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 the experimental and theoretical investigations of structures, the analyses of chemical compositions at the atomic level, and measurements and calculations of physical properties, all of which help us to improve the properties of micro- and nanostructured materials.

Head:
Prof. Spomenka Kobe

One-dimensional **Co-Pt-based nanostructures** were prepared via template-assisted electro-deposition into high-aspect-ratio track-etched polycarbonate membranes. Tubular nanostructures with a diameter of 200 nm and lengths of 1000–8000 nm were obtained directly, without any pore-wall functionalization, as was previously reported to be necessary in the literature. The mechanism of direct tube formation was attributed to the appropriate relative rates of the deposition and the diffusion of the Co^{2+} and Pt^{2+} ions into partially Au-covered pores. We found that diffusion is the rate-determining step of the electro-deposition process; therefore, the stoichiometry and the related properties can be controlled via the electrolyte composition. The highest obtained coercivity was H_C=670 kA/m, which makes these materials interesting for **advanced electronic and magnetic devices**, as media for **high-density magnetic recording** or as a potential **drug-delivery agent**. Furthermore, their large surface-to-volume ratio and Pt content would make them interesting for catalytically driven processes. Another ferromagnetic system, **Fe-Pd**, was successfully synthesized via the electro-deposition method and thin films as well as one-dimensional nanostructures were obtained. The reaction regime was found to be kinetically controlled; therefore, the stoichiometry and the related properties can be influenced via the applied voltage. This knowledge is extremely important since the $Fe_{50}Pd_{50}$ composition gives high coercivities, while the $Fe_{70}Pd_{30}$ composition is a **magnetic shape-memory alloy** capable of producing strains of 6-10 % in moderate magnetic fields.

One-dimensional Co-Pt-based fibril or tubular nanostructures were prepared via template-assisted electro-deposition with the highest coercivity H_C=670 kA/m. These materials can be used in advanced electronic and magnetic devices, and as media for high-density magnetic recording.

The combination of scanning electron microscopy (SEM, FEGSEM) and atomic force microscopy (AFM) was used to analyze the grain size, the distribution and the morphology of the nanoparticles in submicrometre thin films that were obtained by the electro-deposition and laser-ablation methods. An improved method of quantitative electron-probe microanalysis with wavelength-dispersive x-ray spectroscopy (WDXS) was applied for the analysis of the chemical composition of thin nanostructured ferromagnetic Co-Pt films. The results of the microanalysis allowed us to study and define the influence of the process parameters of electro-deposition on the thickness and the composition of Co-Pt films as well as to correlate the composition with the magnetic properties of the material.

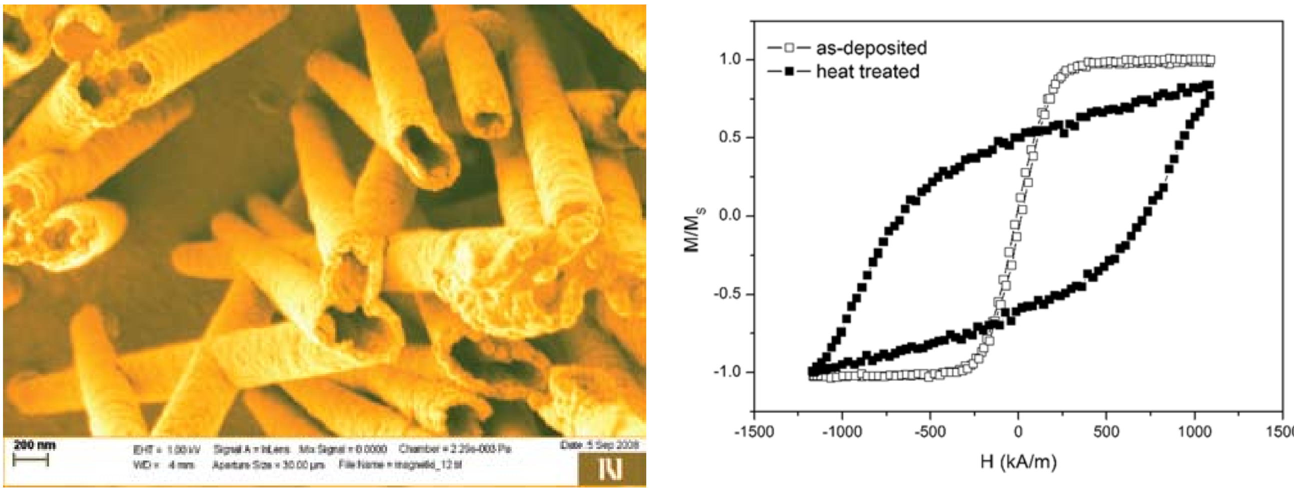

Figure 1: Co-Pt-based tubular structures synthesised with direct electroplating (left). Magnetic properties of the as-deposited Co-Pt-based nanotubes and the heat treated Co-Pt-based nanotubes (right).

