DEPARTMENT FOR NANOSTRUCTURED MATERIALS K-7

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

Head:
Prof. Spomenka Kobe

In 2013 we began work on the EU FP7 project "Nanocrystalline permanent magnets based on hybrid metal-ferrites" (**NANOPYME**). Our role is as the developer of 100-nanometer-scale Sr-ferrite particles via high-energy ball milling, with subsequent activities in the project related to the consolidation of two-phase exchange-coupled materials and the transfer of the process to the industrial partners, including Magneti Ljubljana d.d., during the final year of the project. The first 6-month meeting was held in Ljubljana during the last week of May 2013.

In the frame of ARRS-funded project "The protection of permanent magnets for advanced applications at high temperatures" we designed and developed an effective coating for magnets used at temperatures in the range of 400 °C. Multilayer coatings based on nickel and titanium nitride are proving to be very effective at these very high temperatures, resisting both corrosion and evaporation.

In another study, the so-called **grain-boundary diffusion process** (GBDP) was introduced. This is a post-sintering process, where the diffusion of Dy or Tb along grain-boundaries and into the outer parts of $Nd_2Fe_{14}B$ grains occurs and this contributes to a higher coercivity. The result is a "core-shell" microstructure where the core is represented by the Dy-free $Nd_2Fe_{14}B$ phase and the shell is rich in Dy ($NdDyFe_{14}B$). The first step that is needed in such a process is to coat the commercially available, Dy-free Nd-Fe-B sintered magnet with Dy-powder, in our case DyF_3. The magnets were coated in two different ways. The first is by dip-coating and the second is by the more efficient electrophoretic deposition (EPD). The grain size of the DyF_3-powder was in range of 5 μm to 60 μm and the suspension was based on ethanol. In the case of using EPD, the thickness of the DyF_3-coating was varied from a few to 250 μm. After the coating-process, all the magnets were usually exposed to the same heat treatment at 850 °C for 10 hours and aging at 500 °C for 1 hour in an argon atmosphere. In this step, the so-called GBDP occurs. The magnetic measurements of such magnets were made with a permeameter. When rough calculations were made, to figure out how high is the Dy-concentration after GBDP, it was determined that in a whole magnet there is less than 1 wt. % of Dy and magnetic properties are even better or as good as in the case of magnet produced by the conventional powder metallurgy route that contain 2 wt. % of Dy. For this reason, GBDP based on EPD is an extremely attractive process that leads to a large coercivity improvement (up to 30 %) with only small drop in remanence. This work is part of the European project ROMEO (FP7-NMP-2012-SMALL-6) where one of the main goals is to reduce the usage of expensive heavy rare earths (Dy or Tb) in the NdFeB magnets and at the same time retain or even enhance the magnetic properties.

The deposition process of the **Fe-Pd nanostructured alloys** was kinetically evaluated and the parameters for an optimum composition depending on the system investigated, i.e., $Fe_{70}Pd_{30}$ or $Fe_{50}Pd_{50}$ was given. Magnetic shape memory $Fe_{70}Pd_{30}$ nanorods, which we are investigating in the frame of a national project with NIC and an MNT-ERA-NET project, were successfully deposited in a narrow composition range. Low-temperature SQUID measurements showed an increased magnetization saturation and coercivity,

In October 2013 we began coordinating a new EU FP7 project called "New permanent magnets for electric-vehicle drive applications" (MAG-DRIVE) to develop new processing technologies for rare-earth transition-metal magnets that will be incorporated into electric motors with higher efficiency. The project includes partners from the UK, Germany, Serbia, France and Slovenia. At the JSI, as well as coordinating the project we will be working on innovative compaction techniques such as spark-plasma sintering in an attempt to improve the magnetic properties by reducing as far as possible the grain growth inherent in high-temperature consolidation processes.

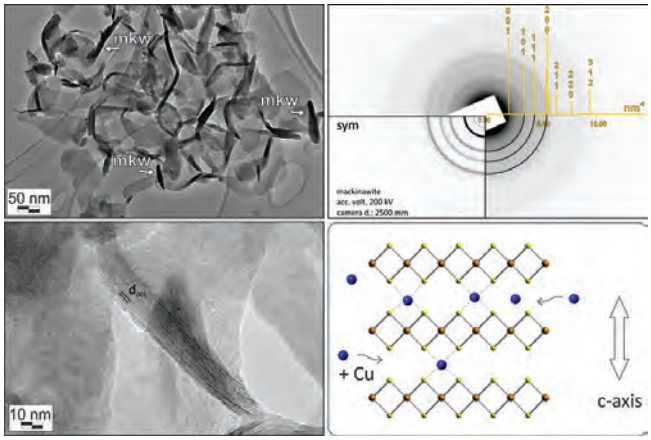

Figure 1: Agglomerates of mackinawite (FeS) leaves with corresponding experimental and simulated EDP. Individual mackinawite crystal with a mechanism of Cu incorporation between the mackinawite layers (TEM Jeol 2100).

Fe-Pd nanorods were successfully implemented in xerogels together with a model drug. The biocompatibility of the system was proven with an in-vivo experiment involving zebra fish. In the $Fe_{50}Pd_{50}$ nanorod system homogenous nanowires were deposited. A low magnetocrystalline phase in the as-deposited state was converted to the highly anisotropic $L1_0$ structure, exhibiting high coercivities *Hc* =128 kA/m.

implying a transformation from a high-temperature austenite cubic phase to a low-temperature tetragonal martensitic phase. The magnetization distribution in FePd single nanowires was found in a single domain state with the preferential easy axis of the magnetization orientated in a parallel direction to the wires; however, the magnetization easy axis in an FePd nanowire array was found to be in the perpendicular direction, due to the expressed dipole-dipole interactions. On the other hand, Co-Pt nanowires of the same morphology exhibited a unique quasi-periodic magnetization distribution due to the anisotropy interplay between the shape anisotropy and the two crystalline anisotropies originating from the Co-Pt fcc and hcp phases. Such nanowires represent suitable candidates for applications such as race-track memory devices. In the past year we have introduced a new field of multi-functional FePt-Au core/shell nanostructures suitable for novel magneto-photo medical curing. A suspension of FePt/SiO_2/Au core/shell nanoparticles in water was irradiated with a laser at the wavelength λ=810nm (P=1W) suitable for curing humans. A significant temperature increment of the media surrounding the nanoparticles was detected.

