ELECTRONIC CERAMICS DEPARTMENT

K-5

The Electronic Ceramics Department is active in research of the synthesis, properties and applications of materials for electronics and energetics, mainly complex multifunctional materials and structures that can perform multiple functions (multifunctional materials). 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.

Head:
Prof. Barbara Malič

In the framework of **lead-free piezoelectric ceramics** we studied the influence of a material's size scale on its functional properties in collaboration with Technical University Darmstadt, Germany. **Sodium niobate** ceramic samples with different grain sizes, from ~150 nm to ~50 μm, were prepared and analyzed using differential scanning calorimetry, dielectric measurements, and ^{23}Na 3QMAS nuclear magnetic resonance (NMR). A size-induced phase transition from the antiferroelectric phase into the ferroelectric polymorph was observed when the grain size decreased below 270 nm. This size-induced phase transition is attributed to the existence of intragranular stresses, induced by the decreased compensation of the ferroelastic energy during the formation of non-180° domain walls, while decreasing the grain size and the large anisotropy of the thermal expansion, and has not been observed in other ferroic systems.

The piezoelectric response of **$BiFeO_3$** ceramics at elevated temperatures, up to 260 °C, has been revealed for the first time. The distinct temperature dependence of the piezoelectric coefficient and phase was attributed to the so-called Maxwell-Wagner mechanism, arising due to the presence of electrical conductivity at the local scale. The results thus identify conductive paths along domain walls and grain boundaries as the key to controlling the temperature-dependent piezoelectric response of $BiFeO_3$ and possibly other, more complex, $BieFO_3$-based piezoceramics.

By means of combined piezoresponse force microscopy and transmission electron microscopy analyses we studied the synthesis-structure-properties relationship in **Sm_2O_3-modified $BiFeO_3$ ceramics**. The results, obtained in collaboration with Ural Federal University in Russia, revealed significant differences in the domain structure and local switching behaviour, depending on the processing method used, i.e., standard solid-state reaction versus mechano-chemical processing. Evidence of an electric-field-induced phase transition from anti-ferroelectric Pbam to ferroelectric R3c phase was provided at the local scale. The transition plays an important role in the functional properties of rare-earth-modified $BiFeO_3$ systems.

In collaboration with the Advanced Materials Department we studied the ferroelectric domain structure of $BaTiO_3$ plates prepared by molten-salt synthesis, using piezoresponse force microscopy. We found that both micrometre-sized as well as submicrometre-sized plates exhibit ferroelectric and piezoelectric properties, which opens up new possibilities for the use of such plates in the field of miniature piezoelectric sensors.

Within the activities on **lead-based piezoelectric ceramics** electric-field-induced changes in 1-xPb($Mg_{1/3}Nb_{2/3}$)O_3-x$PbTiO_3$ (PMN-xPT) ceramics were studied in order to elucidate the complex electromechanical responses in polycrystalline relaxor-ferroelectric materials. By using combined microscopy and diffraction techniques, we aimed to determine the most significant changes of the crystal and domain structures with an applied electric field in different compositions of the PMN-xPT family.

Later, we constructed the micro-cylinder pumps with piezoelectric actuators based on 0.57Pb($Sc_{1/2}Nb_{1/2}$)O_3-0.43$PbTiO_3$ in collaboration

The project entitled "Laboratory for the ultracool preparation of complex oxides", ULTRACOOL in short, was selected by the JSI Director's Council as the most promising and was granted financial support from the Director's fund for 2017. The prize winners are Hana Uršič, Mojca Otoničar and Marko Vrabelj. The financial resources are intended for the construction of a new laboratory, equipped for the preparation of complex-oxide materials at low temperatures (i.e., at or near room temperature).

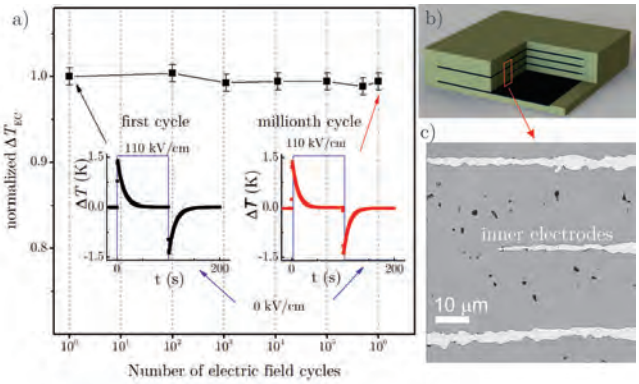

Figure 1: Stability of the electrocaloric effect in multilayer elements of lead magnesium niobate. a) Normalized values of electrocaloric temperature changes (ΔTEC) versus the number of applied electric field cycles. The first and the millionth temperature changes (ΔT) upon electric field of 110 kV/cm are presented in the insest. b) 3D model of multilayer elements c) Microstructure of multilayer element cross-section obtained on a scanning electron microscope.

