mechanisms vs. the microstructure in the $(\text{K}_{0.5}\text{Na}_{0.5})\text{NbO}_3$ thin film via the conductive atomic force microscope (c-AFM). (a) AFM topography and (b) current image at an electric field of 190 kV/cm . For clarity, the inserted boxes highlight the individual grains on the topography and current images.

coupling coefficient of 50 % and an acoustic impedance of 15 MRa can be used for the fabrication of high-frequency ultrasound transducers for medical applications.

We studied the stability of lead zirconate titanate powder (PZT) in water at various pHs. We found that the water-soluble acetate complexes formed on the PZT surface in the acidic conditions that consequently lead to a lead-lean surface of PZT. The ceramic formed from this powder is multiphase with a porosity of 40 %. The density, dielectric and piezoelectric properties of the ceramic processed from the powders aged at pH 7 and 10 were similar to the properties of the reference ceramic, which indicates that the aqueous PZT suspensions have to be prepared at neutral or alkaline pHs.

We prepared BiFeO_3 thick films on different substrates by screen-printing and studied the influence of the annealing temperature on the densification and interface reactions. The key parameters that need to be controlled in order to obtain high-quality films in terms of phase composition and microstructure were identified and include the annealing temperature and the substrate purity. Taking into account such processing parameters, we prepared compositionally improved and highly dense BiFeO_3 thick films on Ag metal foils, which were sintered at temperatures as low as 740 °C. While the local ferroelectric behaviour of the BiFeO_3 film was confirmed by the piezo-response force microscopy analysis, the films were macroscopically still electrically conductive.

We continued investigations of LTCC (Low Temperature Co-fired Ceramics), thick-film materials and processes, used for the fabrication of three-dimensional structures for different micro-electro-mechanical systems (MEMS) and chemical microsystems. The traditional co-operation with our partners HIPOT-RR and the Centre of Excellence NAMASTE continued in the research related to thick-film and LTCC technology. In cooperation with the above mentioned research partners, we evaluated new LTCC tapes developed at the company KEKO Equipment. Several three-dimensional structures were fabricated with both commercial and new LTCC tapes, and the processes and products were benchmarked. Electrochemical sensors with an integrated microfluidic structure were fabricated on the basis of a compatibility study of different electrode and LTCC materials in the frame of the M-ERA.NET INCERSEN project.

The influence of the fraction of the glass-fibre (EGF) reinforcement, from 0 to 15 wt%, on the thermal properties of the polymer-matrix composites with the CaCO_3 mineral filler was studied in collaboration with the company DOMEL. The proper ratio of glass-fibres and mineral filler is important for obtaining good mechanical, and at the same time good thermal, properties of the composites used in the production of high-quality components in the electro industry.

In collaboration with the company ETI Elektroelement d.d. from Izlake we developed an advanced procedure for processing steatite ceramics. The procedure includes the selection of the appropriate raw materials, the milling of steatite suspensions, spray-drying, dry pressing and sintering of the products. The newly developed steatite materials have superior mechanical and electrical properties that significantly exceed the characteristics required according to the standards. For the invention "Development of new steatite material" the researchers from Jožef Stefan Institute and ETI Elektroelement, d. d., were awarded the Silver recognition by the Chamber of Commerce and Industry of Slovenia in September 2015. The researchers also developed a non-porous cordierite ceramic C410 with controlled thermal and mechanical properties and transferred the process to production. The cordierite ceramic with a low and reproducible thermal expansion coefficient combined with excellent mechanical properties was manufactured by selecting the alumina reagent with a given particle size. For this invention the researchers from the Jožef Stefan Institute and ETI Elektroelement, d. d., were awarded the **Puh recognition**.

We organised the international conference PIEZO 2015: Electroceramics for End-Users VIII (January 25-28, 2015, Maribor). The event with almost 100 participants from 19 countries, out of which one-third were from industry, included contributions on electroactive, mainly piezoelectric materials and devices.

