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

Head:
Prof. Barbara Malič

In the framework of **lead-free piezoelectric materials** we were particularly interested in alkali-niobate-based ceramics, which are still considered as one of the most important candidates for the replacement of lead-based perovskites in piezoelectric applications. In collaboration with Keio University from Japan we developed a new synthesis method for the preparation of **fine and single-phase potassium sodium niobate ($K_{0.5}Na_{0.5}NbO_3$) powders**. The method consists of the attrition milling of fine Nb_2O_5 particles suspended in an ethanol solution of sodium and potassium acetates. We obtained a single-phase KNN powder by calcining the milled powder twice at temperatures as low as 450-650°C, which are 100-200°C lower than those typically used during the conventional solid-state synthesis of KNN.

Using optical dilatometry and a detailed microstructural analysis we studied the sintering behaviour of sodium niobate (NaNbO3) powders with particles of nanometre and submicrometre sizes. We found that the initial particle size did not affect the evolution of the microstructure upon annealing, suggesting a key role of the mechanisms responsible for the grain growth in the initial stage of the sintering. By measuring the specific surface area of the specimens, which were annealed at different temperatures, we found that the observed grain growth is due to the surface diffusion. Owing to the low activation energy (50-60 kJ/mol), in fact, this grain-growth mechanism is activated in the initial stage of the sintering and, thus, decreases the driving force for the sintering and prevents any further densification of the powder compact. $NaNbO_3$ ceramics with a relative density of 98% and an average grain size of 0.7±0.29 μm were successfully prepared by hot pressing at 1150°C. The results significantly contribute to the general understanding of the sintering of alkali-niobate-based ceramics and suggest ways to control the microstructure of this important group of lead-free piezoceramics.

As a co-author, Tadej Rojac published a review article on mechanochemical synthesis entitled "Hallmarks of mechanochemistry: from nanoparticles to technology" in the high-impact journal Chemical Society reviews, 2013, 42, 7571 (impact factor for 2012: 24.89).

Within the activities on **lead-based piezoelectric ceramics**, we focused on the solid-state synthesis and characterization of the $Pb(Zr,Ti)O_3$ (PZT) ceramics, mechanically toughened by tetragonal-stabilized zirconia (TZ) particles. In order to achieve a homogeneous distribution of TZ grains within the PZT matrix, we developed a modified solid-state synthesis procedure, consisting of pre-milling, pH adjustment and a modification of the surface of the TZ powder. According to the Voronoi-diagram analysis of the microstructures of the ceramics, the modified synthesis route provided a more homogeneous TZ distribution in the PZT matrix, as compared to the composites processed by conventional means (figure 1). The R-curve measurements, performed at the Technische Universität Darmstadt, however, did not show a measureable difference in the fracture behaviour of the two PZT-TZ composites.

Within the 7FP EU project CERAMPOL and in collaboration with the company HIPOT-RR we continued our work on the **integration of piezoelectric PZT actuators in waste-water cleaning systems**. Based on the vibration measurements of a corundum substrate with integrated piezoelectric actuators, we were able to evaluate the influence of various parameters, such as the type of the piezoelectric material and the position of the actuators, on the amplitude and frequency of the substrate vibration resonances. A numerical analysis of the different substrate/actuator structures showed trends in the vibration behaviour. A combination of the numerical analysis and the experimental verification made it possible to identify the main parameters of the vibration system, like those mentioned above, which will be further optimized within the project.

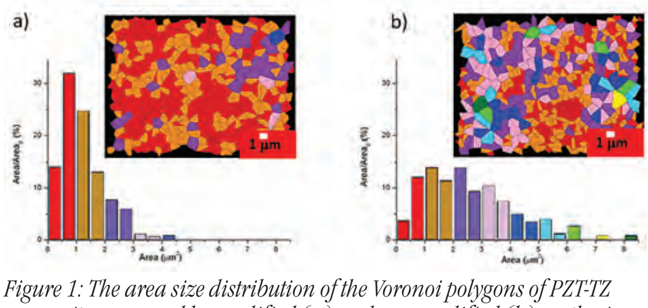

Figure 1: The area size distribution of the Voronoi polygons of PZT-TZ composites prepared by modified (a) and non-modified (b) synthesis methods. The insets show the Voronoi diagrams.

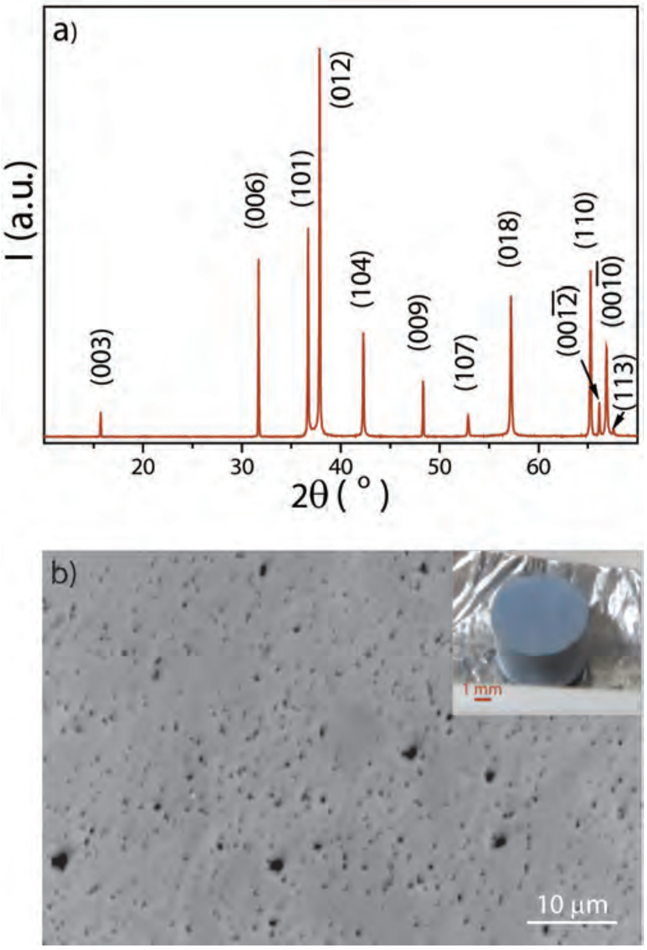

Figure 2: X-ray diffraction pattern (a) and microstructure (b) of $CuAlO_2$ ceramics, sintered at 1100°C for 2 hours in air. The inset shows a photo of the ceramic sample.

The **0.57Pb(Sc1/2Nb1/2)O3–0.43PbTiO3 (PSN-PT)** is a perovskite material that can be used in various piezoelectric applications, including sensors, actuators and ultrasound transducers. The integration of such functional materials onto substrates in the form of thin or thick films often results in thermal stresses in the film, which have their origin in the mismatch between the thermal expansion coefficient of the active layer and the substrate, and may significantly affect the functional response of the material. In order to understand and control these stresses, the linear expansion coefficient of the PSN-PT must be known, in both the unpoled and poled states. We found that the thermal expansion coefficient of PSN-PT increases from 30°C up to the Curie temperature of 260 °C, where it reaches $2.08 \cdot 10^{-6}$ K^{-1}. The phase transition was identified as an anomaly in the expansion between 260 °C and 280 °C. The coefficient of thermal expansion then increases with a further increase in the temperature, reaching $9.66 \cdot 10^{-6}$ K^{-1} at 400 °C. These data will be essential for the integration of PSN-PT in thin- or thick-film structures.