We reported on nitrogen-filled **hollow Co-Pt nanospheres** produced via pulsed-laser ablation (PLA) in ambient nitrogen gas. In this study we have demonstrated that by applying PLA in an ambient nitrogen gas the gas-filled hollow Co-Pt nanospheres can be successfully produced, where the composition of the particles is controlled by the Co-Pt target composition. By means of various techniques of transmission electron microscopy we aimed to characterize both the structure and the composition of synthesised nanospheres as well as to determine the nitrogen pressure inside the individual voids. The data was further employed for the reconstruction of the formation mechanism of Co-Pt gas-filled nanospheres and the suggestions for the general formation mechanism for gas-filled nanospheres in other metallic systems have been made.

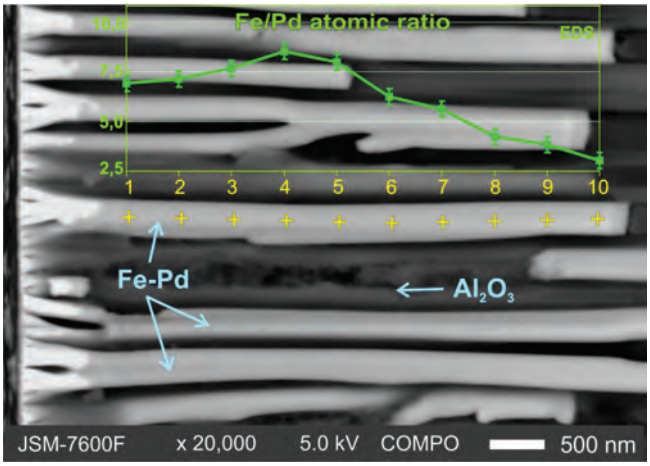

Figure 2: High-resolution FEGSEM micrograph of the Fe-Pd nanorods with superimposed diagram showing the variation of the atomic Fe/Pd ratio along the nanorod (points 1-10). The results were obtained from optimized low-voltage quantitative elemental EDS analysis with submicrometer analytical spatial resolution.

Highly coercive permanent Nd-Fe-B-based magnets were successfully developed from commercially available MQU-F rapidly quenched ribbons with optimized composition by wet coating with DyF_3 in isopropanol and subsequent spark plasma sintering and heat treatment. The highest H_{Ci} enhancement was obtained at 2.2 wt.% Dy-fraction, i.e., from 1580 to 2025 kA/m, which is a 25 % improvement. When more than 3 wt.% of Dy was added, the coercivity enhancement started to decrease, whereas at 4.8 wt.% the coercivity of the as-sintered magnet was lower than it was for the non-coated one and it was further decreasing with the annealing time. Based on the SEM results and the thermodynamic data on DyF_3 and NdF_3 formation enthalpies it appears that at a certain DyF_3 content a continuous NdF_3 layer starts to form that prevents Dy diffusion from the ribbons' interfaces. This explains an optimal addition of DyF_3. This innovative approach of manufacturing fully dense Nd-Fe-B magnets with enhanced coercivity and a gradient microstructure was patented at the European Patent Office under patent number 1556. The research was performed within the scope of the EU project ROMEO.

We investigated the magnetic exchange interaction on the basis of Wannier orbitals obtained from electronic structure calculated ab initio. The so-determined parameters may be applied in the density-matrix-renormalization-group (DMRG) method, which is efficient mainly for one-dimensional systems. Within the framework of the density-functional theory we explored the possibilities for the presence of non-stabilities and **complexities in the Ca-Ga-Cu phase diagram**. We also determined the influence of beryllium on the twin-boundary energy in spinel.

In 2013 we broadened the research work of structural materials within the frame of the **European fusion programme** from ceramic composites SiC/SiC to tungsten-containing composites. For samples preparation we used the same processing technique as for the SiC/SiC and we investigated the influence of the tungsten content on the properties of the W-Si-C composites in the range of low and high tungsten content. The results have confirmed that by optimisation of the process, a relatively high strength can be achieved in both regions.

One of the important research topics is the **electrophoretic deposition** (EPD) of various materials. Among them, in 2013, the main attention has been paid to silicon carbide, carbon nanotubes and polymer polyether-ether-ketone (PEEK). The highest green densities were achieved from aqueous suspensions with a high solids loading (>40 wt. %) and with the optimal addition of surface-active agents, providing that the electrical conductivity is

limited. Based on a comprehensive study of the deposits and suspensions before and after the deposition we explained the process for forming bulk SiC and PEEK parts.

In collaboration with Mechanical Engineer Faculty, UL, we were also dealing with the preparation of homogeneous PEE composites with nanoparticles (MoS_2, WS_2, CNT and graphene). The green parts were densified at various temperatures below and above the melting point and their wear properties were analysed. The results imply a significant influence of the processing temperature.

In the frame of the **project BioTiNet** (FP7-ITN) we continued with the analysis of the properties of **anatase (TiO_2) coatings**, grown by hydrothermal treatment on titanium alloys for bone-implant applications. In collaboration with the University of Barcelona, we confirmed the improved corrosion resistance of the coated alloys; moreover, we also verified the UV photo-induced properties of nanostructured TiO_2 coatings. The excellent photocatalytic activity of the firmly bonded coatings has been confirmed, as well as the UV photo-induced super-hydrophilicity, which appeared also as a prolonged effect (up to two weeks of recovery). In collaboration with the University in Sienna, the effect of the presence of the coating and its pre-irradiation with UV light on plasma protein adsorption have been studied, while in collaboration with the University of Giessen we verified the interaction with human cells. In continuation, the investigation will be completed by the analysis of the proposed bacteriostatic effect after UV pre-irradiation.