Danjela Kuščer and Silvo Drnovšek together with collaborators from the company ETI Elektroelement d.d., Izlake, were awarded the Puh recognition for inventions, development achievements and the use of scientific discoveries in the development of cordierite ceramics with a stable low coefficient of linear thermal expansion.

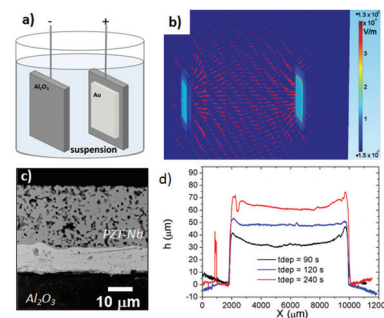


Figure 4: a) Schematic of the electrophoretic set-up. b) The electric field and the current flow between the electrodes. c) Sintered Nb-doped PZT thick film. d) Cross-sectional profiles of the deposits after different deposition times.

Some outstanding publications in the past year

1. Walker, Julian, Bryant, Peter, Kurusingal, Valsala, Sorrell, Charles C., Kuščer, Danjela, Dražić, Goran, Benčan, Andreja, Valanoor, Nagarajan, Rojac, Tadej. Synthesis-phase-composition relationship and high electric-field-induced electromechanical behavior of samarium-modified BiFeO_3 ceramics. *Acta materialia*, ISSN 1359-6454. [Print ed.], 2015, str. 149-159, doi: 10.1016/j.actamat.2014.09.058. [COBISS. SI-ID 28038439]
2. Rojac, Tadej, Uršič, Hana, Benčan, Andreja, Malič, Barbara, Damjanović, Dragan. Mobile domain walls as a bridge between nanoscale conductivity and macroscopic electromechanical response. *Advanced*

functional materials, ISSN 1616-301X, 2015, vol. 25, no. 14, str. 2099-2108, doi: 10.1002/adfm.201402963. [COBISS.SI-ID 28359975]

3. Uršič, Hana, Benčan, Andreja, Dražič, Goran, Esteves, Giovanni, Jones, Jacob L., Usher, Tedi-Marie, Rojac, Tadej, Drnovšek, Silvo, Deluca, Marco, Jouin, Jenny, Bobnar, Vid, Trefalt, Gregor, Holc, Janez, Malič, Barbara. Unusual structural-disorder stability of mechanochemically derived-Pb(Sc[sub](0.5)Nb[sub](0.5))O[sub]3. Journal of materials chemistry. C, Materials for optical and electronic devices, ISSN 2050-7526. [Print ed.], 2015, vol. 3, no. 39, str. 10309-10315, doi: 10.1039/C5TC02205C. [COBISS.SI-ID 28843815]
4. Bernardo, Mara, Malič, Barbara, Kuščer, Danjela. PZT-based thick films prepared by electrophoretic deposition from suspensions with different alcohol-based solvents. Journal of the Electrochemical Society, 2015, vol. 162, iss. 11, str. D3040-D3048, doi: 10.1149/2.0151511jes. [COBISS.SI-ID 28787751]
5. Popović, Arkadije, Bencze, László, Koruza, Jurij, Malič, Barbara. Vapour pressure and mixing thermodynamic properties of the KNbO[sub]3-NaNbO[sub]3 system. RSC advances, ISSN 2046-2069, 2015, vol. 5, no. 93, str. 76249-76256, doi: 10.1039/c5ra11874c. [COBISS.SI-ID 28837927]