In collaboration with the Ecole Polytechnique Fédérale de Lausanne, Switzerland, we studied the **elastic properties of $Pb(Mg_{1/3}Nb_{2/3})O_3$ (PMN) ceramics**. It was shown that the PMN ceramics exhibit true anelastic relaxor behavior with the parameters of the Vogel-Fulcher equation similar to those for dielectric relaxation.

We continued our research on **multiferroic $BiFeO_3$** ceramics, focusing on the $(Bi,RE)FeO_3$ (RE=Sm, Gd, Dy) compositions, which exhibit morphotropic phase boundaries. By combining the milling of the starting powders in ethanol with the addition of polyacrilic acid and subsequent mechanochemical activation, we succeeded in preparing homogeneous powders with the sintering temperatures as low as 800°C. The powders were then used to prepare homogeneous and dense bulk ceramics. Like in the case of $BiFeO_3$, the ceramics modified by the RE oxides exhibited large electric-field induced strains, which exceeded 0.3%. The advantage of these modified ceramics over the unmodified $BiFeO_3$ is that the strain shows little dependence on the driving electric-field frequency; as compared to unmodified $BiFeO_3$, the response of RE-modified ceramics is thus more stable.

In collaboration with the Department for Condensed Matter Physics we studied the **electrocaloric (EC) response** of $0.7Pb(Mg_{1/3}Nb_{2/3})O_3$–$0.3PbTiO_3$ bulk ceramics, processed from mechanochemically activated powders. The highest temperature change of 2.7 K was observed in the vicinity of the critical point, i.e., at 430 K, and under an applied electric field of 90 kV/cm. In addition, we investigated the EC response of the environmentally friendly lead-free relaxor **$K_{0.5}Na_{0.5}NbO_3$-$SrTiO_3$ (KNN-STO)** ceramics. The results confirmed the large EC response in the vicinity of the dielectric anomaly. The EC temperature change at room temperature is comparable to that measured in lead-based ceramics.

Using the inkjet printing of water-based dispersions of submicron lead zirconate titanate (PZT) particles we prepared films with thicknesses of a few micrometres. We confirmed the local piezoelectric response of such PZT films by means of piezo-response force microscopy.

In the framework of **lead-free ferroelectric thin films** prepared by Chemical Solution Deposition, we collaborated with the Ecole Centrale Paris, France, and investigated the phase transitions of KNN thin films deposited onto (111)Pt/TiO_2/SiO_2/Si substrates. The purpose was to compare the phase-transition behaviour of the KNN films with two different microstructures, i.e., columnar and granular. Raman spectroscopy and X-ray diffraction analysis confirmed the presence of both phase transitions as observed in the KNN powder, i.e., the monoclinic-to-tetragonal (T_{M-T}) and the tetragonal-to-cubic (T_{T-C}). Whereas the T_{M-T} transition of the film with the columnar microstructure was similar to that observed in the KNN powder, the Curie temperature (T_{T-C}) was slightly lower. We attribute this lowering of the T_C to the presence of tensile stresses, which develop as a consequence of the thermal expansion coefficient mismatch between the film and the substrate.

Within the project FERROPATCH in the frame of the program JP PECS of the European Space Agency (ESA) we prepared **$Ba_{0.5}Sr_{0.5}TiO_3$ (BST) thin-film varactors** on alumina substrates. Single-phase and dense films with homogenous microstructures and thicknesses between 70 nm and 600 nm were prepared by annealing the as-deposited films at temperatures up to 900°C. The highest dielectric permittivity was measured in the 170-nm-thick sample and was 1310 at 100 kHz and 1210 at 10 GHz. In addition, we also studied the synthesis of BST nanoparticles, which were prepared via the thermal degradation of acetylacetone precursors in oleylamine under the presence of stearic acid, used as surfactant. The particles were amorphous and crystallized into the perovskite phase after annealing at 700 °C.

The work within the 7FP EU ORAMA project was concentrated on the synthesis of oxide semiconductors and dielectrics for **transparent electronics**. $CuAlO_2$, which is a p-type semiconductor, was synthesized by annealing a stoichiometric mixture of nano-boehmite (AlOOH) and Cu_2O at 1100°C in an argon atmosphere. In contrast to the conventional synthesis from a mixture of oxide powders, this synthesis method represents an efficient way toward the phase-pure delafossite. By sintering the as-prepared powder compacts at 1100°C for 2 hours in air, we succeeded in preparing X-ray-diffraction phase-pure ceramics with 86% of relative density, which can be used as sputtering targets (figure 2).

Our studies related to thin dielectric films with a high permittivity for transparent electronic components were focused on thin films based on Ta_2O_5 and Ta_2O_5-Al_2O_3-SiO_2, which were prepared by Chemical Solution Deposition. The films, deposited onto glass substrates and processed at temperatures up to 400°C, showed an optical transmittance of ~80 %, a dielectric permittivity of ~20 and a low leakage current. These films are thus suitable for use in thin-film capacitors or transistors. In addition, we adopted inkjet printing for the deposition of thin films of n-type conducting oxides based on ZnO and SnO_2 onto various substrates.

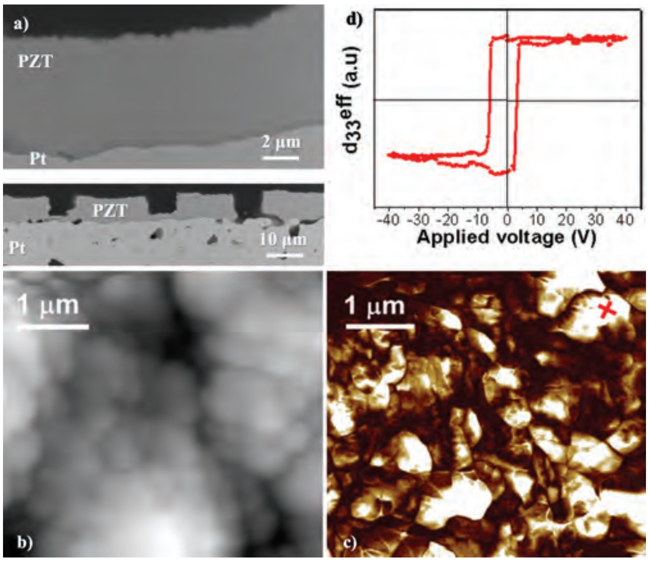

Figure 3: PZT thick film on the Pt/Al2O3 substrate prepared by inkjet printing. a) scanning electron microscopy (SEM) image of the cross-section b) atomic-force miscoscopy (AFM) image and c) out-of-plane amplitude PFM image of the surface of the PZT thick film; d) local d33(V) hysteresis loop obtained from a selected area on the film.