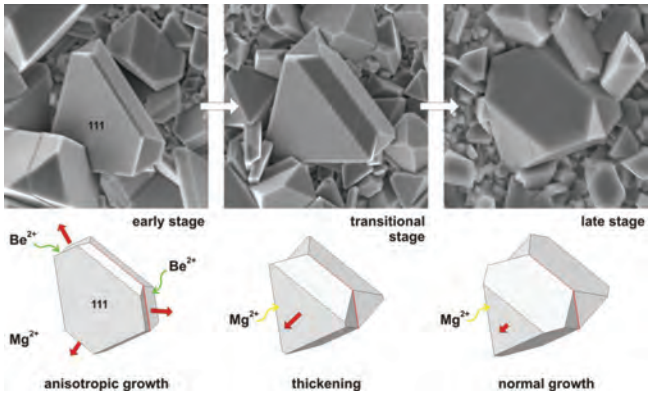

Figure 3: Development of (111) twin grains in MgAl2O4 spinel. Until the twin-boundary-forming dopant is available, the grains grow exaggeratedly along this boundary and consequently develop plate-like morphology unusual for the cubic spinel. Subsequently they thicken according to the normal grain growth Ostwald ripening law.

We prepared bioactive biodegradable scaffolds from composites of gellan gum reinforced with bioactive-glass nanoparticles, which helped to enhance the microstructure (pore size and interconnectivity), mechanical properties and formation of hydroxyapatite in simulated body fluid. Optimisation of the processing resulted in further improved mechanical properties by a better particles distribution in the polymer matrix and an increased amount of bioactive-glass reinforcement.

The investigations of materials for **biomedical application** involved the preparation and analysis of the scaffolds for hard-tissue engineering that is a topic of the COST action NAMABIO (From nano to macro biomaterials and applications to stem cells regenerative orthopaedic and dental medicine).

Within investigations of n-type **oxide thermoelectric materials** we synthesized Nb-doped $SrTiO_3$. The basic microstructure of solid-solution $Sr(Ti_{0.8}Nb_{0.2})O_{3-x}$ was modified in two ways: with the addition of $Sr_3Ti_2O_7$ nucleation seeds and/or with the addition of SrO-excess. $Sr_3Ti_2O_7$ seeds were synthesized by molten salt approach. In the case when excess SrO was added to a $Sr(Ti_{0.8}Nb_{0.2})O_{3-x}$ solid solution we obtained material that was composed of two phases, namely, $Sr(Ti_{0.8}Nb_{0.2})O_{3-x}$ and polytypic Ruddlesden-popper phases. More or less ordered single planar faults with the SrO structure were also observed in the perovskite matrix. Measurements of thermoelectric properties of so far synthesized materials showed that the achieved a ZT value of approximately 0.12.

In the field of oxide thermoelectric materials we studied the influence of the sintering method (pulse electric current sintering – PECS, microwave sintering) and doping with oxides of Al, Mn, Fe, Ce and Nd on the structure, microstructure development and thermoelectric characteristics of ceramics in the system $(ZnO)_xIn_2O_3$ (k = 5, 11).

Perovskite materials such as $SrTiO_3$ nanostructures are suitable for many applications such as oxygen sensing and tunable HTS (high temperature superconducting) microwave filters. The potential advantages of the nanostructured forms have been, however, scarcely explored compared to other oxides. The synthesis of perovskite $SrTiO_3$ nanostructures via sol-gel electrophoretic deposition (EPD) into anodic aluminium oxide (AAO) membranes has proven to be very successful and useful. When measuring the electrical properties of SrTiO3 nanotubes we obtained interesting scientific findings, which were published in the journal Materials Chemistry and Physics. In the article titled: "Insight into the structural, electrical and photoresponse properties of individual Fe:$SrTiO_3$ nanotubes" we reported on the structural and electrical properties of individual iron-doped strontium titanate nanotubes (Fe:$SrTiO_3$) grown by electrophoretic deposition (EPD). The Fe:$SrTiO_3$ nanotubes were assessed for the first time, showing high stability and reproducibility. This result paves the way to the further development of more complex titanate-based devices, as for instance nanostructured oxygen Fe:$SrTiO_3$ sensors. From the experimental data it was concluded that

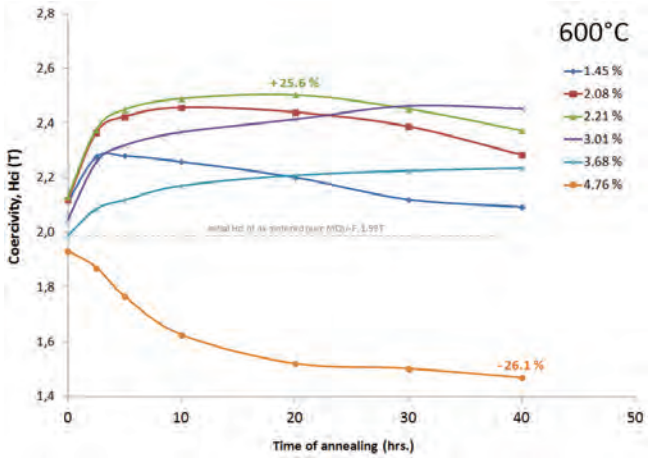

Figure 4: Coercivity dependence of spark plasma sintered and annealed MQU-F42 commercial alloy on addition of DyF_3 powder from isopropanol suspension

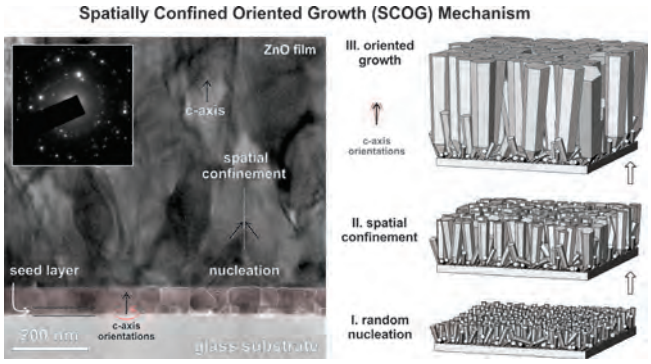

Figure 5: Cross-section TEM image of seed-layer and initial stages of film growth with illustrated SCOG mechanism. SCOG mechanism is expressed through three distinct growth stages: (i) random nucleation, (ii) spatial confinement, and (iii) oriented growth.