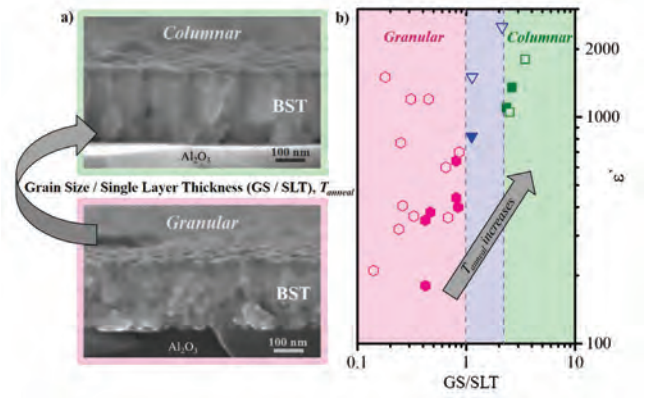

Figure 2: a) Schematic presentation of the evolution of microstructure from granular to columnar in the case of $Ba_{0.5}Sr_{0.5}TiO_3$ (BST) thin films prepared by Chemical Solution Deposition. b) Dielectric permittivity plotted as a function of GS/SLT ratio for various $Ba_xSr_{1-x}TiO_3$, x=0-1, thin films taken from the literature (open symbols) and prepared in the frame of our study (full symbols).

with the Faculty of Electrical Engineering, University of Ljubljana. This was the first time that the relaxor-ferroelectric material has been used in a piezoelectric micropump application.

The **electrocaloric (EC) effect** is defined as the adiabatic temperature change that is induced by the application or removal of an external electric field in a polar material. Cooling technology based on the EC effect has the potential for a broad range of applications, including on-chip cooling and temperature regulation, due to its high efficiency and compactness. Electric fields needed to reach EC temperature changes (DT_{EC}), suitable for applications in cooling technology, at least 2 K, are close to the dielectric breakdown strength of EC bulk ceramic materials, typically about 100 kV/cm. In order to reduce the applied voltage for a given DT_{EC}, we prepared **multilayer cooling elements** of relaxor $Pb(Mg_{1/3}Nb_{2/3})O_3$ (PMN) with internal platinum electrodes by tape-casting and lamination in collaboration with the company KEKO-Equipment, Žužemberk, Slovenia. The thicknesses of the ceramic and platinum layers were about 30 mm and 4 mm, respectively. The **EC effect's stability (EC fatigue)** for multilayer elements was studied in collaboration with Institute of Materials Science, Technische Universität Darmstadt, Germany. The multilayer elements were subjected to 10^6 unipolar cycles at an electric field amplitude of 110 kV/cm. The initially measured EC temperature change of 1.45 K decreased by only 0.01 K upon cycling, exhibiting a fatigue-less behaviour. These results justify the choice of relaxor-based multilayers as the working bodies in EC cooling devices, where the materials should withstand numerous electric field cycles with high electric field amplitudes, sometimes exceeding 100 kV/cm, and therefore, represent another step towards the application of EC ceramic materials in solid-state cooling. (Figure 1)

Further, we studied a **multicaloric effect** in polycrystalline $Pb(Fe_{1/2}Nb_{1/2})O_3$. Ceramics were prepared by the mechano-chemical activation of constituent oxides, followed by sintering at 1000 °C in an oxygen atmosphere. The maximum magnetocaloric temperature change (0.16°C at 50 kOe) was obtained at -271 °C. The pronounced electrocaloric effect was determined at room temperature (0.81 °C at 80 kV/cm), while the maximum value of the electrocaloric temperature change 1.29 °C was obtained near the paraelectric-ferroelectric phase transition (i.e., at 100 °C).