Within the research on the processing of **piezoelectric thick films** by the **electrophoretic deposition (EPD) process**, we systematically studied the influence of the polyacrylic acid / organic base ratio on the electrical conductivity of the dispersion and on the thickness uniformity of the as-deposited layers. At the optimal polyacrylic acid / organic base ratio we obtained a stable dispersion of donor-doped PZT particles in ethanol with a low electrical conductivity. The deposited layer had a thickness of 30 µm and was uniform and homogeneous. The dispersions were used for the processing of thick films on curved porous PZT substrates. In the next step and in collaboration with researchers from François-Rabelais University from Tours, France, we fabricated geometrically-focused high-frequency ultrasound transducers (US) for medical diagnoses. With the colleagues from Tours we also investigated the functional properties of $0.65Pb(Mg_{1/3}Nb_{2/3})O_3$–$0.35PbTiO_3$ (PMN–PT) thick films for US transducers. The results suggest that the PMN–PT thick-films transducers are superior to those made from the standard Pb(Zr,Ti)O_3 (PZT) piezoelectric material.

We fabricated a ceramic micro reactor with large cavities for the catalytical production of hydrogen from methanol and water by using LTCC technology.

We studied the preparation of **PZT ceramics with a controlled amount, size and distribution of pores**, which could be used as substrates for high-frequency ultrasound transducers. The method consists of the hetero-coagulation of PZT and polymethyl methacrylate (PMMA) particles.

We developed a procedure for the processing of aqueous dispersions of ceramic particles, suitable for the patterning of thick films by piezoelectric inkjet printing. We reduced the average particle size of a micron-sized PZT powder to a few tens of nanometres by milling and provided an effective dispersion of PZT particles in water by controlling the pH of the dispersion, and the type and amount of dispersant. The ink with an optimized average PZT particle size, surface tension and viscosity was inkjet printed onto platinised corundum substrates. The inkjet printed structures, dried and fired at 1100°C, were dense and ~5 µm thick. The local piezoelectric response of the PZT film was confirmed using ab atomic force microscope equipped with a piezoresponse-force module (figure 3).

By optimizing the rheological properties of the ink we improved the procedure for the processing of **KNN thick films using screen-printing technology**. The films were deposited onto substrates with different thermal expansion coefficients, so that different degrees of in-plane biaxial stresses were induced in the films. The influence of these stresses was reflected in the structural and functional properties of the films. The most important is the phenomenon of 'self-poling' of the KNN thick films, the extent of which depended on the mechanical stresses, i.e., on the type of the substrate.

We continued the investigations on **LTCC (Low Temperature Co-fired Ceramics)**, used for the fabrication of 3D structures for different electromechanical (MEMS - Micro Electro Mechanical Systems) and chemical microsystems. In collaboration with the partners from Montanuniversität Leoben, Austria, we studied the influence of the firing conditions on the microstructure and mechanical properties of Du Pont LTCC. We concluded that the porosity has a major influence on the elastic modulus, the fracture toughness, the hardness and the biaxial flexural strength

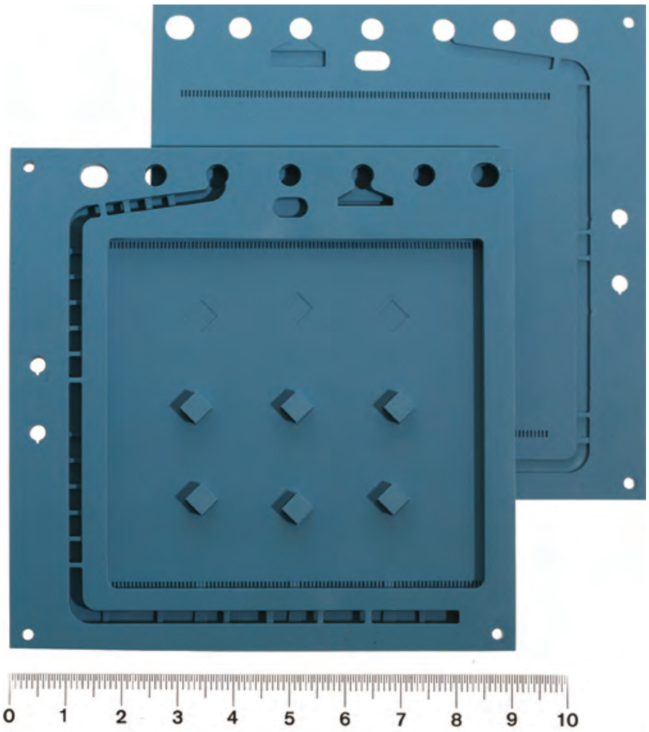

Figure 4: LTCC reactor for high-temperature catalytic production of hydrogen from methanol and water. The external dimensions of the structure are 90 mm × 90 mm × 9.2 mm and the volume of the buried cavities is 18.7 cm^3. The figure shows the bottom part of the reactor with nine supports.

of the LTCC. If the LTCC materials are fired at elevated temperatures for prolonged periods, so that the porosity is reduced, their properties remained unchanged, regardless of the firing temperature and/or firing time. This finding is important for the design and production of ceramic pressure sensors and other MEMS devices, which require relatively long firing procedures at higher temperatures, as compared to the conditions usually required for the processing of LTCC. In 2013 we reinforced the collaboration with KEKO Oprema d.o.o. in the field of materials and technologies based on LTCC.

Traditional co-operation with the research partners from HIPOT-RR and Centre of Excellence NAMASTE continued in all the research projects related to thick-film and LTCC technology. With the group from the company KEKON d.o.o. we continued our research in the field of functional thick-film materials, in particular, we investigated **new thick-film lead-free resistors** as possible sensor elements. We found that the temperature dependence of resistivity of these materials satisfies the needs for the application, however, the "gauge" factors, i.e., the dependence of the resistivity on the deformation, are three times lower than required, so that these materials are not suitable as pressure sensors. We also tested a commercial ESL 3411-I thick-film resistor with a **high and linear dependence of resistivity versus temperature** and a low sheet resistivity. The results suggested that this material is compatible with LTCC tapes and that it could be used for temperature measurements over large surfaces. This material was successfully used as a sensor for temperature control and regulation in large LTCC chemical reactors.

Within the programme JE PECS of the European Space Agency (ESA), we continued our work on the CERACON project, together with the partners from the Department of Systems and Control, and the National Institute of Chemistry. The topic of the project was the **design and fabrication of LTCC-based micro reactors** and the necessary periphery for the high-temperature catalytic transformation of methanol and water into hydrogen. It is worth mentioning that we succeeded in designing and constructing two reactors, i.e., one for the steam reforming and the other for the removal of the residual carbon monoxide from gas products. Both reactors had large buried cavities where the chemical reactions take place; the volume of the reformer and the reactor for CO removal was 18.7 cm^3 and 5.4 cm^3, respectively. These, rather extreme dimensions for LTCC technology, were fabricated in order to satisfy the required production of 85 litres of hydrogen per hour. The realisation of these **particularly large cavities** required special LTCC lamination procedures and a controlled firing process. The final dimensions of the reformer and the reactor for CO-removal were, respectively, 90 mm × 90 mm × 9.2 mm and 90 mm × 36 mm × 9.2 mm (figure 4).