The influence of an organic vehicle and the amount of added varistor powder filler on the rheological characteristics of pastes and their screen-printing performance was studied. A paste with high solids load of 70% and good printing characteristics was developed and enables preparation of dense layers of varistor ceramics with good electrical characteristics at low sintering temperature of 900 °C, typical for the screen-printing hybrid circuit technology.

the polycrystalline form of Fe:$SrTiO_3$ nanotubes is the major limitation to attain high photoconductivity gains when exposed to UV-light.

We optimized parameters for the anodization of aluminium alloys. The obtained oxide layer was coloured by selected ion. In the case of copper ions we obtained a purple colour of oxide layer. This work was performed in cooperation with the department of thin films and surfaces (F3) and Impol industry.

In the field of **dye-sensitized solar cells** (DSSCs) we focused our research on the fabrication of high-efficient photo-anodes composed of TiO_2 nanotubes. A self-ordered, vertically aligned TiO_2 nanotubes, were grown on electropolished titanium foil by anodic oxidation in viscous organic electrolyte. By changing the anodization parameters (temperature, time, applied voltage, electrolyte composition) TiO_2 nanotube arrays with different morphologies were obtained. Some of the TiO_2 nanotubes were additionally treated with $TiCl_4$ or with TiO_2 P25. The prepared photo-anodes were assembled into flexible and nonflexible DSSCs. Measured current-voltage characteristics showed that the maximum energy conversion efficiency for flexible DSSCs was 2.1% and for nonflexible 5.9%.

We developed homogeneous coarse-grained low-voltage **ZnO-based varistor ceramics** doped with $Bi_4Ti_3O_{12}$ or $Bi_{12}TiO_{20}$ and other varistor dopants having breakdown voltage in the range from 20 to 40V/mm and nonlinearity coefficient α above 20. The development was based on the discovery that rapid decomposition of pre-reacted phases from the Bi_2O_3-TiO_2 system into TiO_2-rich Bi_2O_3 liquid phase enhances formation of inversion boundaries in the ZnO grains, which results in homogeneous grain growth and microstructure development.

Applications involving **transparent conducting films** (TCFs), such as flat-panel displays and touch screens technologies, are dominated by indium-tin-oxide (ITO). Increasing prices of indium makes a strong argument for alternative TCFs with competitive characteristics and lower price. We demonstrate the potential of highly oriented zinc oxide (ZnO) films grown on glass substrates under low-temperature hydrothermal (HT) conditions at 90 °C from aqueous solutions of Zn-nitrate and Na-citrate. Formation of a continuous ZnO seed-layer with proper thickness, grain size, connectivity and orientation of seed-grains on glass is shown to be essential to achieve conditions for the growth of highly oriented (0001), smooth, transparent and conductive ZnO films according to the spatially confined oriented growth (SCOG) mechanism. The film grown on a homogeneous seed-layer with grain size of about 20 nm showed optical transmittance of up to 82% and relatively low resistivity for undoped ZnO ceramic in order of few 100 Ω sq^{-1}. Such characteristics are explained by highly oriented crystalline texture and high coalescence of ZnO crystals in these films.

In collaboration with the company VARSI we continued the development of special varistors for overvoltage protection of renewable energy systems (solar panels and wind turbine generators). The result is new types of varistors with high stability under dc field for operation under harsh climate conditions (temperature, humidity).

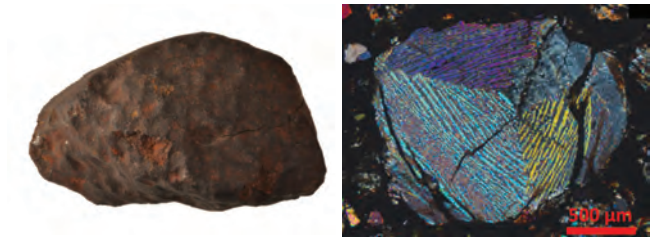

Figure 6:
Left – meteorite Jezersko (mass 1380 g)
Right – Typical barred olivine chondrule observed in cross-polarized light

In the development of cost-effective and **environment friendly photovoltaic systems** the Cu_2ZnSnS_4-type films (CZTS) showed very promising. CZTS is p-type semiconductor with preferred optical band gap at 1.5eV and high absorption coefficient made of well abundant and hence cheap elements, which are also nontoxic. We studied preparation of CZTS films by sol-gel spin coating and annealing in sulphur-rich atmosphere at 500°C on flexible metal substrates of Al, Ti, Cu and Mo.

In the field of **photocatalysis** we designed and fabricated Ti-foil based microreactor with titania nanotubes and anatase nanoparticles. Basic photocatalytic properties and design was published in ACS applied materials & interfaces (IF 5). Using this microreactor we performed series of experiments where we studied the mechanisms of degradation reactions for various types of organic substances. It was found that during the decomposition of organics containing chlorine the efficiency of the microreactor seriously decreased. With EPR measurements we tried to establish the mechanism of this phenomena, namely the chlorine could adsorb on the surface of nano-anatase particles and due to steric effects hindered the adsorption of the organic molecules or could produce chlorine radicals which are concurrent

to hydroxyl radicals. The photocatalysis of zinc oxide as a function of crystallinity and particle size was also studied and published in Applied Catalysis. B, Environmental (IF 5,8).

Self-assembly of Ge, Ni and Co quantum dots in amorphous silica matrix after the high-energy ions irradiation was investigated using electron microscopy and microanalysis. With co-workers we published series of 4 papers on self-organization of quantum dots. With the synthesis parameters we were able to prepare different superstructures. In collaboration with scientists from Portugal the influence of carbon nano-tubes addition to TiO_2 and morphologies if titania on photocatalytical degradation of caffeine were explained in papers published in Catalysis Today.