Figure 3: Cover of the Informacije MIDEM journal showing the amplitude image of local piezoelectric response in a $0.65Pb(Mg_{1/3}Nb_{2/3})O_3$–$0.35PbTiO_3$ thick film obtained by piezoresponse force microscope. Researchers from the Electronic Ceramics Department are actively involved in the publication as well as the editing of the Informacije MIDEM journal. The department co-organized the 53rd International Conference on Microelectronics, Devices and Materials with the workshop "Materials for Energy Conversion and their Applications: Electrocalorics and Thermoelectrics" MIDEM 2017, which was held at the Jožef Stefan Institute.

In the frame of the **M-ERA.NET PiezoMEMS** project we continued research of ferroelectric $K_{0.5}Na_{0.5}NbO_3$-based thin films for piezoelectric energy-harvesting applications together with partners from Poland and Romania. By optimizing the chemical composition and solution-based processing of **$K_{0.5}Na_{0.5}NbO_3$** thin films, doped with strontium and manganese, we successfully reduced the leakage current density by almost an order of magnitude, reaching $\approx 2 \cdot 10^{-8}$ A/cm^2 at the electric field amplitude 100 kV/cm.

In collaboration with Materials and Research Technology Department, Luxembourg Institute of Science and Technology, Luxembourg, we investigated the evolution of the microstructure of tunable ferroelectric **$Ba_{0.5}Sr_{0.5}TiO_3$ (BST) thin films** by Chemical Solution Deposition. The films were prepared on alumina substrates by repeated deposition-drying-pyrolysis-annealing steps at temperatures between 640 °C and 900 °C. The elements of the microstructure, i.e., grain size (GS) and shape, in relation to the thickness of individual layers (SLT), were correlated with the annealing temperature. We found that for our processing conditions the BST films annealed at 640–800 °C had granular microstructures with 10-40-nm large equiaxed grains and with GS/SLT<1. Only at temperatures 880 °C the films consisted of columnar grains with an average lateral grain size of about 90 nm and with GS/SLT>2.5. Such an evolution of the microstructure was explained in the frame of the Microstructural Zone Model for solution-derived thin films. In parallel with the observed changes in the microstructure, the kHz-range dielectric permittivity of the films increased by almost an order of magnitude, from around 180 to 1350, which showed that the model can serve as an effective guideline for designing thin films with tailored functional properties suitable, for example, in microwave-range telecommunications. (Figure 2)

In the frame of the **M-ERA.NET INTcerSEN** project we successfully prepared screen-printed $0.65Pb(Mg_{1/3}Nb_{2/3})O_3$–$0.35PbTiO_3$ **thick films** on metalized **low-temperature co-fired ceramic** (LTCC) substrates. Such substrates are interesting for micro-electro mechanical systems, for example, in piezoelectric sensors and actuators, where functional layers are usually Pb-based perovskites. Special attention was given to the influence of the Au, Ag and Ag/Pd electrode materials coated over the LTCC on the functional properties of the films. The best phase purity, dielectric and piezoelectric properties were obtained in the films on gilded substrates. The piezoelectric coefficient d33 of the films on gilded LTCC substrates was 120 pC/N. (Figure 3)

We investigated the preparation of environmentally benign **thick-film** piezoelectrics based on $K_{0.5}Na_{0.5}NbO_3$ on metalized ceramic substrates using the **electrophoretic deposition method** for applications in high-frequency

ultrasound transducers and energy harvesters. With numerical modelling we demonstrated that the most thickness-uniform deposit is obtained by applying a constant current between two electrodes with similar dimensions separated by a few mm, wheich we confirmed with experiments. After sintering at 1100 °C the 30 μm-thick films exhibited promising dielectric and electromechanical properties, the latter measured in collaboration with researchers from François-Rabelais University Tours, France. The thick films exhibited piezoelectric coefficient d_{33} up to 80 pC/N and thickness coupling factor k_t up to 35 %. (Figure 4)

We proceeded with microstructural investigations of a few μm to several tens of μm thick $BiFeO_3$ films deposited on platinized Al_2O_3. The thick-films were prepared by the **screen-printing method**.

In collaboration with colleagues from the Condensed Matter Department we investigated how the surface properties of a substrate influence the resolution and stability of **inkjet-printed** functional-oxide **nanostructures**. We found that the wetting of an organic-precursor-based ink is easily modified by adjusting the thermal treatment conditions of a few nm thick layer of a polymer deposited on a selected substrate.