Awards and Appointments

1. Tanja Pečnik: Award for the best oral presentation among young researchers at the 23rd International Conference on Materials and Technologies, Portorož: Dielectric properties of the solution-derived Ba_{0.5}Sr_{0.5}TiO₃ thin films
2. Marko Vrabelj: 2nd place at the competition of young researchers at the 23rd International Conference on Materials and Technologies, Portorož: Electrocaloric Effect in 0.9Pb(Mg_{1/3}Nb_{2/3})O₃-0.1PbTiO₃ Bulk Ceramics with Grain Sizes in Micron Range
3. Gorazd Frontini, Janez Holc, Danjela Kuščer, Irena Ramšak, Marija Raspotnik, Helena Razpotnik: Golden recognition for the innovation, Trbovlje, Chamber of Commerce and Industry of Slovenia, Regional Chamber Zasavje, Recognition for innovation: The development of the new steatite materials
4. Gorazd Frontini, Janez Holc, Danjela Kuščer, Irena Ramšak, Marija Raspotnik, Helena Razpotnik: Silver national recognition for the innovation, Brdo pri Kranju, Chamber of Commerce and Industry of Slovenia: Recognition for innovation: The development of the new steatite materials
5. Ines Bantan, Silvo Drnovšek, Danjela Kuščer, Helena Razpotnik: Puh Acknowledgement, Portorož, Republic of Slovenia, The Government of the Republic of Slovenia, Puh Acknowledgement for inventions, development achievements and use of the scientific discoveries in the development of cordierite ceramics with a stable low coefficient of linear thermal expansion

Organization of Conferences, Congresses and Meetings

1. Piezo 2015: Electroceramics for End-Users VIII, Maribor, Slovenia, January 25 – 28, 2015
2. 3rd Central and Eastern European Conference on Thermal Analysis, and Calorimetry, Ljubljana, Slovenia, August 25 – 28, 2015
3. 51th International Conference on Microelectronics, Devices and Materials with the Workshop on Terahertz and Microwave Systems – MIDEM 2015, Bled, Slovenia, September 23 – 25, 2015

Patent granted

1. 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, US8987097 (B2), US Patent Office, 24. 03. 2015.

INTERNATIONAL PROJECTS

- | | |
|--|--|
| 1. Feasibility Study and Fabrication of LTCC based PCB Multilayer
Prof. Barbara Malič
Ctr Carinthian Tech Research Ag | Prof. Barbara Malič
European Commission |
| 2. 7FP - CERAMPOL; Ceramic and Polymeric Membrane for Water Purification of Heavy Metal and Hazardous Organic Compound
Asst. Prof. Danjela Kuščer Hrovatin
European Commission | 4. Processing-properties Relationship in Lead-free (K,Na)NbO ₃ -based Piezoelectric Materials
Asst. Prof. Tadej Rojac
Slovenian Research Agency |
| 3. 7FP - PI; The Piezo Institute - European Expertise Centre for Multifunctional and Integrated Piezoelectric Devices | 5. Study on the Process and Mechanism of Novel Electronic Ceramics
Prof. Barbara Malič
Slovenian Research Agency |

6. Multiferroic Composites for Novel Applications
Asst. Prof. Andreja Benčan Golob
Slovenian Research Agency
7. Functional Heterogeneity in Complex Oxides: Chemical Clustering, Atomic Displacements, and Polar Nanoregions
Dr. Hana Uršič Nemevšek
Slovenian Research Agency
8. Towards Oxide Based Electronics
Dr. Katarina Vojisavljević
Cost Office

RESEARCH PROGRAM

1. Electronic Ceramics, Nano-, 2D and 3D Structures
Prof. Barbara Malič

R & D GRANTS AND CONTRACTS

1. Nanostructures for high-efficiency solar cells and photovoltaic
Prof. Barbara Malič
2. Tunable ferroelectric thin film capacitors for agile microwave antennas
Prof. Barbara Malič
3. High-performance piezoelectric materials for sensors and actuators in high-temperature applications
Asst. Prof. Tadej Rojac
4. New advanced electrocaloric materials for novel environmentally-friendly dielectric