We synthesized and further investigated Cu-doped Fe-sulphides. With electron microscopy, X-Ray diffraction and magnetic measurements we showed the influence of copper on the first precipitate and on the subsequent phase transformations in FeS system. TEM investigation of Cu-doped mackinawite-like FeS showed enhanced crystallinity accompanied with expansion of the unit cell along the c-axis, proportional to the amount of Cu adsorbed between the (001) layers of the mackinawite structure. The subsequent solvothermal treatment and sulphurization of undoped FeS resulted in formation of pyrite, at low doping Cu-rich mackinawite and cubic (Fe,Cu)S with a sphalerite-type structure were formed, while at higher Cu concentrations the end-products were chalcopyrite and bornite, corresponding to the initial amount of Cu in the reagents. These mackinawite properties can be also used for sorption of Cu, Ni or Cr from degraded environment. The results of work were published in two scientific articles.

In the frame of the basic research project 'Twinning, epitaxies and phase transformations in minerals' we continued with nanostructural investigations of growth-type transformational defects in different systems. In the spinel-chrysoberyl system we confirmed our hypothesis that twinning in $MgAl_2O_4$ spinel is triggered by the addition of BeO. The results of this work are published in CrystEngComm (IF 3.879). In the rutile-hematite system we studied the mechanism of topotaxial transformation of ilmenite to rutile and hematite. These minerals are related through a common close-packed oxygen sublattice. While ilmenite and hematite have a rhombohedral symmetry, the rutile lattice is slightly tetragonally distorted. Under certain conditions, ilmenite transforms (oxidises) to rutile and hematite, where rutile lamellas precipitate along structurally defined crystal planes of the precursor and finally form reticulated network also known as sagenite. The products of ilmenite oxidation are common in nature and the reaction is also of technological importance for the production of rutile from ilmenite precursor. In the previous year we finished a study of topotaxial rutile-hematite intergowths from the locality Mwinilunga in Zambia, where we determined the crystallographic relationship between rutile and hematite and suggested a mechanism of their formation based on an extensive transmission electron microscopy study. A manuscript for the journal 'Contributions to Mineralogy and Petrology' is in preparation. In addition we started a detailed study of the ilmenite to rutile/hematite transformation mechanism at the atomic level. For this purpose we performed thermal or hydrothermal treatment of natural single crystals of ilmenite. The results show that different transformation mechanism exists based on the treatment technique. During hydrothermal treatment, transformation is based on the dissolution-precipitation mechanism, while during thermal treatment; the recrystallisation is based on the internal rearrangement of atomic within the rigid oxygen sublattice.

We successfully synthesised simple and complex twins of spinel, which proved that the ccp-hcp transformation is caused by the presence of beryllium at the (111) twin boundaries. At higher BeO additions we observed the formation of epitaxial overgrowths of spinel with $BeMg_3Al_8O_{16}$ taaffeite-type compounds. This finding has a potential applicative value since twinned spinel grains develop a plate-like morphology that may improve the mechanical properties of spinel-based ceramics.

Up to date three meteorites have been found on the territory of Slovenia, one stony and two iron types. The highly conserved stone meteorite named after the location Jezersko has recently joined to the collection of Slovenian meteorites. The detailed studies of the meteorite Jezersko, which were performed jointly at the Jožef Stefan Institute, Geological Survey of Slovenia, Faculty of Natural Sciences and the Museum for Natural History of Slovenia offers us an unique opportunity for in-depth understanding of the origin and evolution of our solar system in the last ~ 4.6 billion years. **Meteorite Jezersko** was registered into the database of all known meteorites in Lunar and Planetary Institute (Meteoritical Bulletin Database).

Within the ARRS project J2-4237 we have investigated the innovative materials using advanced methods of high-resolution scanning electron microscopy (FEGSEM) and quantitative elemental analyses by energy-dispersive and wavelength-dispersive X-ray spectroscopies (EDS, WDS). These methods were modified and improved for reliable materials characterization on submicrometer and nanometre-scale. Using the electron backscatter diffraction (EBSD) analysis we have investigated the crystallinity and the presence of quasicrystals in complex metallic alloys based on Al and Gd-Cu-Ca.

For industrial partners and other research institutions we have performed the analyses and expertise related to microstructural characterization of various materials which were included in

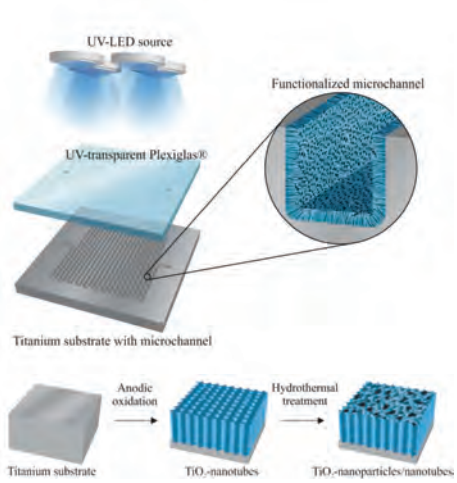

Figure 7: Schematic presentation of photocatalytic microreactor and its design and fabrication

Members of the department have also been active in the promotion of science. In 2013 we presented some of the achievements in the TV programme "Bite the Science". Under the umbrella of the Slovenian Society for Science and Engineering (SATENA) we organised the first two sets of popular lectures on science for general public ("Science on the street, knowledge and ideas on the go".

the research and development of new products. Main collaborations were realized with SwatyComet Maribor, Cinkarna Celje, Belinka Ljubljana, UL-NTF Department of Materials and Metallurgy, Ljubljana, RC SIMIT Kidričevo, Ortopedska Bolnišnica Valdoltra Ankaran.

One of the important research areas of the group is the implementation of various electron microscopy analytical techniques within **the existing EU project ESTEEM2**, such as electron energy-loss spectroscopy (EELS), high-resolution scanning transmission electron microscopy (STEM, HAADF-STEM) electron holography and mechanical preparation of the TEM samples. The research group is additionally strongly involved in managing of the Center for Electron Microscopy within the frame of the National Infrastructure Center for microstructural and surface analysis. Implementation of various electron microscopy analytical techniques and the possibility for researchers to access research infrastructure for electron microscopy is of utmost importance for numerous research institutions, industrial partners, as well as for graduate and post-graduate education.