As part of the research on conducting oxides for gas sensing in collaboration with University Brescia, Italy and University Guilan, Iran we prepared zinc stannate ceramic targets for RF sputtering of thin films, suitable as active layers for the sensing of ethanol, acetone and nitrogen dioxide.

LTCC (Low Temperature Co-fired Ceramics) and thick-film materials and processes have been investigated for the design and fabrication of microfluidic ceramic systems. The flow rate, the hydrodynamic resistance of the channels and the diodicity of the valves were studied depending on the shape and dimensions of elements and the type of fluidic media. Results are useful in designing various microfluidic components, devices and systems. On this basis and with the cooperation of partners (**Centre of Excellence NAMASTE, HIPOT-RR** and **KEKO Equipment**), we successfully integrated pressure and electrochemical sensors into the fluidic system without any degradation of the fluidic properties in the observed channel. (Figure 5)

In collaboration with the company **ETI Elektroelement** d.o.o., Izlake, we processed cordierite ceramics with a reproducible low thermal expansion coefficient and with excellent mechanical properties by sintering in a narrow temperature range, which was achieved by optimisation of the amount and particle size of alumina. The cordierite material, suitable for automatic, large-scale production, was patented.

Excellent in Science in the field of technology nominated by Slovenian Research Agency! The achievement "Interpretation of electric conductivity of domain walls in bismuth ferrite" ranked in the selection of Excellent in 2017. (T. Rojac, A. Benčan Golob, G. Dražić, H. Uršič Nemevšek, B. Jančar, G. Tavčar, M. Makarovič, J. Walker in B. Malič, Nat. Mater. 16, 3, 2017)

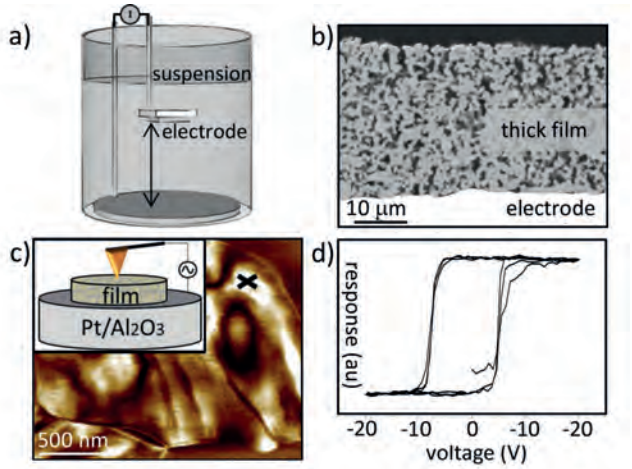

Figure 4: a) Schematic representation of electrophoretic deposition setup. (b) Microstructure of $(K_{0.5}Na_{0.5})_{0.99}Sr_{0.005}NbO_3$ thick film on Pt/Al_2O_3 obtained by electrophoretic deposition and subsequent sintering at 1100 °C. c) Amplitude image of local piezoelectric response in thick film obtained by piezoresponse force microscope. d) Local hysteresis loop obtained from a selected area on the film (marked by x in panel c).

Relaxor multilayer elements exhibited a fatigue-less electrocaloric (EC) effect even after 10^6 unipolar cycles at an electric field amplitude of 110 kV cm^{-1}, which makes them suitable candidates for the working bodies in EC cooling devices.

Some outstanding publications in the past year

1. Rojac, Tadej, Benčan, Andreja, Dražić, Goran, Sakamoto, Naonori, Uršič, Hana, Jančar, Boštjan, Tavčar, Gašper, Makarovič, Maja, Walker, Julian, Malič, Barbara, Damjanović, Dragan. Domain-wall conduction in ferroelectric $BiFeO_3$ controlled by accumulation of charged defects. Nature materials, ISSN 1476-1122, 2017, vol. 16, no. 3, str. 322-327, doi: 10.1038/nmat4799. [COBISS.SI-ID 29936679]
2. Fulanović, Lovro, Koruza, Jurij, Novak, Nikola, Weyland, Florian, Malič, Barbara, Bobnar, Vid. Fatigue-less electrocaloric effect in relaxor $Pb(Mg_{1/3}Nb_{2/3}O_3Pb(Mg_{1/3}Nb_{2/3}O_3$, *Journal of the European ceramic society*, ISSN 0955-2219. [Print ed.], 2017, vol. 37, no. 15, str. 5105-5108, doi: 10.1016/j.jeurceramsoc.2017.06.011. [COBISS.SI-ID 30569511]
3. Matavž, Aleksander, Bobnar, Vid, Malič, Barbara. Tailoring ink-substrate interactions via thin polymeric layers for high-resolution printing. *Langmuir*, ISSN 0743-7463, 2017, vol. 33, no. 43, str. 11893-11900, doi: 10.1021/acs.langmuir.7b02181. [COBISS.SI-ID 30841383]
4. Mercier, Hugo, Malič, Barbara, Uršič, Hana, Hreščak, Jitka, Levassort, Franck, Kuščer, Danjela. Electrophoretic deposition and properties of strontium-doped sodiumpotassium niobate thick films. Journal of the European ceramic society, ISSN 0955-2219., 2017, vol. 37, iss. 16, str. 5305-5313, doi: 10.1016/j.jeurceramsoc.2017.06.030.