In collaboration with the company ETI d.d. Izlake we investigated various silicate materials, i.e., steatite and cordierite, which are used in electrical engineering as heat or electrical insulators. We systematically studied the influence of raw materials on the microstructure, mechanical and electrical properties of the ceramics. At the optimal amount of selected raw materials and at the optimal milling conditions we prepared a new type of dense, alkaline steatite with a high flexural strength (~185 MPa) and a high specific electrical resistivity (~0.8 MΩ m). The resulting material was prepared on a production scale in the company and is now used for the fabrication of electrical fuses.

Some outstanding publications in the past year

1. Baláž, P., Rojac, T., et al.: Hallmarks of mechanochemistry: from nanoparticles to technology. Chemical Society reviews, vol. 42, 7571–7637, 2013, doi: 10.1039/C3CS35468G [COBISS.SI-ID 26654759]
2. Hreščak, J., Benčan, A., Rojac, T., Malič, B: The influence of different niobium pentoxide precursors on the solid-statesynthesis of potassium sodium niobate, J. Eur. Ceram. Soc., vol. 33, 3065–3075, 2013, doi: 10.1016/j.jeurceramsoc.2013.07.006
3. Vojisavljević, K., Malič, B., Mamoru, S., Drnovšek, S., Kosec, M.: Solid state synthesis of nano-boehmite-derived CuAlO2 powder and processing of the ceramics, J. Eur. Ceram. Soc., vol. 33, 3231–3241, 2013, doi: 10.1016/j.jeurceramsoc.2013.05.025
4. Kuščer, D., Noshchenko, O., Uršič, H., Malič, B.: Piezoelectric properties of ink-jet printed lead zirconate titanate thick films confirmed by piezoresponse force microscopy, J. Am. Ceram. Soc., vol. 96, 2714–2717, 2013, doi: 10.1111/jace.12532

5. Kupec, A., Gemeiner, P., Dkhil, B., Malič, B.: Phase transitional behavior of potassium sodium niobate thin films, Thin solid films, vol. 539, 317–322, 2013, doi: 10.1016/j.tsf.2013.05.098

Organization of conferences, congresses and meetings

1. COST Training school on characterization of materials, Ljubljana, Slovenia, 28.–29. 1. 2013

Patent granted

1. Luca Gregoratti, Marco Peloi, Marija Kosec, Danjela Kuščer, Giuseppina Palma, A material in the form of lithium fluoride powder containing colour centres, method for preparation and use thereof, US8535434 (B2), US Patent Office, 17.9.2013.
2. Kostja Makarovič, Janez Holc, Darko Belavič, Marko Hrovat, Marija Kosec, Multilayer ceramic structures for non-contact dielectric heating of liquids, SI24008 (A), Urad RS za intelektualno lastnino, 30.8.2013.
3. Marina Santo-Zarnik, Darko Belavič, Marjan Hodnik, Sandi Kocjan, A pressure-sensor module with a ceramic cantilever sensing structure, SI24085 (A), Urad RS za intelektualno lastnino, 29.11.2013.

INTERNATIONAL PROJECTS

1. 7FP - ORAMA; Oxide Materials Towards a Matured Post-silicon Electronics Era
   European Commission
   Prof. Barbara Malič
2. 7FP - CERAMPOL; Ceramic and Polymeric Membrane for Water Purification of Heavy Metal and Hazardous Organic Compound
   European Commission
   Asst. Prof. Danjela Kuščer Hrovatin
3. 7FP - PI; The Piezo Institute - European Expertise Centre for Multifunctiona and Integrated Piezoelectric Devices
   European Commission
   Prof. Barbara Malič
4. CERACON; Integration and Control of Liquid Fuel processor based on Ceramic Micro-Systems
   ESA/ESTEC
   Asst. Prof. Marko Hrovat
5. COST MP0904; SIMUFER: Single- and Multiphase Ferroics and Multiferroics with Restricted Geometries
   COST Office
   Prof. Barbara Malič
6. FERRO-PATCH; Frequency and Polarisation Agile Microstrip Patch Antenna based on Ferrelectric Varactors
   ESA/ESTEC
   Prof. Barbara Malič
7. Solution Processing of Thin Films for Transparent Electronics (TRANS)
   Slovenian Research Agency
   Prof. Barbara Malič
8. Dielectric Spectroscopy and Tunability of Low-Temperature Rocessed Complex Perovskites
   Slovenian Research Agency
   Prof. Barbara Malič

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. Oxide-Based Components for Transparent Electronics
   Prof. Barbara Malič
3. Tunable Ferroelectric Thin Film Capacitors for Agile Microwave Antennas
   Prof. Barbara Malič
4. High-performance Piezoelectric Materials for Sensors and Actuators in High-temperature Applications
   Asst. Prof. Tadej Rojac
5. Textured Ceramic Films for Sensors and Actuators
   Asst. Prof. Tadej Rojac
6. Materials and Technologies for Chemical Microsystems
   Asst. Prof. Andreja Benčan Golob
7. $Pb(Sc_{0.5}Nb_{0.5})O_3$–$PbTiO_3$ Thick Films for Sensor and Actuator Applications
   Dr. Hana Uršič Nemevšek

NEW CONTRACTS

1. Evolution of Microstructure in Non-porous Bulk Ceramics with Selected Properties for Applications in Low Temperature Cofired Ceramic (LTCC) structures
   Keko – Oprema, d. o. o., Žužemberk
   Prof. Barbara Malič
2. Materials and Technologies for Chemical Microsystems
   Keko – Oprema, d. o. o., Žužemberk
   Asst. Prof. Andreja Benčan Golob
3. Nanomaterials in Ceramics-Feasibility Study
   RC eNeM
   Prof. Barbara Malič

VISITORS FROM ABROAD

1. Julian Walker, School of Materials Science & Engineering, University of New South Wales, Sydney, Australia, 1. 1.–31. 7. 2013
2. Prof. Liliana Mitoseriu, University "Al. I. Cuza", Faculty of Physics, Iasi, Romania, 23.–30. 1. 2013
3. Dr. Denis Schütz, CD-Lab for Advanced Ferroic Materials, Graz, Austria, 27. 1.–14. 4. 2013
4. Dr. Nadejda Horchidan, University "Al. I. Cuza", Faculty of Physics, Iasi, Romania, 27. 1.–22. 2. 2013
5. Andre-Pierre Abellard, Université François Rabelais, Tours, France, 2.–29. 3. 2013
6. Pierrick Chevreux, Ecole Nationale Supérieure Céramique Industrielle, Limoges, France, 3. 3.–7. 6. 2013
7. Prof. Dragan Damjanovic, Swiss Federal Institute of Technology-EPFL, Lausanne, Switzerland, 6.–9. 3. 2013
8. Dr. Marco Deluca, Institut für Struktur- und Funktionskeramik, Montanuniversität Leoben, Materials Center Leoben Forschung GmbH, Leoben, Austria, 15. 3. 2013
9. Naima Benyagoub, Magali Leger, Prof. Marc Lethiecq, Prof. Franck Levassort, Université François Rabelais, Tours, France, 24.–29. 3. 2013
10. Dr. Marko Budimir, Institute for Nuclear Technology-INETEC, Zagreb, Croatia, 13. 5. 2013
11. Prof. Jürgen Rödel, Technische Universität Darmstadt, Darmstadt, Germany, 16.–17. 5. 2013
12. Prof. Klaus Reichmann, Graz University of Technology, Graz, Austria, 17. 5. 2013
13. Prof. Angus I. Kingon, Brown University, Rhode Island, USA, 9.–17. 6. 2013