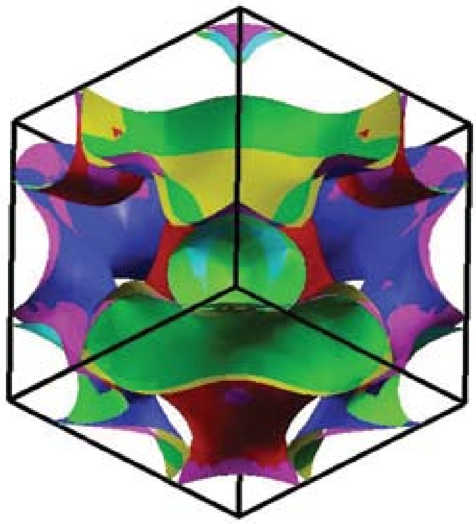

Figure 2: Picture of the Fermi surface (visualized with the program Xcrysden) for the majority spin states in the magnetocaloric alloy $LaFe_{13}$

We found a new composition of quasicrystal phase (i-phase), $Ti_{58}Zr_{24}Ni_{18}$, which has not been reported previously. This material absorbed the largest amount of hydrogen of all our samples, up to 2.4 mass percent.

We continued our work on **quasicrystals** as a promising material for **hydrogen storage** by performing melt-spinning experiments on Ti-Zr-Ni-Cu alloys with various compositions: $Ti_{40}Zr_{40}Ni_{20}$, $Ti_{45}Zr_{38\text{-}x}Ni_{17}Cu_x$ (x=3.5), $Ti_{53}Zr_{27\text{-}x}Ni_{20}Cu_x$ (x=3.5) and $Ti_{58}Zr_{24\text{-}x}Ni_{18}Cu_x$ (x=3.5). We were mainly interested in the formation of the icosahedral quasicrystalline phase (the i-phase). From previous studies we know that the optimal cooling rate for i-phase formation is at a wheel speed of 22 m/s. Using this technique we prepared a series of samples under identical conditions, varying only the composition. XRD results showed that the i-phase is formed across a relatively wide range of compositions. Also, with increasing content of titanium from the ideal value (40 at.%) the content of crystalline phases increases (the hexagonal C14 Laves phase and the FCC cubic (Ti, Zr) solid solution). Doping with copper, in general, does not contribute to a higher i-phase content. With a higher titanium-to-zirconium ratio the quasicrystalline lattice constant a_q is linearly decreasing. A **new composition of i-phase** was found, i.e., $\mathbf{Ti_{58}Zr_{24}Ni_{18}}$, which to the best of our knowledge has not been reported previously. This material absorbed the largest amount of hydrogen of all our samples, up to **2.4 mass** percent. Using XPS analysis we determined that the thickness of the oxide layer containing TiO_2 and ZrO_2 in the surface of melt-spun ribbons was 5 nm. Using mass spectrometry we analysed the desorbed hydrogen and discovered that the **bonding energy of the hydrogen** depends only on the structure of the material, and not on the composition, nor on the content of bonded hydrogen.

In the frame of the EU MNT-ERA.Net project "Hydrogen-impermeable nano-material coatings for steels" (Hy-nano-IM) we investigated the possibility of producing **hydrogen-impermeable coatings** for steels for the long-term storage and transport of gaseous and liquid hydrogen. Initial efforts have been focused on depositing diamond-like carbon (DLC) layers, either directly onto a steel substrate, or in combination with a chromium layer, to improve the adhesive properties. High-resolution transmission electron microscopy has been employed to investigate the layer thickness and the state of the boundaries between the steel, chromium and DLC.

The technologically interesting properties of materials were studied within the framework of the density-functional theory. We focused on **calculations of the transport properties** in the approximants of quasicrystals and the alloys which exhibit magnetocaloric effect by applying the semi-classical Boltzman theory and the relaxation-time approximation.

In the field of intermetallic alloys with **magnetocaloric properties** we continued our research by studying iron substitutions in the matrix phase. We observed very significant differences in terms of the macrostructures, microstructures and magnetic properties. The matrix phase with the $\mathbf{Gd_5(Si,Ge)_4}$ composition and no iron addition is gradually replaced by the new matrix phase $Gd_5(Si,Ge)_3$, when substituted with iron. The iron contributes mainly to the grain-boundary phases that are formed and to a change in the relative amounts of Si and Ge in the matrix phases. The final properties are strongly dependent on the element that is substituted. This also affects the transition temperature of the alloy. The low losses and the broad **ΔS peak** suggest that the first-order transition is suppressed when substituting germanium. However, this is not the case when substituting silicon. Here, a sharp peak and large hysteresis losses are present. The TEM study confirmed the presence of twins in the $Gd_5Si_2Ge_2$ sample and revealed the presence of features not seen previously in the iron-containing sample, such as amorphous regions, dislocations, planar faults and crystallographically related grains.