Awards and appointments

1. Saša Novak Krmpotič, State (Zois) recognition of scientific achievements in the field of materials, Ljubljana, 22. 11. 2013
2. Nina Kostevšek, Kristina Žužek Rožman, Sašo Šturm, Spomenka Kobe, "Hybrid FePt/Au Nanoparticles With a Combined Magneto-Photothermal Effect", The best presentation among young researchers in the research field Nanomaterials and Nanotechnology, 21st Conference on Materials and Technology, Portorož, Slovenia, 13.–15. 11. 2013
3. Marja Jerič, Miran Čeh, "Molten salt synthesis of Nb-doped $Sr_3Ti_2O_7$ platelet seeds", The best poster among young researchers in the research field Nanomaterials and Nanotechnology, 21st Conference on Materials and Technology, Portorož, Slovenia, 13.–15. 11. 2013
4. Medeja Gec, Matic Krivec, Kristina Žagar, Luka Suhadolnik, Darja Jenko, Goran Dražić, Miran Čeh, "Comparison of TEM lamella preparation techniques on titania nanotube-arrays/metal Ti interface", MC2013 Best poster award in Instrumentation and Methods, at the MC2013 Microscopy Conference, Regensburg, Germany, 25.–30. 8. 2013
5. Sandra Drev, Aleksander Rečnik, Nina Daneu, "Twinning and inclusions in chrysoberyl from Pratinhas, Brazil", MC2013 Best poster award in Materials scince at the MC2013 Microscopy Conference, Regensburg, Germany, 25.–30. 8. 2013

Organization of conferences, congresses and meetings

1. 1st CalGadX Conference, Ljubljana, Slovenia, 12.–13. 12. 2013
2. 21st International Conference on materials and Technologies, Portorož, Slovenia, 13.–15. 11. 2013 (co-organisation)
3. C-MAC Days 2013, Ljubljana, Slovenia, 9.–12. 12. 2013 (members of Science Board and General Assembly in European integrated Center for the Development of New Metalic Alloys and Compounds (C-MAC))
4. EMAS 2013, 13th European Workshop on Modern Developments and Applications in Microbeam Analysis Porto, Portugal, 14.–18. 5. 2013 (members of Managing Board of European Microbeam Analysis Society)
5. Microscopy Conference 2013, MCM2013, Regensburg, Germany, 25.–30. 8. 2013 (members of International Advisory Board)
6. Fusion Expo: The Big Bang, UK Young Scientists & Engineers Fair, London, United Kingdom, 14.–17. 3. 2013 (co-organisation)
7. Fusion Hands on experiments at ECSITE Annual Conference, Gothenburg, Sweeden, 6.–8. 6. 2013 (co-organisation)
8. Fusion Expo: Science Days 2013, Rust, Germany, 10.–12. 10. 2013 (co-organisation)
9. Fusion Expo: Scientific Festival Week of Science and Technology 2013, Prague, Czech Republic, 1.–15. 11. 2013 (co-organisation)
10. Fusion Expo: Campus Drie Eiken, Antwerpen, Belgium, 21.–22. 11., 26.–27. 11. 2013 (co-organisation)

INTERNATIONAL PROJECTS

1. Services for the Exports
   Foreign Clients
   Dr. Zoran Samardžija
2. 7FP - MACAN; Merging Atomistic and Continuum Analysis of Nanometer Length-scale Metal-oxide Systems for Energy and Catalysis Applications
   European Commission
   Asst. Prof. Aleksander Rečnik
3. 7FP - 2020 Interface; Nanoscale of Tribological Interfaces for Clean and Energy-Efficient Diesel and Gasoline Power Trains
   European Commission
   Asst. Prof. Matej Andrej Komelj
4. 7FP - BioTiNet; Academic-Industrial Initial Training network on Innovative Biocompatible Titanium-based Structures for Orthopaedics
   European Commission
   Prof. Spomenka Kobe
5. 7FP - ESTEEM 2; Enabling Science and Technology through European Electron Microscopy
   European Commission
   Prof. Miran Čeh
6. 7FP - NANOPYME; Nanocrystalline Permanent Magnets Based on Hybrid Metal-Ferrites
   European Commission
   Asst. Prof. Paul John McGuiness
7. 7FP - Fusion Expo; Fusion Expo Support Action under EFDA Work Programme, Task Agreement WP10-PIN-FUSEX
   Ministry of Education, Science and Sport
   Asst. Prof. Saša Novak Krmpotič
8. 7FP - EURATOM; Review R&D on Materials - 4.1.1.2., WP11-DAS-MAT-M03-01/MHEST/PS
   Ministry of Education, Science and Sport
   Asst. Prof. Saša Novak Krmpotič
9. 7FP - ROMEO, Replacement and Original Magnet Engineering Options
   European Commission
   Prof. Spomenka Kobe
10. 4.1.1.-FU, EURATOM-MHEST; Development of W-Containing Composites
    Ministry of Education, Science and Sport
    Asst. Prof. Saša Novak Krmpotič
11. 4.1.2.-FU, EURATOM-MHEST; Development of W-Containing Composites
    Ministry of Education, Science and Sport
    Asst. Prof. Saša Novak Krmpotič
12. 7FP - MAG-DRIVE; New Permanent Magnets for Electric-Vehicle Drive Application
    European Commission
    Asst. Prof. Paul John McGuiness
13. MODEF - Creazione e Sperimentazione Congiunta di Modelli per l'Ottimizzazione dell'Utilizzo di Energia Fotovoltaica
    Unindustria Rovigo
    Dr. Zoran Samardžija
14. COST MP1005, NAMABIO; From Nano to Macro Biomaterials (Design, Processing, Characterization, Modelling) and Applications to Stem Cells Regenerative Orthopedic and Dental Medicine
    COST Office
    Asst. Prof. Saša Novak Krmpotič
15. Minerals as a Precursors for Advanced Technologies
    Slovenian Research Agency
    Asst. Prof. Nina Daneu
16. Microstructural Investigation of Materials for Hydrogen Storage and Correlation with Desorption Properties
    Slovenian Research Agency
    Asst. Prof. Sašo Šturm
17. Experimental and Theoretical Investigation of Hydrogen Sorption in Mg-Zr-Fe-Ni and Ti-Fe-Ni Systems
    Slovenian Research Agency
    Dr. Andraž Kocjan
18. The CALGAD-X Project: New Calcium-Gadolinium-X Complex Metallic Alloys
    Slovenian Research Agency
    Prof. Spomenka Kobe
19. Study of Chemical Strain in Perovskites Doped With Aliovalent Cations by Applying In-Situ X-Ray Diffraction, Dilatometry and Advanced Transmission Electron Microscopy Techniques
    Slovenian Research Agency
    Asst. Prof. Sašo Šturm