14. Goran Mišković, Vienna University of Technology, Institute of Sensor and Actuator Systems, Wienna, Austria, 13. 6. 2013
15. Dr. Vassilios Binas, Foundation for Research & Technology Hellas (FORTH), Institute for Electronic Structure and Laser (IESL), Crete, Greece, 8.–25. 9. 2013
16. Dr. Gregor Trefalt, University of Geneva, Geneva, Switzerland, 9.–13. 9. 2013
17. Prof. Raul Bermejo, Institut für Struktur-und Funktionskeramik, Montanuniversität Leoben, Leoben, Austria, 22.–23. 9. 2013
18. Prof. Mariuca Gartner, Prof. dr. Maria Zaharescu, "Ilie Murgulescu" Institute of Physical Chemistry of Romanian Academy, Bucharest, Romania, 4.–8. 11. 2013

STAFF

Researchers
1. Asst. Prof. Andreja Benčan Golob
2. *Dr. Elena Chernyshova*, left 12.09.13*
3. Asst. Prof. Marko Hrovat
4. Asst. Prof. Danjela Kuščer Hrovatin
5. **Prof. Barbara Malič, Head**
6. Dr. Tadej Rojac
7. Dr. Marina Santo Zarnik*
8. Dr. Hana Uršič Nemevšek

Postdoctoral associates
9. Dr. Georgia Basina
10. Dr. Mara Bernardo Sacristan
11. Dr. Kostja Makarovič*
12. Dr. Brigita Rožič
13. Dr. Katarina Vojisavljević

Postgraduates
14. Tina Bakarič, B. Sc.
15. Raluca-Camelia Frunza, B. Sc.
16. Jitka Hreščak, B. Sc.
17. Evgeniya Khomyakova, B. Sc.
18. *Dr. Jurij Koruza, left 01.08.13*
19. Alja Kupec, B. Sc.
20. Oleksandr Noshchenko, B. Sc.
21. Jernej Pavlič, B. Sc.
22. Tanja Pečnik, B. Sc.
23. Jerca Praprotnik, B. Sc.
24. Marko Vrabelj, B. Sc.

Technical officers
25. Darko Belavič*, B. Sc.
26. Andraž Bradeško, B. Sc.
27. Jena Cilenšek, B. Sc.
28. Silvo Drnovšek, B. Sc.
29. Brigita Kmet, B. Sc.
30. *Milena Pajić, B. Sc., left 01.05.13*

Technical and administrative staff
31. Tina Ručigaj, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLE

1. Ilze Aulika, Silvana Mergan, Andreja Benčan, Q. Zhang, Alexandr Dejneka, Marija Kosec, K. Kundzins, D. Demarchi, P. Civera, "Impact of crystallisation processes on depth profile formation in solgel $PbZr_{0.52}Ti_{0.48}O_3$ thin films", *Advances in applied ceramics*, vol. 112, issue 1, pp. 55-58, 2013.
2. Darko Belavič, Marko Hrovat, Gregor Dolanc, Kostja Makarovič, Marina Santo-Zarnik, "Design and fabrication of an LTCC structure for a microceramic combustor: invited paper", *J. microelectron. electron. packag.*, vol. 9, no. 3, pp. 120-125, 2013.
3. N. Bensemma, Gregor Trefalt, Sebastjan Glinšek, Marija Kosec, K. Taïbi, M. Abbaci, "Investigation of the $BaTiO_3BaMg_{1/3}Nb_{2/3}O_3$ system estructural, dielectric, ferroelectric and electromechanical studies", *Journal of electroceramics*, vol. 30, no. 4, pp. 206-212, 2013.
4. Vid Bobnar, Hana Uršič, Goran Casar, Silvo Drnovšek, "Distinctive contributions to dielectric response of relaxor ferroelectric lead scandium niobate ceramic system", *Phys. status solidi, b Basic res.*, vol. 250, no. 10, pp. 2232-2236, 2013.
5. Goran Casar, Xinyu Li, Jurij Koruza, Qiming M. Zhang, Vid Bobnar, "Electrical and thermal properties of vinylidene fluoride-trifluoroethylene-based polymer system with coexisting ferroelectric and relaxor states", *J. Mater. Sci.*, vol. 48, no. 22, pp. 7920-7926, 2013.
6. Jovana Ćirković, Katarina Vojisavljević, Maja Šćepanović, Aleksander Rečnik, Goran Branković, Zorica Branković, Tatjana Srećković, "Hydrothermally assisted complex polymerization method for barium strontium titanate powder synthesis", *J. sol-gel sci. technol.*, vol. 65, issue 2, pp. 121-129, 2013.
7. Jitka Hreščak, Andreja Benčan, Tadej Rojac, Barbara Malič, "The influence of different niobium pentoxide precursors on the solid-statesynthesis of potassium sodium niobate", *J. Eur. Ceram. Soc.*, vol. 33, issue 15-16, pp. 3065-3075, 2013.
8. Alja Kupec, Pascale Gemeiner, Brahim Dkhil, Barbara Malič, "Phase transitional behavior of potassium sodium niobate thin films", *Thin solid films*, vol. 539, pp.317-322, 2013.
9. Danjela Kuščer, Tina Bakarič, Bojan Kozlevčar, Marija Kosec, "Interactions between lead-zirconate titanate, polyacrylic acid, and polyvinyl butyral in ethanol and their influence on electrophoretic deposition behavior", In: Proceedings of the 4th International Conference on Electrophoretic Deposition: Fundamentals and Applications, October 2-7, 2011, Puerto Vallarta, Mexico, *J. Phys. Chem. B*, vol. 117, no. 6, pp. 1651-1659, 2013.
10. Danjela Kuščer, Oleksandr Noshchenko, Hana Uršič, Barbara Malič, "Piezoelectric properties of ink-jetprinted lead zirconate titanate thick films confirmed by piezoresponse force microscopy", *J. Am. Ceram. Soc.*, vol. 96, no. 9, pp. 2714-2717, 2013.
11. Kostja Makarovič, Andreja Benčan, Marko Hrovat, Janez Holc, Barbara Malič, Marija Kosec, Raúl Bermejo, Irina Kraleva, "The effect of phase composition on the mechanical properties of LTCC material", *International journal of applied ceramic technology*, vol. 10, issue 3, pp. 449-457, 2013.
12. Kostja Makarovič, Anton Meden, Marko Hrovat, Darko Belavič, Janez Holc, Marija Kosec, "Non-destructive quantitative phase analysis of an LTCC material", *Microelectron. int.*, vol. 30, no. 2, pp. 73-76, 2013.
13. Matejka Podlogar, Damjan Vengust, Jacob J. Richardson, Martin Strojnik, Matjaž Mazaj, Gregor Trefalt, Nina Daneu, Aleksander Rečnik, Slavko Bernik, "Parametric study of seed-layer formation for low-temperature hydrothermal growth of highly oriented ZnO films on glass substrates", *Phys. status solidi, A Appl. mater. sci.,* vol. 210, issue 6, pp. 1083-1092, 2013.
14. Jürgen Rödel, Yo-Han Seo, Andreja Benčan, Barbara Malič, Marija Kosec, Kyle Webber, "R-curves in transformation toughened lead zirconate titanate", *Eng. fract. mech.*, vol. 100, pp. 86-91, 2013.
15. Brigita Rožič, Marko Jagodič, Sašo Gyergyek, Zvonko Jagličić, Samo Kralj, Vassilios Tzitzios, George Cordoyiannis, Zdravko Kutnjak, "Indirect magnetoelectric coupling in mixtures of magnetite and ferroelectric liquid crystal", In: Proceedings of the ISAF ECAPD PMF 2012, International Symposium on Applications of Ferroelectrics; European Conference on the Applications of Polar Dielectrics; International Symposium Piezoresponse Force Microscopy and Nanoscale Phenomena in Polar Materials, 9-13 of July, 2012, Aveiro, Portugal, *Ferroelectrics*, vol. 448, no. 1, pp. 12-16, 2013.
16. Brigita Rožič, Jurij Koruza, Zdravko Kutnjak, George Cordoyiannis, Barbara Malič, Marija Kosec, "The electrocaloric effect in lead-free $K_{0.5}Na_{0.5}NbO_3 - SrTiO_3$ ceramics", In: Proceedings of the ISAF ECAPD PMF 2012, International Symposium on Applications of Ferroelectrics; European Conference on the Applications of Polar Dielectrics;