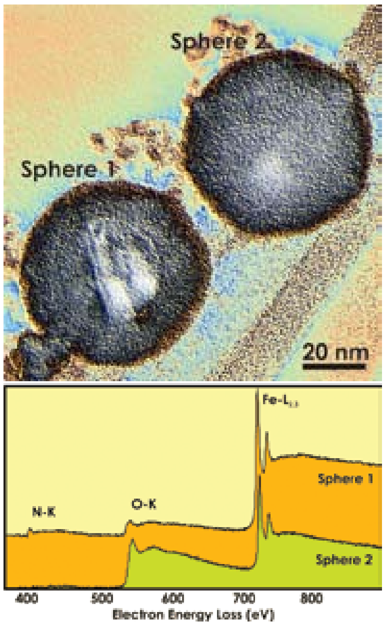

Figure 3: Above: TEM image of two representative in-situ nitrogenated Sm-Fe-based nanospheres prepared by PLD: one amorphous and the other with a core-shell structure, where the amorphous rim and the crystalline core can be differentiated. Below: EEL spectra confirming that the nitrogen is associated only with the core-shell-type of nanospheres.

Nanostructured magnetic-based materials, such as in-situ-nitrogenated Sm-Fe-based **magnetic nanospheres** prepared by pulsed-laser deposition (PLD), were investigated by employing state-of-the-art techniques of TEM. The magnetic response of individual nanospheres was detected and quantified for the first time in this system by applying **electron holography**. The development and implementation of electron holography is part of the **EU project ESTEEM**. The electron energy-loss spectroscopy (EELS) technique was implemented to study multilayer coatings based on the Ti/Al/Cr/V-N system. By using **spatially resolved EELS** we were able to simultaneously detect and quantify the amount of N and the related electronic structure in the investigated phases, enabling us to trace the compositional and structural differences across the interfaces localized over only a few nanometres. In the Zn-Mn-O system the thermal evolution of spinel phases was found to be induced by the Mn(IV) to Mn(III) reduction

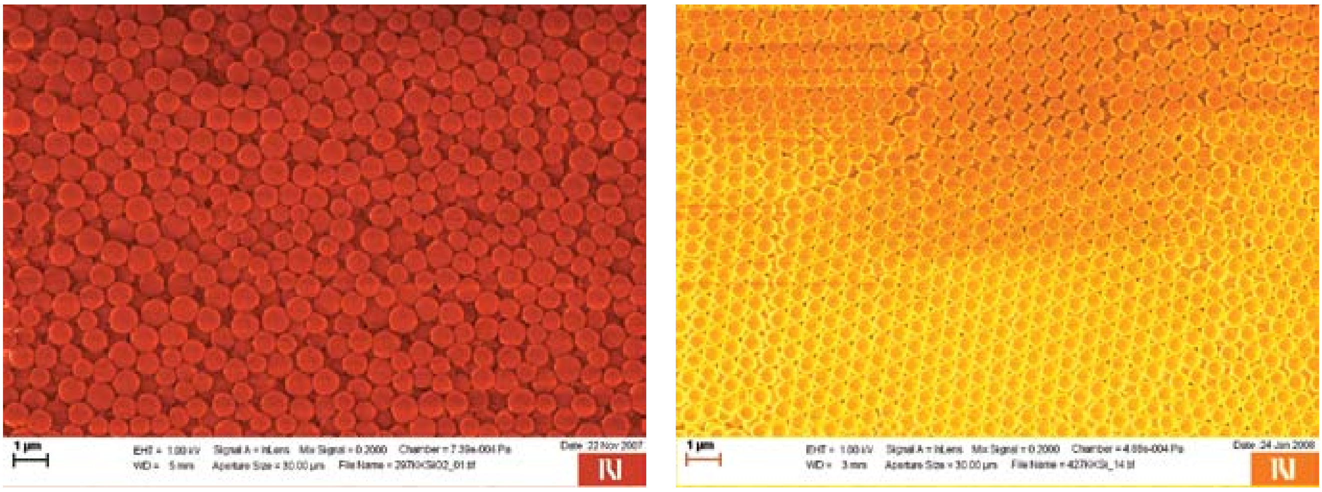

Figure 4. Random structure (left) and well-ordered structure (right) of nanosized SiO_2 in a deposit processed by electrodeposition. The ordering was achieved by adjusting the surface charge of the particles (Collaboration with NICS).

process. This phenomenon was successfully experimentally verified by tracing the Mn^{4+}/Mn^{3+} ratio of the spinel phases sintered at different temperatures by a detailed fine-structure analysis of the EELS $Mn\text{-}L_{2,3}$ ionization edges. We also studied doped anatase nanowires using HRTEM and EDXS. By combining electrical measurements with TEM studies a potential use of nanostructured anatase for Li-based batteries was successfully demonstrated.