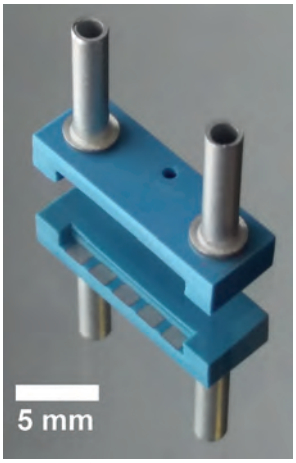

Figure 5: Fluidic channel in LTCC structure with integrated pressure sensor.

5. Rojac, Tadej, Damjanović, Dragan. Domain walls and defects in ferroelectric materials. *Japanese journal of applied physics*, ISSN 0021-4922, 2017, vol. 56, no. 10S, str. 10PA01-1-10PA01-4, doi: 10.7567/JJAP.56.10PA01. [COBISS.SI-ID 30744615]

Awards and Appointments

1. Andraž Bradeško: ranked among the best posters at the 2017 IEEE International Symposium on Applications of Ferroelectrics (ISAF), Atlanta, USA, Institute of Electrical and Electronics Engineers (IEEE)
2. Mojca Otoničar, Hana Uršič, Marko Vrabelj: JSI Director's fund for 2017, Ljubljana, JSI Director's Council, for the project entitled Laboratory for the ultracool preparation of complex oxides - ULTRACOOL

Organization of Conferences, Congresses and Meetings

1. MIDEM 2017: 53rd International Conference on Microelectronics, Devices and Materials with the Workshop on Materials for Energy Conversion and their Applications: Electrocalorics and Thermoelectrics, Ljubljana, 4–6 October 2017

Patents granted

1. Ines Bantan, Danjela Kuščer, Janez Holc, Process for manufacturing cordierite ceramics having controlled and reproducible mechanical and thermal properties, EP3115347 (B1), European Patent Office, 01. 11. 2017.
2. Barbara Malič, Hana Uršič, Marija Kosec, Silvo Drnovšek, Jena Cilenšek, Zdravko Kutnjak, Brigita Rožič, Uroš Flisar, Andrej Kitanovski, Marko Ožbolt, Uroš Plaznik, Alojz Poredoš, Urban Tomc, Jaka Tušek, Method for electrocaloric energy conversion, EP3027980 (B1), European Patent Office, 18. 10. 2017.

INTERNATIONAL PROJECTS

1. COST action TO-BE: Towards Oxide-Based Electronics
   Asst. Prof. Hana Uršič Nemevšek
   Cost Office
2. Fabrication and Modelling of Integrated Piezoelectric Structures for High-frequency Ultrasound Applications
   Asst. Prof. Danjela Kuščer Hrovatin
   Slovenian Research Agency
3. Domain Structure of Complex Oxides
   Asst. Prof. Hana Uršič Nemevšek
   Slovenian Research Agency
4. Local Structure of Relaxor Ferroelectrics - The Key to Understanding the Functional properties
   Asst. Prof. Andreja Benčan Golob
   Slovenian Research Agency
5. Piezoelectric Films for Microelectromechanical Systems Based on Environment Friendly Perovskite Materials
   Prof. Barbara Malič
   Slovenian Research Agency