International Symposium Piezoresponse Force Microscopy and Nanoscale Phenomena in Polar Materials, 9-13 of July, 2012, Aveiro, Portugal, *Ferroelectrics*, vol. 446, no. 1, pp. 39-35, 2013.
17. Marina Santo-Zarnik, Darko Belavič, Vlasta Sedlakova, Josef Sikula, Martin Kopecky, Petr Sedlak, Jiri Majzner, "Comparison of the intrinsic characteristics of LTCC and silicon pressure sensors by means of 1/f noise measurements", *Radioengineering (Prague)*, vol. 22, no. 1, pp. 227-232, 2013.
18. Marina Santo-Zarnik, Vlasta Sedlakova, Darko Belavič, Josef Sikula, Jiri Majzner, Petr Sedlak, "Estimation of the long-term stability of piezoresistive LTCC pressure sensors by means of low-frequency noise measurements", *Sens. actuators, A, Phys.*, vol. 199, pp. 334-343, 2013.
19. Yo-Han Seo, Daniel J. Franzbach, Jurij Koruza, Andreja Benčan, Barbara Malič, Marija Kosec, Jacob L. Jones, Kyle Webber, "Nonlinear stress-strain behavior and stress-induced phase transitions in soft $Pb(Zr_{1-x}Ti_x)O_3$ at the morphotropic phase boundary", *Phys. rev., B, Condens. matter mater. phys.*, vol. 87, no. 9, pp. 094116-1-094116-11, 2013.
20. Hana Uršič, Dragan Damjanović, "Anelastic relaxor behavior of $Pb(Mg_{1/3}Nb_{2/3})O_3$", *Appl. phys. lett.*, vol. 103, no. 7, pp. 072904-1-072904-4, 2013.
21. Hana Uršič, Janez Holc, Marija Kosec, "Influence of the sintering conditions on the properties of 0.57PSN0.43PT ceramics prepared from mechanochemically activated powder", *J. Eur. Ceram. Soc.*, vol. 33, no. 4, pp. 795-803, 2013.
22. Hana Uršič, Franck Levassort, Janez Holc, Marc Lethiecq, Marija Kosec, "$0.65Pb(Mg_{1-3}Nb_{2-3})O_3 0.35PbTiO_3$ thick films for high-frequency piezoelectric transducer applications", *Jpn. j. appl. phys.*, vol. 52, no. 5, pp. 055502-1-055502-6, 2013.
23. Hana Uršič, Barbara Malič, Jena Cilenšek, Tadej Rojac, Brigita Kmet, Marija Kosec, "Linear thermal expansion coefficients of relaxor-ferroelectric $0.57Pb(Sc_{1/2}Nb_{1/2})O_3 - 0.43PbTiO_3$ ceramics in a wide temperature range", *J. Eur. Ceram. Soc.*, vol. 33, no. 11, pp. 2167-2171, 2013.
24. Mirjana M. Vijatović Petrović, Jelena D. Bobić, Hana Uršič, J. Banys, Biljana Stojanović, "The electrical properties of chemically obtained barium titanate improved by attrition milling", *J. sol-gel sci. technol.*, vol. 67, no. 2, pp. 267-272, 2013.
25. Katarina Vojisavljević, Barbara Malič, Senna Mamoru, Silvo Drnovšek, Marija Kosec, "Solid state synthesis of nano-boehmite-derived $CuAlO_2$ powder and processing of the ceramics", *J. Eur. Ceram. Soc.*, vol. 33, no. 15/16, pp. 3231-3241, 2013.

REVIEW ARTICLE

1. Peter Baláž *et al.* (16 authors), "Hallmarks of mechanochemistry: from nanoparticles to technology", *Chem. Soc. rev.*, vol. 42, issue 18, pp. 7571-7637, 2013.

PUBLISHED CONFERENCE CONTRIBUTION (INVITED LECTURE)

1. Danjela Kuščer, Andre-Pierre Abellard, Marija Kosec, Franck Levassort, "Piezoelectric thick-film structures for high-frequency transducer applications prepared by electrophoretic deposition", In: *Processing and properties of advanced ceramics and composites V*, (Ceramic transactions, vol. 240), Narottam P. Bansal, ed., [S. l.], Wiley, 2013, pp. 131-141.
2. Marina Santo-Zarnik, Milenko Pavlović, Darko Belavič, Vlasta Sedlakova, Josef Sikula, Jiri Majzner, "Effect of media on the warm-up and the offset characteristic of piezoresistive ceramic pressure sensors", In: *Proceedings*, EDS'13, Electronic Devices and Systems IMAPS CS International Conference 2012, June 26-27, 2013, Brno, Czech Republic, Ondrej Hegr, ed., Brno, Vysoké učení Technické v Brně, 2013, pp. XXI-XXVI.