Our research work also involves **colloidal processing**, which enables us to prepare composite materials with improved properties as well as to develop new forming techniques. Based on a comprehensive study of the electrokinetic behaviour of the fine particles and fibres we developed an efficient electric-field-assisted technique for the infiltration of thick ceramic fibre-fabrics with ceramic particles and hence to prepare **composites SiC_f/SiC** and **C_f/SiC**, which are being developed as part of a collaboration within the European Fusion Research Programme and with the French Atomic Energy Agency, CEA. The electrophoretic deposition technique has also been employed for the deposition of a **thin bioglass coatings** on metallic body implants and, in collaboration with National Institute of Chemistry, Ljubljana, for the assembly of monodispersed SiO_2 nanospheres as well as for the separation of the inclusion bodies used as therapeutic agents from the bacteria matrix.

A part of the research within the EU 6FP project **MEDDELCOAT** has been focused on the synthesis and study of **bioactive titania coatings** on Ti6Al4V body implants that should, in particular, prevent the diffusion of toxic elements (Al, V) from the alloy into the body. A layer of anatase, up to 1 µm thick, has been successfully synthesized by hydrothermal treatment and proved to beneficially affect the wetting behaviour as well as a the cells' response.

We continued the research and development of new fusion-relevant materials within the **European fusion programme** Euratom. The first batch of fibre-reinforced composite samples for neutron irradiation has been prepared and in collaboration with the Department for Reactor Physics irradiated in the TRIGA reactor and analyzed for their activation. It has been proved that the activations were lower than those for the other available fusion-relevant materials. Lately, the most attention has been paid to the required increase in thermal conductivity, which we have tried to increase by the incorporation of tungsten or carbon nanotubes.

The nucleation and crystallization of various **nanomaterials** were investigated using analytical electron microscopy. In collaboration with different research groups from Slovenia, Croatia, Greece and Portugal we studied the evolution of particles in NiO, SiO_2, InN, CeO_2 and TiO_2. Using high-resolution electron microscopy and Z-contrast imaging we determined the quantity, morphology and the position of the nanoparticles of Pt and Au on matrix CeO_2-TiO_2 used as a material for catalysis. We also studied the development and the structure of ZnO nanoparticles and the formation of mesoporosity in SiO_2 gels. Together with our industrial partner Cinkarna Celje we investigated the chemical composition and the structure of nanometre-sized Al_2O_3-SiO_2 coatings on the top of **TiO_2 rutile particles**, which improve the optical and chemical properties of the pigment. We found that at the coating–rutile particle interface there is a very thin layer (a few atomic layers thick) of alumina. Based on these results the technological procedure during the fabrication of the rutile pigment was optimized.

In the field of the **nanostructural engineering** of semiconducting materials we have shown in several polycrystalline materials that special boundaries are responsible for anisotropic and exaggerated grain growth. The most common types of special boundaries in semiconducting materials are the so-called inversion boundaries (IBs), which form with the addition

The magnetic response of individual nanospheres of Sm-Fe-Ta-N was detected and quantified for the first time by applying electron holography. The development and implementation of electron holography is part of the EU project ESTEEM.

Composite materials with improved properties were prepared by using colloidal processing. In the frame of the European fusion research programme we developed an efficient electric-field-assisted technique for the infiltration of thick ceramic fibre-fabrics with ceramic particles and hence to prepare composites of SiC_f/SiC and C_f/SiC.