RESEARCH PROGRAM

1. Nanostructured Materials
   Prof. Spomenka Kobe

R&D GRANTS AND CONTRACTS

1. New Metallic Materials for Thermal Storage of Digital Information
   Dr. Andraž Kocjan
2. Near-net Shape Nanoparticle-Reinforced Polymer-Composites for Highly-Loaded Advanced Mechanical Components with Superior Tribological Performance
   Asst. Prof. Saša Novak Krmpotič
3. Novel Functionalized Nanomaterials for Applications as Nano- or Biosensors/Actuators/ Bioresponsive (Carrier) Systems
   Asst. Prof. Kristina Žužek Rožman
4. Twinning, Epitaxy and Phase Transformations in Minerals
   Asst. Prof. Nina Daneu
5. Electron Microscopy and Microanalysis of Materials on Submicrometer scale
   Dr. Zoran Samardžija
6. Hydrothermal Synthesis of Strongly Adhered TiO2 Photocatalytic Coatings on Metallic Substrates
   Asst. Prof. Goran Dražić
7. Microbial Adhesion Management on Material Surfaces
   Asst. Prof. Goran Dražić
8. Development of the Model of the System for Intelligent Support of the Selection of Suitable Powder Material when Developing Sintered Products
   Asst. Prof. Saša Novak Krmpotič
9. Modification of TiO2 Nanoparticle Surface: Prevention of Agglomeration and Preservation of Intrinsic Properties
   Asst. Prof. Aleksander Rečnik
10. Innovative Production Systems for Vaccines and Regenerative Medicine
    Asst. Prof. Aleksander Rečnik
11. High-coercivity Nd-Fe-B Bonded Magnets for Automotive Applications
    Prof. Spomenka Kobe
12. Protected Permanent Magnets for Advanced High-Temperature Applications
    Asst. Prof. Paul John McGuiness
13. Materials and Technologies for Applications of ZnO-based Thick Film Varistors and Oxide Thermoelectrics
    Asst. Prof. Slavko Bernik
14. Colour, Absorption and Protective Nanolayer Coatings for Aluminium alloy
    Prof. Miran Čeh
15. NSFM: Novel Smart Filtration Media
    Asst. Prof. Kristina Žužek Rožman
16. Advanced Methods and Technologies for Processing of a New Generation of ZnO-based Varistor Ceramics
    Asst. Prof. Slavko Bernik
17. Irradiation and Analysis of Si Samples
    Asst. Prof. Saša Novak Krmpotič
18. MODEF - Creazione e Sperimentazione Congiunta di Modelli per l'Ottimizzazione dell'Utilizzo di Energia Fotovoltaica
    Dr. Zoran Samardžija

NEW CONTRACTS

1. The Study of Self-cleaning and Abrasion Resisting Properties of Carbon-, Para-aramid- or Glass-fibre-based Composite Materials by Applying Photocatalytic and/or Mechanical Resistant Nanoparticles
   Asst. Prof. Sašo Šturm
2. Multipole Magnetisation of NdFeB Bonded Magnets for Rotor Application
   Prof. Spomenka Kobe
3. Cofinancing of the L2-4097 Application Project: High-coercivity Nd-Fe-B Bonded Magnets for Automotive Applications
   Prof. Spomenka Kobe
4. Cofinancing of the L2-4192 Application Project: Materials and Technologies for Applications of ZnO-based Thick Film Varistors and Oxide Thermoelectrics
   Asst. Prof. Slavko Bernik
5. Cofinancing the L2-4099 Application Project: Protected Permanent Magnets for Advanced High-Temperature Applications
   Asst. Prof. Paul John McGuiness