PUBLISHED CONFERENCE CONTRIBUTION

1. Andre-Pierre Abellard, Franck Levassort, Jean Marc Grégoire, Marc Lethiecq, Danjela Kuščer, Janez Holc, "PZT thick films obtained by electrophoretic deposition (EPD) process for high frequency focused transducers", In: *IUS 2012*, 2012 IEEE International Ultrasonic Symposim, October 7-10, 2012, Dresden, German, [S. l.], IEEE, 4 pp..
2. Tina Bakarič, Danjela Kuščer, Barbara Malič, "Keramika svinčevega cirkonata titanata z določeno obliko in velikostjo por", In: *Slovenski kemijski dnevi 2013, Maribor, 10.-12. september 2013*, Zdravko Kravanja, ed., Darinka Brodnjak-Vončina, ed., Miloš Bogataj, ed., Maribor, Fakulteta za kemijo in kemijsko tehnologijo, 2013, 7 pp.
3. Darko Belavič, Marko Hrovat, Kostja Makarovič, Vlasta Sedlakova, Josef Sikula, Marina Santo-Zarnik, "Investigations of thic K-film piezoresistors terminated with silver-based thick-film conductors", In: *Proceedings*, EDS'13, Electronic Devices and Systems IMAPS CS International Conference 2012, June 26-27, 2013, Brno, Czech Republic, Ondrej Hegr, ed., Brno, Vysoké učení Technické v Brně, 2013, pp. 218-223.
4. Barbara Bertoncelj, Katarina Vojisavljević, Janez Rihtaršič, Gregor Jelenc, Barbara Malič, Marko Stušek, Darko Belavič, "Characterization of glass fiber reinforced composites for housing of electrical motors", In: *Proceedings*, 49th International Conference on Microelectronics, Devices and Materials & theWorkshop on Digital Electronic Systems, September 25 - September 27, 2013, Kranjska Gora, Slovenia, Andrej Žemva, ed., Polona Šorli, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2013, pp. 101-106.
5. Goran Casar, Jurij Koruza, Vid Bobnar, Xinyu Li, Qiming M. Zhang, "Nonlinear dielectric response of polymer system with coexisting ferroelectric and ralaxor states", In: *2013 Joint UFFC, EFTF and PFM Symposium*, International Ultrasonics Symposium (IUS), Joint IEEE International Symposium on the Applications of Ferroelectrics (ISAF) and Piezoresponse Force Microscopy and Nanoscale Phenomena in Polar Materials (PMF), Joint International Frequency Control Symposium (IFCS), and European Frequency and Time Forum (EFTF), 21-25 July 2013, Prague, Czech RepublicIEEE Ultrasonics, Ferroelectrics, and Frequency Control Society International Ultrasonics Symposium (IUS), Joint IEEE International Symposium on the Applications of Ferroelectrics (ISAF) and Piezoresponse Force Microscopy and Nanoscale Phenomena in Polar Materials (PMF), Joint International Frequency Control Symposium (IFCS), and European Frequency and Time Forum (EFTF), 21-25 July 2013, Prague, Czech Republic, [S. l.], IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society, 2013, pp. 159-161.
6. Goran Casar, Xinyu Li, Jurij Koruza, Qiming M. Zhang, Vid Bobnar, "Electrical and thermal properties of polymer systems with coexisting ferroelectric and relaxor states", In: *Zbornik*, 5. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana = 5th Jožef Stefan International Postgraduate School Students Conference, 23. maj 2013, Ljubljana, Slovenija, Nejc Trdin, ed., et al, Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2013, pp. 250-256.
7. Gregor Dolanc, Marko Hrovat, Primož Fajdiga, Stanko Hočevar, Andrej Pohar, Kostja Makarovič, Darko Belavič, "System with ceramic LTCC micro-reactor for steam reforming", In: *Proceedings*, 49th International Conference on Microelectronics, Devices and Materials & theWorkshop on Digital Electronic Systems, September 25 - September 27, 2013, Kranjska Gora, Slovenia, Andrej Žemva, ed., Polona Šorli, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2013, pp. 251-256.
8. Raluca C. Frunza, Brigita Kmet, Karsten Rachut, Marko Jankovec, Marko Topič, Andreas Klein, Barbara Malič, "Solution-derived Ta_2O_5-based dielectric thin films for transparent electronic devices", In: *Proceedings*, 49th International Conference on Microelectronics, Devices and Materials & theWorkshop on Digital Electronic Systems, September 25 - September 27, 2013, Kranjska Gora, Slovenia, Andrej Žemva, ed., Polona Šorli, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2013, pp. 239-244.
9. Raluca C. Frunza, Martin Strojnik, Marko Jankovec, Marko Topič, Barbara Malič, "Investigation of the structural, optical and electrical properties of Ta_2O_5-rich thin films from solution", In: *Zbornik*, 5. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana = 5th Jožef Stefan International Postgraduate School Students Conference, 23. maj 2013, Ljubljana, Slovenija, Nejc Trdin, ed., et al, Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2013, pp. 268-277.
10. Marko Hrovat, Darko Belavič, Kostja Makarovič, ""Green" thick film resistors on various substrates", In: *Proceedings*, 49th International Conference on Microelectronics, Devices and Materials & theWorkshop on Digital Electronic Systems, September 25 - September 27, 2013, Kranjska Gora, Slovenia, Andrej Žemva, ed., Polona Šorli, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2013, pp. 257-261.
11. Marko Hrovat, Darko Belavič, Kostja Makarovič, "Lead-free thick-film resistors on slumina and LTCC substrates", In: *Extended abstracts*, ISSE 2013, 36th International Spring Seminar on Electronics Technology,

"Automative electronics", Alba, Iulia, Români, Emilian Ceuca, ed., Manuela Franz, ed., Johann Nicolics, ed., [S. l., s. n.], 2013, 5 pp.