RESEARCH PROGRAM

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

R & D GRANTS AND CONTRACTS

1. Photovoltaic cell and module inhomogenity analysis and performance monitoring in power plants through lifetime
   Prof. Barbara Malič
2. New advanced electrocaloric materials for novel environmentally-friendly dielectric refrigeration technology
   Prof. Barbara Malič
3. Multifunctional materials for actuator and cooling devices
   Asst. Prof. Tadej Rojac
4. Advanced electrocaloric energy conversion
   Prof. Barbara Malič
5. Microelectromechanical and electrocaloric layer elements
   Prof. Barbara Malič
6. Ferroelectric ceramic layer elements with designed domain structure for efficient energy harvesting and conversion
   Prof. Barbara Malič
7. Integrated sensors with microfluidic features using LTCC technology
   Asst. Prof. Hana Uršič Nemevšek
   Ministry of Education, Science and Sport
8. Piezoelectric MEMS for efficient energy harvesting
   Prof. Barbara Malič
   Ministry of Education, Science and Sport
9. Inkjet Printing of PZT Test Structures
   Prof. Barbara Malič
   Epcos Ohg
10. Analysis of piezoelectric elements from different producers
    Prof. Barbara Malič
11. Laboratory for the ultracool preparation of complex oxides – ULTRACOOL
    Asst. Prof. Hana Uršič Nemevšek, Dr. Mojca Otoničar

NEW CONTRACTS

1. Consulting on the development of the steatite material, analysis of raw materials and sintered samples, and on-demand consulting on the industrial production process
   Prof. Barbara Malič
   Eti d. d.
2. 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
3. Ferroelectric ceramic layer elements with planned domain structure for efficient collection and conversion of energy
   Prof. Barbara Malič
   Keko - Oprema d. o. o. Žužemberk

VISITORS FROM ABROAD

1. Agnieszka Monika Paszkowska, Maria Curie-Skłodowska University, Lublin, Poland, 24 October 2016 to 31 March 2017
2. Karolina Szymanek, Maria Curie- Skłodowska University, Lublin, Poland, 24 October 2016 to 31 March 2017
3. Hugo Mercier, University François-Rabelais of Tours, Tours, France, 5–18 February 2017; 9–22 April 2017; 18 May to 2 June 2017 and 18 September to 14 October 2017
4. Dr Gregor Trefalt, University of Geneva, Geneva, Switzerland, 16 February 2017
5. Martina Guliš, University of Zagreb, Zagreb, Croatia, 6 March to 6 June 2017

6. Prof. Dr Jacob L. Jones, North Carolina State University, Raleigh, North Carolina, USA, 7–8 March 2017
7. Stjepan Golubić, M.Sc., Bjelovar University of Applied Sciences, Bjelovar, Croatia, 20–21 March 2017
8. Zoran Vrhovski, M.Sc., Bjelovar University of Applied Sciences, Bjelovar, Croatia, 20–21 March 2017
9. Dr. Soma Dutta, Materials Science Division, National Aerospace Laboratories, Bangalore, Karnataka, India, 31 March to 24 August 2017
10. Allard Mathéo, University François-Rabelais of Tours, Tours, France, 3 April to 23 June 2017
11. Hafsa Znibrat, University François-Rabelais of Tours, Tours, France, 3 April to 23 June 2017
12. Prof. Dr Franck Levassort, University François-Rabelais of Tours, Tours, France, 17–19 May 2017
13. Prof. Dr Isabelle Laffez, University François-Rabelais of Tours, Tours, France, 17–19 May 2017
14. Dr Julian Walker, Pennsylvania State University, USA, 26–30 June 2017
15. Goran Benkek, Bjelovar University of Applied Sciences, Bjelovar, Croatia, 3 July to 8 September 2017
16. Miriam Karpińska, Wroclaw University of Science and Technology, Wroclav, Poland, 10 July 2017 to 13 October 2017
17. Izabela Rutkowska, AGH University of Science and Technology, Krakov, Poland, 10 July to 7 September 2017
18. Dr Magdalena Wencka, Institute of Molecular Physics Polish Academy of Sciences, Poznan, Poland, 16 August 2017
19. Prof. Dr Naonori Sakamoto, Research Institute of Electronics, Department of Engineering, Graduate School of Integrated Science and Technology, Shizuoka University, Shizuoka, Japan, 14–23 September 2017
20. Ivan Šimunović, Bjelovar University of Applied Sciences, Bjelovar, Croatia, 4 September to 1 December 2017
21. Asterios Mantzanis, University of Ioannina, Ioannina, Greece, 27 September to 20 December 2017
22. Dr Kerstin Schmoltner, EPCOS OHG A TDK Group Company, Deutschlandsberg, Austria, 28 September 2017
23. Dr Manfred Schweinzger, EPCOS OHG A TDK Group Company, Deutschlandsberg, Austria, 28 September 2017
24. Dr Denis Orosel, EPCOS OHG A TDK Group Company, Deutschlandsberg, Austria, 28 September 2017
25. Dr Antje Kynast, PI Ceramic GmbH, Lederhose, Germany, 4–6 October 2017
26. Dr Holger Neubert, Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden, Germany, 4–6 October 2017
27. Dr Sylvia Gebhardt, Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden, Germany, 4–6 October 2017
28. Dr Xavier Moya, Department of Materials Science & Metallurgy, University of Cambridge, Cambridge, United Kingdom, 4–6 October 2017
29. Prof. Dr Brahim Dkhil, Laboratoire Structures, Propriétés et Modélisation des Solides, Centrale Supélec, Université Paris-Saclay, Châtenay-Malabry, France, 4–6 October 2017
30. Dr Emmanuel Defay, Luxembourg Institute of Science and Technology, Luxembourg, Luxembourg, 4–6 October 2017
31. Ana Čukman, Bjelovar University of Applied Sciences, Bjelovar, Croatia, 27 November 2017 to 23 February 2018