- refrigeration technology
Prof. Barbara Malič
5. Micro-electromechanical and electrocaloric layer elements
Prof. Barbara Malič
6. Processing of stable aqueous suspensions for fabrication of electrotechnical elements based on steatite ceramic
Dr. Katja Makovšek
7. Integrated sensors with microfluidic features using LTCC technology
Dr. Hana Uršič Nemevšek
8. Piezoelectric MEMS for efficient energy harvesting
Prof. Barbara Malič
9. International Conference PIEZO 2015, Maribor, Slovenia, 25.-28.01.2015
Prof. Barbara Malič
10. Programme for Students and Early Stage Researchers at PIEZO 2015: Microstructure-properties Relationship in Piezoelectric Ceramics which will take Place from January 25th to January 28th, 2015
Prof. Barbara Malič

NEW CONTRACTS

1. Research of compatibility of LTCC materials and conductive pastes, with the emphasis on appropriate adhesion of the conductive material on LTCC and on simultaneous densification of both materials
Prof. Barbara Malič
Keko - Oprema d. o. o. Žužemberk
2. Research of silicate based technical ceramics
Prof. Barbara Malič
Razvojni Center Enem Novi Materiali d. o. o.

VISITORS FROM ABROAD

1. Marco Deluca, Institut für Struktur-und Funktionskeramik, Montanuniversität Leoben, Leoben, Austria, January 15 – 16, 2015
2. Dragan Damjanovic, Ceramics Laboratory, Swiss Federal Institute of Technology-EPFL, Lausanne, Switzerland, January 23 – 26, 2015
3. Jacob L. Jones, North Carolina State University, Raleigh, USA, January 25 – February 1, 2015
4. Arai Takashi, Shizuoka University, Shizuoka, Japan, March 24 – 29, 2015
5. Adis Dzunuzović, Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia, March 23 – April 3, 2015
6. Hisao Suzuki, Research Institute of Electronics, Shizuoka University, Shizuoka, Japan, April 21 – 23, 2015
7. Andrei Rotaru, National Institute for Laser, Plasma and Radiation Physics, Bucharest, Romania, May 15, 2015
8. Marko Budimir, Institute for Nuclear Technology-INETEC, Zagreb, Croatia, June 4 – 5, 2015
9. Camilla Baratto, CNR National Institute of Optics, Brescia, Italy, June 4 – 5, 2015
10. Isabella Concina, Department of Information Engineering, University of Brescia, Brescia, Italy, June 4 – 5, 2015
11. Karim-Alexandros Kantre, National Technical University of Athens, Athens, Greece, August 15 – November 15, 2015
12. K. T. Ramakrishna Reddy, Department of Physics, Sri Venkateswara University, Tirupati, India, September 29, 2015
13. Chae Il Cheon, Hoseo University, Dongnam-gu, South Korea, October 1, 2015
14. Hugo Mercier, GREMAN UMR CNRS 7347-François Rabelais, University of Tours, Tours, France, October 1 – December 31, 2015
15. Antonio Petošić, Department of Electroacoustics, Faculty of Electrical Engineering and Computing, Zagreb, Croatia, October 15, 2015
16. Marko Hrovat, Department of Electroacoustics, Faculty of Electrical Engineering and Computing, Zagreb, Croatia, October 15, 2015
17. Lisha Liu, School of Materials Science & Engineering, University of New South Wales, Sydney, Australia, October 15 – December 31, 2015
18. Luca Gregoratti, Elettra-Sincrotrone Trieste SCpA, Trieste, Italy, October 22, 2015
19. Matic Krivec, Carinthian Tech Research, Villach, Austria, November 4, 2015
20. Jochen Bardong, Carinthian Tech Research, Villach, Austria, November 4, 2015
21. Alfred Binder, Carinthian Tech Research, Villach, Austria, November 4, 2015
22. Brienne Johnson, North Carolina State University, Raleigh, USA, November 8 – 17, 2015
23. Mateo Markov, Technical College Bjelovar, Bjelovar, Croatia, November 9 – December 31, 2015
24. Nikola Ilić, Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia, November 21 – 28, 2015
25. Jelena Bobić, Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia, November 29 – December 4, 2015
26. Biljana Stojanović, Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia, November 29 – December 3, 2015
27. Jurij Koruza, Technical University Darmstadt, Darmstadt, Germany, December 18, 2015