12. Petra Jenuš, Darja Lisjak, Danjela Kuščer, Darko Makovec, Mihael Drofenik, "Co-sintering of magnetoelectric composites of Co-ferrite and selected ferroelectrics", In: *Zbornik*, 5. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana = 5th Jožef Stefan International Postgraduate School Students Conference, 23. maj 2013, Ljubljana, Slovenija, Nejc Trdin, ed., et al, Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2013, pp. 278-287.
13. Milenko Pavlović, Marina Santo-Zarnik, Sandi Kocjan, Marko Stušek, Darko Belavič, "Prelininary media-compatibility tests for LTCC-based pressure sensors", In: *Proceedings*, 49th International Conference on Microelectronics, Devices and Materials & theWorkshop on Digital Electronic Systems, September 25 - September 27, 2013, Kranjska Gora, Slovenia, Andrej Žemva, ed., Polona Šorli, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2013, pp. 173-179.
14. Tanja Pečnik, Sebastjan Glinšek, Brigita Kmet, Raluca C. Frunza, Barbara Malič, "Solution derived $Ba_{0.5}Sr_{0.5}TiO_3$ thin films on polycrystalline alumina substrates", In: *Proceedings*, 49th International Conference on Microelectronics, Devices and Materials & theWorkshop on Digital Electronic Systems, September 25 - September 27, 2013, Kranjska Gora, Slovenia, Andrej Žemva, ed., Polona Šorli, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2013, pp. 235-238.
15. Tanja Pečnik, Sebastjan Glinšek, Brigita Kmet, Barbara Malič, "Microstructure and kHz- and GHz- range dielectric properties of polycrystalline $Ba_{0.5}Sr_{0.5}TiO_3$ thin films", In: *2013 Joint UFFC, EFTF and PFM Symposium*, International Ultrasonics Symposium (IUS), Joint IEEE International Symposium on the Applications of Ferroelectrics (ISAF) and Piezoresponse Force Microscopy and Nanoscale Phenomena in Polar Materials (PMF), Joint International Frequency Control Symposium (IFCS), and European Frequency and Time Forum (EFTF), 21-25 July 2013, Prague, Czech RepublicIEEE Ultrasonics, Ferroelectrics, and Frequency Control Society International Ultrasonics Symposium (IUS), Joint IEEE International Symposium on the Applications of Ferroelectrics (ISAF) and Piezoresponse Force Microscopy and Nanoscale Phenomena in Polar Materials (PMF), Joint International Frequency Control Symposium (IFCS), and European Frequency and Time Forum (EFTF), 21-25 July 2013, Prague, Czech Republic, [S. l.], IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society, 2013, pp. 108-110.
16. Katarina Vojisavljević, Biljana Stojanović, Brigita Kmet, Jena Cilenšek, Barbara Malič, "Chemical synthesis of nanocrystalline $CuAlO_2$ via nitrate-citrate combustion route", In: *Slovenski kemijski dnevi 2013, Maribor, 10.-12. september 2013*, Zdravko Kravanja, ed., Darinka Brodnjak-Vončina, ed., Miloš Bogataj, ed., Maribor, Fakulteta za kemijo in kemijsko tehnologijo, 2013, 7 pp.
17. Marko Vrabelj, Hana Uršič, Brigita Rožič, Zdravko Kutnjak, Silvo Drnovšek, Barbara Malič, "Electrocaloric properties of $0.7Pb(Mg_{1/3}Nb_{2/3})O_3 - 0.3PbTiO_3$ ceramics", In: *2013 Joint UFFC, EFTF and PFM Symposium*, International Ultrasonics Symposium (IUS), Joint IEEE International Symposium on the Applications of Ferroelectrics (ISAF) and Piezoresponse Force Microscopy and Nanoscale Phenomena in Polar Materials (PMF), Joint International Frequency Control Symposium (IFCS), and European Frequency and Time Forum (EFTF), 21-25 July 2013, Prague, Czech RepublicIEEE Ultrasonics, Ferroelectrics, and Frequency Control Society International Ultrasonics Symposium (IUS), Joint IEEE International Symposium on the Applications of Ferroelectrics (ISAF) and Piezoresponse Force Microscopy and Nanoscale Phenomena in Polar Materials (PMF), Joint International Frequency Control Symposium (IFCS), and European Frequency and Time Forum (EFTF), 21-25 July 2013, Prague, Czech Republic, [S. l.], IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society, 2013, pp. 310-312.
18. Marko Vrabelj, Hana Uršič, Brigita Rožič, Zdravko Kutnjak, Silvo Drnovšek, Barbara Malič, "Electrocaloric properties of $0.7Pb(Mg_{1/3}Nb_{2/3})O_3 - 0.3PbTiO_3$ ceramics prepared from mechanochemically activated powder", In: *Proceedings*, 49th International Conference on Microelectronics, Devices and Materials & theWorkshop on Digital Electronic Systems, September 25 - September 27, 2013, Kranjska Gora, Slovenia, Andrej Žemva, ed., Polona Šorli, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2013, pp. 231-234.

Independent Component Part or a Chapter in a Monograph

1. Sebastjan Glinšek, Barbara Malič, Marija Kosec, "Low-temperature processing", In: *Chemical solution deposition of functional oxide thin films*, Theodor Schneller, et al, Dordrecht, Springer, 2013, pp. 431-444.
2. Marko Hrovat, Darko Belavič, Jena Cilenšek, "Thick-film resistor material: structural and electrical characteristics", In: *Resistors: theory of operation, behavior and safety regulations*, (Electrical engineering developments, Physics research and technology), Roy Abi Zeid Daou, ed., New York, Nova, 2013, pp. 17-36.
3. Danjela Kuščer, Zhijian Shen, "Advanced direct forming processes for the future", In: *Advanced ceramics for dentistry*, Zhijian Shen, ed., Tomaž Kosmač, ed., Amsterdam ... [et al.], Elsevier, 2013, pp. 375-390.
4. Barbara Malič, Sebastjan Glinšek, Theodor Schneller, Marija Kosec, "Mixed metallo-organic precursor systems", In: *Chemical solution deposition of functional oxide thin films*, Theodor Schneller, et al, Dordrecht, Springer, 2013, pp. 51-70.
5. Barbara Malič, Alja Kupec, Marija Kosec, "Thermal analysis", In: *Chemical solution deposition of functional oxide thin films*, Theodor Schneller, et al, Dordrecht, Springer, 2013, pp. 163-180.

Patent Application

1. Urban Tomc, Andrej Kitanovski, Marko Ožbolt, Uroš Plaznik, Uroš Flisar, Jaka Tušek, Alojz Poredoš, Barbara Malič, Hana Uršič, Silvo Drnovšek, Jena Cilenšek, Zdravko Kutnjak, Brigita Rožič, *Method for electrocaloric energy conversion,* EP13179000.8, European Patent Office, 1.8.2013.

Patent

1. Luca Gregoratti, Marco Peloi, Marija Kosec, Danjela Kuščer, Giuseppina Palma, *A material in the form of lithium fluoride powder containing colour centres, method for preparation and use thereof,* US8535434 (B2), US Patent Office, 17.9.2013.
2. Kostja Makarovič, Janez Holc, Darko Belavič, Marko Hrovat, Marija Kosec, *Multilayer ceramic structures for non-contact dielectric heating of liquids,* SI24008 (A), Urad RS za intelektualno lastnino, 30.8.2013.
3. Marina Santo-Zarnik, Darko Belavič, Marjan Hodnik, Sandi Kocjan, *A pressure-sensor module with a ceramic cantilever sensing structure,* SI24085 (A), Urad RS za intelektualno lastnino, 29.11.2013.

Mentoring

1. Jurij Koruza, *Sintering and phase transition behaviour of sodium niobate:* doctoral dissertation, Ljubljana, 2013 (mentor Barbara Malič; co-mentor Tadej Rojac).
2. Kostja Makarovič, *The effect of processing conditions on the phase composition, structure and properties of low temperature co-fired ceramics:* doctoral dissertation, Ljubljana, 2013 (mentor Andreja Benčan Golob; co-mentor Barbara Malič).