of specific dopants. By understanding the structure and formation mechanism of these defects it is possible to correlate their atomistic structure and chemistry with exaggerated grain growth and the final physical properties of the material. This bottom-up approach provides the means for the nanostructural engineering of electronic devices based on these materials. The synthesis of **ZnO nano- and microstructures** was studied by using the solid-vapour thermal sublimation methods. Different structures were prepared on either monocrystalline Si(111) or polycrystalline Al_2O_3 substrates. The influence of processing parameters on the morphology of the ZnO structure was investigated. The processing parameters for the reproducible synthesis of either ZnO tetrapodes or arrays of ZnO nanorods were determined. Also, the synthesis of ZnO nanopowder from water solutions with different concentrations of Zn-acetate using a combination of spray-drying and the decomposition of Zn-acetate powder to ZnO, either by conventional or microwave calcinations, was studied. The advantages of microwave calcinations resulted in the preparation of uniform ZnO powder with the size of the spherical particles being about 80 nm and the crystallite size being about 20 nm. Based on studies of **ZnO ceramics** doped with only up to several 1000 ppm of Bi_2O_3 and Sb_2O_3 we determined the conditions for tailoring the microstructure using the IB-induced grain-growth mechanism. We prepared a fine-grained and, like the first one, also a coarse-grained ZnO ceramic doped with Bi_2O_3 and Sb_2O_3, with an average grain size much larger than in pure ZnO, sintered under the same conditions. Consequently, we were able to prepare low-doped varistor ceramics with the addition of only about 3 wt.% of varistor dopants (typical additions are about 10 wt.%) with the grain size in the range from 22 μm to 7 μm, the breakdown voltage from 100 V/mm to 330 V/mm and the nonlinearity between 30 and 50. The synthesis of conductive **polymer composites** was also studied. Using thermal curing of the mixtures from a polyethylene powder (matrix) and varistor powder (filler), varistor-type polymer composites with current-voltage nonlinearity expressed in the nonlinear coefficient ranging from 9 to 17, depending on the amount of filler and the curing temperature, were prepared. Also, **hollow varistors** with lengths from 30 to 60 mm, outer diameter 10 to 25 mm and wall thickness from 2 to 4 mm, were successfully prepared using slip-casting technology of a varistor water suspension into a gypsum mould.

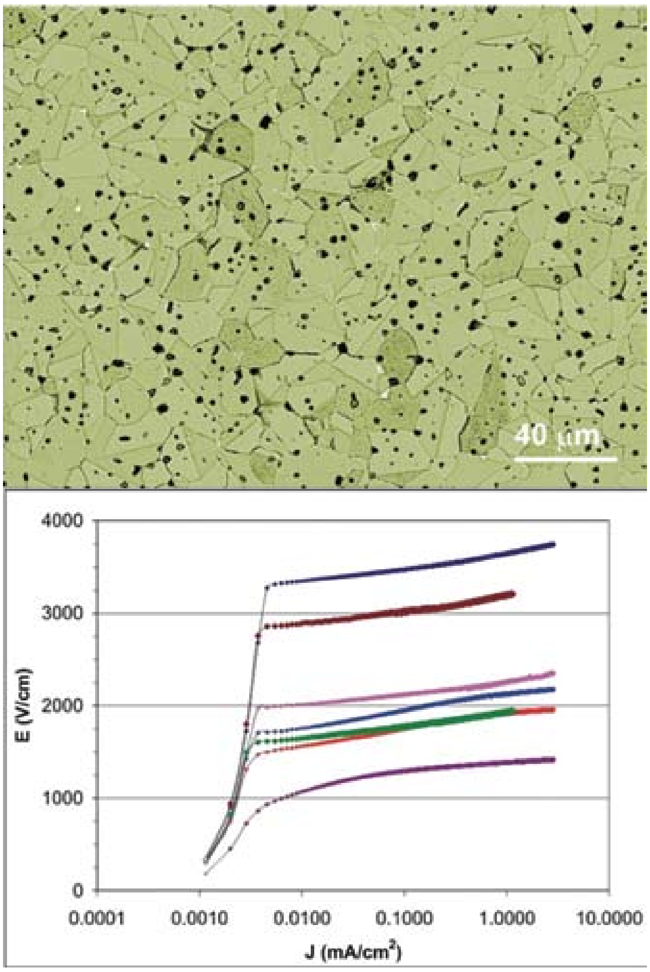

Figure 5: Tailoring the microstructure using an inversion-boundary-induced grain-growth mechanism enabled us to prepare ZnO varistor ceramics with the desired grain size. These ceramics have excellent varistor characteristics expressed by the current-voltage coefficient of nonlinearity in the range from 30 to 50, and the breakdown voltage in the range from 100 V/mm to more than 300 V/mm, depending on the ZnO grain size, which is in the range from 7 μm to 22 μm.

Perovskite $BaTiO_3$ **nanorods** and $SrTiO_3$ **nanotubes** were synthesized by sol-gel electrophoretic deposition into track-etched hydrophilic polycarbonate (PC) membranes and/or anodic aluminium oxide (AAO) membranes. The stability of the sols and the optimization of the parameters for the electro-deposition was a prerequisite for successful synthesis. The obtained nanorods and nanotubes were polycrystalline in nature with diameters ranging from 100 to 250 nm and grain sizes from 25 to 50 nm. Electron diffraction studies and high-resolution TEM revealed that the $BaTiO_3$ nanorods consist of all three polymorph structures (cubic, tetragonal and hexagonal), while the $SrTiO_3$ nanotubes possess a cubic structure. Hydrothermal synthesis was used to synthesize $BiFeO_3$, goethite and hematite in various nanosized morphologies. **Multiferroic** $BiFeO_3$ and hematite were obtained in the shape of isotropic nanocubic crystals, while goethite was prepared as nanorods. The aspect ratio of the goethite nanorods was controlled by varying the concentration of Bi^{3+} ions in the reaction. The observed stacking faults in the hematite may indicate potential sites for additional Bi^{3+} incorporation, suggesting a possible mechanism for the synthesis of **nanosized** $BiFeO_3$ in **anisotropic morphologies**.