STAFF

Researchers

1. Asst. Prof. Andreja Benčan Golob
2. Asst. Prof. Goran Dražić*
3. Asst. Prof. Danjela Kuščer Hrovatin
4. **Prof. Barbara Malič, Head**
5. Asst. Prof. Tadej Rojac
6. Dr. Hana Uršič Nemevšek

Postdoctoral associates

7. *Dr. Mara Bernardo Sacristan, left 01.04.15*
8. Dr. Raluca-Camelia Frunza
9. *Dr. Alja Kupec, left 01.04.15*
10. Dr. Kostja Makarovič*
11. *Dr. Katja Makovšek, left 01.07.15*
12. Dr. Katarina Vojisavljević
13. Dr. Julian Bradley Walker

Postgraduates

14. *Tina Bakarič, B. Sc., left 01.11.15*

15. Andraž Bradeško, B. Sc.
16. Lovro Fulanović, B. Sc.
17. Jitka Hreščak, B. Sc.
18. Evgeniya Khomyakova, B. Sc.
19. *Dr. Jernej Pavlič, left 01.02.15*
20. Tanja Pečnik, B. Sc.
21. Marko Vrabelj, B. Sc.

Technical officers

22. Darko Belavič, B. Sc.
23. Silvo Drnovšek, B. Sc.
24. Brigita Kmet, B. Sc.

Technical and administrative staff

25. Tina Ručigaj, B. Sc.

Note:

* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLE

- Andre-Pierre Abellard, Danjela Kuščer, Marc Lethiecq, Barbara Malič, Franck Levassort, "Processing and electromechanical properties of lead zirconate titanate thick films by electrophoretic deposition", *Advances in applied ceramics*, vol. 114, no. 4, pp. 198-204, 2015.
- D. O. Alikin, A. P. Turygin, Julian Walker, Tadej Rojac, Vladimir V. Shvartsman, V. Ya. Shur, Andrei L. Kholkin, "Quantitative phase separation in multiferroic $\text{Bi}_{0.88}\text{Sm}_{0.12}\text{FeO}_3$ ceramics via piezoresponse force microscopy", *J. appl. phys.*, vol. 118, no. 7, pp. 072004-1-072004-5, 2015.
- Robin Amisse, Moulay Tahar Sougrati, Lorenzo Stievano, C. Davoisne, Goran Dražić, Bojan Budič, Robert Dominko, Christian Masquelier, "Singular structural and electrochemical properties in highly defective LiFePO_4 powders", *Chem. mater.*, vol. 27, iss. 12, pp. 4261-4273, Jun. 2015.
- Tina Bakarič, Bojan Budič, Barbara Malič, Danjela Kuščer, "The influence of pH dependent ion leaching on the processing of lead-zirconate-titanate ceramics", *J. Eur. Ceram. Soc.*, vol. 35, no. 8, pp. 2295-2302, 2015.
- C. Baratto, Ramesh Kumar, G. Faglia, Katarina Vojisavljević, Barbara Malič, "p-Type copper aluminum oxide thin films for gas-sensing applications", *Sens. actuators, B, Chem.*, vol. 209, pp. 287-296, 2015.
- Darko Belavič, Andraž Bradeško, Marina Santo-Zarnik, Tadej Rojac, "Construction of a piezoelectric-based resonance ceramic pressure sensor designed for high-temperature applications", *Metrol. Syst. Pomiarowe*, vol. XXXII, no. 3, pp. 331-340, 2015.
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MENTORING

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2. Aleksander Matavž, *Inkjet printing of transparent metal oxide-based nano-capacitors*: master's thesis, Ljubljana, 2015 (mentor Barbara Malič).
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