VISITORS FROM ABROAD

1. Prof. Bojana Obradović, Prof. Vesna Mišković-Stanković, Jovana Zvicer, Tehnološko-metalurški fakultet, Univerzitet u Beogradu, Belgrade, Serbia, 25. 1. 2013
2. Prof. Hiroshige Kikura, Tokyo Institute of Technology, Tokyo, Japan, 25. 2. 2013
3. Dr. Meltem Sezen, Sabanci University, Nanotechnology Research and Application Center, Istanbul, Turkey, 17.–22. 3. 2013
4. Dr. Guorong Li, Chinese Academy of Science, Shanghaj, China, 3.–7. 4. 2013
5. Samed Cetinkaya, Technology and R&D Application and Research Center, Mustafa Kemal University, Hatay, Turkey, 4. 4.–31. 12. 2013
6. Xiangkai Xiao, Chinese Academy of Science, Shanghai Institute of Ceramics, Shanghai, China, 3. 4.–30. 9. 2013
7. Prof. Jean-Marie Dubois, Institut Jean Lamour, Nancy, France, 20.–27. 2. 2013
8. Enrico Catalano, University of Piemonte Orientale "A. Avogadro", Laboratory of Biomedical and Dental Materials, Novara, Italy, 22. 4.–24. 5. 2013
9. Dr. Branko Matović, Institut za nuklearne nauke Vinča, Beograd, Serbia, 28. 4.–4. 5. 2013
10. Dr. Jakub Michalski and Marta Bojarska, Wydział Inżynierii Materiałowej Politechniki Warszawskiej, INMAT, Warszaw, Poland, 9. 5. 2013
11. Prof. Boštjan Markoli, Dr. Iztok Naglič, Faculty of Natural Sciences, University of Ljubljana, 9. 5. 2013
12. Alessia Bolla, Politecnico di Torino, Torino, Italy, 25. 5.–28. 7. 2013
13. Dr. Cesar de Julian Fernandez, Dr. Claudio Sangregorio, Dr. Elisabetta Lottini, Dr. Alberto Lopez Ortega, Consorzio interuniversitario nazionale per la scienza e tecnologia dei materiali - INSTM, Florence, Italy, 30.–31. 5. 2013
14. Dr. Alberto Bollero, María Jesús Villa, Dr. Julio Camarero, The Institute for Advanced Studies in Nanoscience - IMDEA, Madrid, Spain, 30.–31. 5. 2013
15. Dr. Irena Škulj and Uroš Bavdek, Magneti d.d. Ljubljana, Ljubljana, Slovenia, 30.–31. 5. 2013
16. Judit Almunia, Dr. Ana Belen Seoane, Ingeniería magnética aplicada s.l. - IMA s.l., Barcelona, Spain, 30.–31. 5. 2013
17. Prof. José Francisco Fernández, Dr. Adrián Quesada, Agencia estatal consejo superior de investigaciones científicas - CSIC, Madrid, Spain, 30.–31. 5. 2013
18. Dr. S. Erokhin, Dr. Dimitri Berkov, Verein zur förderung von innovation durch forschung, entwicklung und technologietransfer e.v. - INNOVENT, Jena, Germany
19. Dr. Mogens Christensen, Aarhus universitet - AU, Aarhus, Denmark, 30.–31. 5. 2013
20. Dr. Matylda Guzik, Dr. Stefano Deledda, Institutt for energiteknikk - IFE, Kjeller, Norway, 30.–31. 5. 2013
21. Dr. Bogi Bech Jensen, Muhammad Fasil, Danmarks Tekniske Universitet – DTU, Kongens Lyngby, Denmark, 30.–31. 5. 2013
22. Dr. Pilar Marín, Ana Aragón, Universidad complutense de Madrid - UCM, Madrid, Spain, 30.–31. 5. 2013
23. Prof. Jean-Marie Dubois, Institut Jean Lamour, Nancy, France, 5.–10. 5. 2013
24. Prof. Nazanin Emami, Arash Golchin, Fatima Nowshir, Silvia Suner, Stephan Schnabel, Alaleh Safari, Jorge Rituerto, Jinxia Li, Lule tekniska universitet, Lule , Sweden, 4. 6. 2013
25. Prof. Werner Mader, Institut für Anorganische Chemie – Univeristät Bonn, Bonn, Germany, 31. 7.–11. 8. 2013
26. Prof. Jean-Marie Dubois, Institut Jean Lamour, Nancy, France, 25.–28. 8. 2013
27. Dr. Claudia Silva, Faculdade de Engenharia da Universidade do Porto - FEUP, Porto, Portugal, 23.–27. 9. 2013
28. Dr. Adrian Silva, Faculdade de Engenharia da Universidade do Porto, Departemento de Engenharia Quimica, Porto, Potrugal, 20.–25. 8. 2013
29. Dr. Mehmet Ali Gülgün, Dr. Cleva Ow-Yang, Sabanci University, Istanbul, Turkey, 18.–23. 9. 2013
30. Prof. Peter van Aken, Max-Planck-Institut Stuttgart, Stuttgart, Germany, 19.–20. 9. 2013
31. Prof. Joachim Kleebe, Dr. Marc Rubat du Merac, Technische Universität Darmstadt, Darmstadt, Germany, 9.–12. 10. 2013
32. Dr. Gerhard Niedermayr, Rudolf Hartmann, Naturhistorisches Museum Wien, Vienna, Austria, 16.–17. 10. 2013
33. Dr. Allan Walton, Dr. Vicky Mann, Magnetic Materials Group (MMG), Metallurgy and Materials, University of Birmingham, Birmingham, United Kingdom, 1. 10. 2013
34. Dr. Katarina Ćirić, Dr. Jana Radaković, Institut of Nuclear Sciences Vinča, Belgrade, Serbia, 12.–17. 11. 2013
35. Prof. Mihály Pósfai, Univesity of Veszprem, Veszprem, Hungary, 20. 11. 2013
36. Prof. Monica Ferraris, Politecnico di Torino, Torino, Italy, 15. 11. 2013
37. Prof Jean-Marie Dubois, Institut Jean Lamour, Nancy, France, 5.–12. 10. 2013
38. Dr. Nikola Novaković, Dr. Jasmina Grbović Novaković, Dr. Ljiljana Matović, Sandra Kurko, Institut of Nuclear Sciences Vinča, Belgrade, Serbia, 29. 10.–4. 11. 2013
39. Prof. Jean-Marie Dubois, Dr. Vincent Fournee, Dr. Julien Ledieu, Dr. Emilie Gaudry, Dr. Merie-Cecile De Weerd, Dr. Pascal Boulet, Institut Jean Lamour, Nancy, France, 5.–13. 12. 2013

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BIBLIOGRAPHY

Original Article

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3. Sigrid Bernstorff, Václav Holý, Jan Endres, Václav Valeš, Jaroslav Sobota, Zdravko Siketić, Iva Bogdanović-Radović, Maja Buljan, Goran Dražić, "Co nanocrystals in amorphous multilayers - a structure study", *J. Appl. Crystallogr.*, vol. 46, no. 6, pp. 1711-1721, Dec. 2013.

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5. Maja Buljan *et al.* (13 authors), "Ge quantum dot lattices in Al_2O_3 multilayers", *J. nanopart. res.*, vol. 15, no. 3, pp. 1485-1-1484-13, 2013.
6. Maja Buljan *et al.* (11 authors), "Tuning the growth properties of Ge quantum dot lattices in amorphous oxides by matrix type", *J. Appl. Crystallogr.*, vol. 46, no. 5, pp. 1490-1500, 2013.
7. Maja Buljan, Nikola Radić, Iva Bogdanović-Radović, Zdravko Siketić, K. Salamon, M. Jerčinović, Mile Ivanda, Goran Dražić, Sigrid Bernstorff, "Influence of annealing conditions on the structural and photoluminescence properties of Ge quantum dot lattices in a continuous Ge + Al_2O_3 film", *Phys. status solidi, A Appl. mater. sci.,* vol. 210, issue 8, pp. 1516-1521, 2013.
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