One of the important research areas of the group is the **implementation** and **development** of various **electron microscopy analytical techniques** within the existing EU project ESTEEM, such as electron energy-loss spectroscopy (EELS), high-resolution scanning transmission electron microscopy (STEM, HAADF-STEM), electron holography and the mechanical preparation of TEM samples. In atomically resolved HAADF-STEM we were among the first to show, on the model ceramic materials $CaTiO_3$, $SrTiO_3$ and $BaTiO_3$, that the local lattice distortions, apart from chemical composition, significantly influence experimentally determined intensities of single-atom columns. Furthermore, we showed that realistic values of the Debye-Waller factor for atoms comprising the investigated structure (interface, planar fault, etc.) are needed for an exact quantitative interpretation of the experimental HAADF-STEM intensities. Only then can the intensities of atom columns in the simulated images correspond to true values and can they be successfully compared with the intensities in simulated images. The research group is additionally heavily involved in managing the **Center for Electron Microscopy** within the frame of the national infrastructure Center for Microstructural and Surface Analysis. The implementation of various electron microscopy analytical techniques and the possibility for researchers to access a research infrastructure for electron microscopy is of utmost importance for numerous research institutions, industrial partners, as well as for graduate and post-graduate education.

Hydrothermal synthesis was used to synthesize $BiFeO_3$, goethite and hematite in various nanosized morphologies. Multiferroic $BiFeO_3$ and hematite were obtained in the shape of isotropic nanocubic crystals, while goethite was prepared as nanorods.

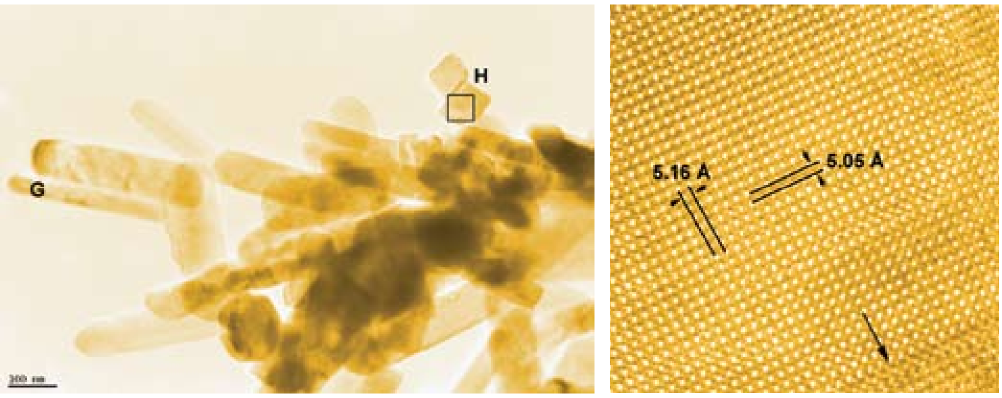

Figure 6: (left) Goethite (G) nanorods and hematite (H) nanocubes after 1 week of hydrothermal reaction. (right) HRTEM of hematite with stacking faults (denoted by arrow).

The most important technological achievements in the past year

1. Novak, Saša, Rade, Katja, Koenig, Katja, Boccaccini, Aldo R. Electrophoretic deposition in the production of SiC composites for fusion reactor applications, J. Eur. Ceram. Soc., 28 (2008)14, 2801-2807.
2. Cefalas, Alciviadis-Constantinos, Kobe, Spomenka, Dražić, Goran, Sarantopoulou, Evangelia, Kollia, Zoe, Stražišar, Janez, Meden, Anton. Nanocrystalization of $CaCO_3$ at solid/liquid interfaces, Appl. surf. sci., 254 (2008)21, 6715-6724.
3. Kocjan, Andraž, McGuiness, Paul J., Rajić Linarić, Maša, Kobe, Spomenka. Amorphous-to-quasicrystalline transformations in the Ti-Zr-Ni and Ti-Hf-Ni systems, J. alloys compd., 457 (2008)1/2, 144-149.
4. Srećković, Tatjana, Bernik, Slavko, Čeh, Miran, Vojisavljević, Katarina. Microstructural characterization of mechanically activated ZnO powders, J. Microsc. (Oxf.), 232 (2008)3, 639-642.
5. Lazar, Petr, Šturm, Sašo, N-K electron energy-loss near-edge structures for TiN/VN layers : an ab initio and experimental study, Anal. bioanal. chem., 390 (2008)6, 1447-1453.