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17. Uroš Prah, B. Sc.

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20. Brigita Kmet, B. Sc.

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22. Tina Ručigaj Korošec, B. Sc.
23. *Matejka Šmit, B. Sc., left 15.07.17*

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. M. Airimioaei, M. T. Buscaglia, I. Tredici, U. Anselmi-Tamburini, Adrian Ciomaga, L. P. Curecheriu, Andreja Benčan, Vincenzo Buscaglia, Liliana Mitoseriu, "$SrTiO_3BaTiO_3$ nanocomposites with temperature independent permittivity and linear tunability fabricated using field-assisted sintering from chemically synthesized powders", *J. mater. chem. C*, **5**, 35, 9028-9036.
2. Denis Alikin, A. P. Turygin, Julian Walker, Andreja Benčan, Barbara Malič, Tadej Rojac, Vladimir Shur, Andrei L. Kholkin, "The effect of phase assemblages, grain boundaries and domain structure on the local switching behavior of rare-earth modified bismuth ferrite ceramics", *Acta mater.*, **125**, 265-273, 2017.
3. Riccardo Arpaia, Dmitri Golubev, Reza Baghdadi, Regina Ciancio, Goran Dražić, Pasquale Orgiani, Domenico Montemurro, Thilo Bauch, Floriana Lombardi, "Transport properties of ultrathin $YBa_2Cu_3O_{7-\delta}$ nanowires: a route to single-photon detection", *Physical review. B*, **96**, 6, 064525, 1 Aug. 2017.
4. Darko Belavič, Andraž Bradeško, Tomaž Kos, Tadej Rojac, "Design and integration of a piezoelectric vibrating device in an LTCC structure", *Microelectron. int.*, **34**, 3, 121-126, 2017.
5. Blaž Belec, Goran Dražić, Sašo Gyergyek, Benjamin Podmiljšak, Tanja Goršak, Matej Komelj, Julio J. Nogués, Darko Makovec, "Novel Ba-hexaferrite structural variations stabilized on the nanoscale as building blocks for epitaxial bi-magnetic hard/soft sandwiched maghemite/hexaferrite/maghemite nanoplatelets with out-of-plane easy axis and enhanced magnetization", *Nanoscale*, **9**, 44, 17551-17560, 2017.
6. Romana Cerc Korošec, Matej Felicijan, Boštjan Žener, Matevž Pompe, Goran Dražić, Jana Padežnik Gomilšek, Boris Pihlar, Peter Bukovec, "The role of thermal analysis in optimization of electrochromic effect of nickel oxide thin films, prepared by the sol-gel method: Part 3", *Thermochim. acta*, **655**, 344-350, Sep. 2017.
7. Andrej Čampa, Marko Berginc, Katarina Vojisavljević, Barbara Malič, Peter Panjan, Marko Topič, "Optical and electrical properties of gallium doped indium tin oxide optimized for low deposition temperature applications", *Thin solid films*, **621**, 52-57, Jan. 2017.
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