Patent granted

1. Tool for measuring magnetic properties at high temperatures
   Paul J. McGuiness, Gregor Geršak, Spomenka Kobe
   patent US7368906 B2

Awards and Appointments

1. Katja Koenig: "Influence of the suspension stability on the electrophoretic deposition of nanosized alumina and silica"; 3rd Best Poster Award, HOT NANO TOPICS 2008, Workshop "Functional nanostructures and particles", Portorož, 26-30 May 2008.
2. Katarina Rade: "Hungry Bacteria Was Here". 3rd Best nanoArt Contribution at the HOT NANO TOPICS 2008, Portorož, 23-30 May 2008, for the nanoArt photo of the Hydroxyapatite precipitated from simulated body fluid on bio-glass substrate.

Organization of conferences, congresses and meetings

1. WomenInNano Winter School, Kranjska Gora, Slovenia, 5–8 Feb. 2008
2. Hot Nano Topics 2008 incorporating SLONANO2007; 3 overlapping workshops on current hot subjects in nanoscience, Portorož, Slovenia, 23–30 May 2008 (co-organisation)
3. 1st International Conference on Materials and Technology sponsored by FEMS and IUVSTA, Portorož, Slovenia, 13–15 Oct. 2008 (co-organisation)
4. European School in Materials Science: Properties and Application of Complex Metallic Alloys, Ljubljana, Slovenia, 26–31 May 2007 (co-organisation)
5. 20th Workshop on rare Earth Permanent Magnets and Applications, REPM ‘08, Heraklion, Crete, Greece, 8–10 Sept. 2008 (member of International Scientific Board)

INTERNATIONAL PROJECTS

1. Development of Composites with Advanced/Alternative Manufacturing Concepts: Vacuum slip inflitration of SiC/SiC - 4.1.2. FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Goran Dražič, Asst. Prof. Saša Novak Krmpotič
2. Develošment of functional material for insulating flow channel inserts: Ceramic Processing of SiC Composites for Functional Application - 4.1.1. FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič, Asst. Prof. Goran Dražić
3. Research Unit - Administration and Services - RU-FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič, Prof. Milan Čerček
4. FUSEX: Fusion Expo Support Action
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič, Melita Lenošek
5. SiC/SiC composite for structural application in fusion reactor, WPO08-09-MAT-SiSiC, EUROATOM-MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA, FU07-CT-2007-00065
   Asst. Prof Goran Dražić
6. Multifunctional Bioresorbable Biocompatible Coatings with Biofilm Inhibition and Optimal Implant Fixation
   MEDDELCOAT
   6. FP, NMP3-CT-2006-026501
   EC; Prof. Jozef Vleugels, Katholieke Universiteit Leuven, Research & Development, Leuven, Belgium
   Asst. Prof. Saša Novak Krmpotič
7. Enabling Science and Technology through European Electron Microscopy
   ESTEEM
   6. FP, 026019
   EC; Prof. Gustaaf Van Tendeloo, Universiteit Antwerpen, Antwerpen, Belgium
   Asst. Prof. Miran Čeh, Dr. Sašo Šturm
8. Complex Metallic Alloys
   CMA
   6. FP, NMP3-CT-2005-500140
   EC; Centre National de la Recherche Scientifique, Paris, France
   Prof. Spomenka Kobe, Prof. Janez Dolinšek, Dr. Peter Panjan
9. Strengthening the Role of Women Scientists in Nano-Science
   WOMENINNANO
   6. FP, SAS6, 016754
   EC; Dr. Annett Gebert, IFW Dresden, Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden E.V., Dresden, Germany
   Prof. Spomenka Kobe
10. Hydrogen Impermeable Nano-material Coatings for Steels
    Hy - Nano – IM
    MNT ERA NET
    Dr. Paul McGuiness
11. Development of Ceramic Matrix Composite for Advanced Nuclear Applications, with an SiC Continuous Fiber Reinforcement and a Nanostructured Carbide Matrix, Processes by the Electrophoretic Infiltration
    1000-07-380046
    Dr. Jérôme Canel, Commissariat à l'énergie atomique - CEA Saclay, Gif-sur-Yvette, France
    Asst. Prof. Saša Novak Krmpotič
12. Influence of Quantum Effects on Vibrational Properties of Nano-crystalline Silicon
    BI-HR/07-08-028
    Dr. Davor Gracin, Rudjer Boškovic Institute, Zagreb, Croatia
    Asst. Prof. Miran Čeh
13. Enviromental Hydrogen-based Recycling of Nd-Fe-B magnets
    BI-CN/05-07/008
    dr. Gaolin Yan, Harbin Institute of Technology, ShenZhen Graduate School, HIT Campus of ShenZhen University Town, ShenZhen, China
    dr. Paul McGuiness
14. Structural and Chemical Characterization of Titanate-based Nanorods and Nanotubes
    BI-CN/07-09-006
    Prof. Hui Gu, Shanghai Institute of Ceramics, Shanghai, China
    Asst. Prof. Miran Čeh
15. Synthesis and Characterization of Nanostructured Catalytic Materials
    BI-PT/08-09-003
    Dr. Adrian M.T. Silva, Associated Laboratory LSRE/LCM, FEUP-University of Porto, Porto, Portugal
    Asst. Prof. Goran Dražić
16. Development of Single Crystalline and Electroceramic Materials by Sintering Process
    BI-TR/05-08-002
    Prof. Mehmet Ali Gülgün, Sabanci University, Orhanli Tuzla, Istanbul, Turkey
    Asst. Prof. Miran Čeh
17. Texturing and Characterisation of ZnO-based Ceramics
    BI-TR/05-08-003
    Prof. Ender Suvaci, Anadolu University, Department of Materials Science and Engineering, Eskisehir, Turkey
    Dr. Slavko Bernik
18. ZnO-Nanostructures for Novel Applications
    BI-RS/08-09-015
    Dr. Zorica Branković, Center for multidisciplinary studies, Belgrade, Serbia
    Dr. Slavko Bernik
19. Development of fusion relevant ceramic matrix composites,BI-GB/08-007
    prof. dr. Aldo Boccaccini, Imperial College London, Department of Materials, London, UK
    doc. dr. Saša Novak Krmpotič

R & D GRANTS AND CONTRACTS

1. Fabrication of novel thin films by pulser-laser ablation with in situ ICP-MS analysis of target plumes for deposition control
   Prof. Spomenka Kobe
2. Nanostructural engineering of semiconducting materials
   Dr. Aleksander Rečnik
3. A development of low-activation material for the first wall in fusion reactor
   Asst. Prof. Saša Novak Krmpotič
4. The influence of magnetic structure of the materials on the magnetocaloric effect
   Dr. Matej Andrej Komelj
5. Ecotechnological 1D nanomaterials: Synthesis and characterisation of 1D titanate nanomaterials doped with transition metal ions
   Dr. Polona Umek, Dr. Sašo Šturm
6. Physics and chemistry of interfaces of nanostructured metallic materials
   Asst. Prof. Miran Čeh
7. Low-doped ZnO-based ceramics for energy varistors
   Dr. Slavko Bernik

8. Hard magnetic Co-Pt thin films produced with electrodeposition
Prof. Spomenka Kobe, Dr. Kristina Žužek Rožman
9. Development of ceramic matrix composite for advanced nuclear applications, with an sic continuous fiber reinforcement and a nanostructured carbide matrix, processes by the electrophoretic infiltration
Dr. Saša Novak Krmpotič

RESEARCH PROGRAM

1. Nanostructured materials
Prof. Spomenka Kobe

VISITORS FROM ABROAD

1. Aidan Taylor, Erich Smid Institut für Materialwissenschaft und Montanuniversität Leoben, Leoben, Austria, 28 Jan. to 1 Feb. 2008
2. Dr Davor Gracin, Institut Rudjer Bošković, Zagreb, Croatia, 30 Jan. 2008
3. Prof. Marie-Geneviève Barthes-Labrousse, CNRS, Centre d'Etudes de Chimie Metallurgique, Vitry Cedex, France, 5–6 Feb. 2008
4. Karl Höhner, Temas AG, Arbon, Switzerland, 5–6 Feb. 2008
5. Prof. Aldo Boccaccini, Imperial College London, London, United Kingdom, 24 May 2008
6. Dr Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 25–30 May 2008
7. Prof. Mihaly Posfai, Ilona Kósa and Dorottya Sára Csákberényi Nagy, University of Pannonia, Veszprém, Hungary, 24–25 May 2008
8. Prof. Michael Coey, Trinity College, Dublin, Ireland, 30–31 May 2008
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11. Prof. J.-M. Dubois, CNRS, Ecole de Mines, Nancy, France, 9 Feb. 2008
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13. Dr Mehmet Ali Gülgün, Sabanci University, Istanbul, Turkey, 1 Oct. 2008 to 28 Feb. 2009
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16. Prof. J.-M. Dubois, CNRS, Ecole de Mines, Nancy, France, 30 Sept. to 1 Oct. 2008
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THESIS

B. Sc. Thesis

1. Vesna Papež, *Electrochemical deposition of hard magnetic Co-Pt-based thin films* (Prof. Boris Pihlar, Dr. Kristina Žužek Rožman)