ADVANCED MATERIALS

The study of the soft magnetic composites with ferrite as an insulation part.
supervisor: doc. RNDr. Ján Füzer, PhD.
study form: full time
Annotation: The study is oriented on investigation of the NiFe and FeSi based composite materials with ferrite as a nonconductive binder. Potential advantage of spinel ferrites when used as electroinsulating layer instead of other insulations is their ferrimagnetic behavior, improving the magnetic interaction between the ferromagnetic powder particles in the final composite. Part of the work is the investigation of the electrical resistivity, wideband complex permeability and energy losses in prepared soft magnetic composites. The aim is optimization of preparation process of soft magnetic materials with required magnetic properties at middle-frequencies.

Influence of anisotropy induced by thermal treatment on structural and magnetic properties of rapidly quenched soft magnetic materials
supervisor: prof. RNDr. Rastislav Varga, DrSc.
consultant: doc. RNDr. Zuzana Vargová, PhD.
study form: full time
Annotation: The aim of the work is to study the influence of anisotropy induced by thermal treatment (under mechanical stress, magnetic field, etc.) on structural and magnetic properties of rapidly quenched materials in the shape of ribbons and wires.

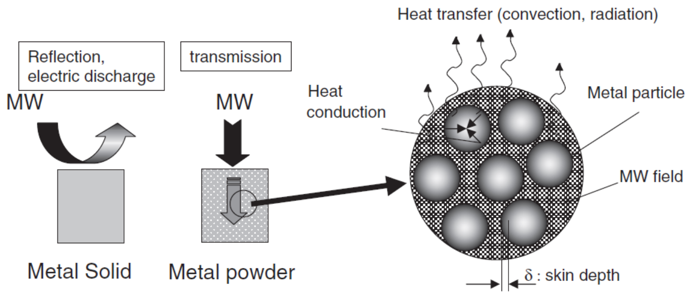
The study of magnetic and structural properties nanoparticles for magnetic hypertermia
supervisor: doc. RNDr. Adriana Zeleňáková, PhD.
consultants: doc. RNDr. Vladimír Zeleňák, PhD., RNDr. Anna Alexovič Matiašová, PhD.
study form: full- time
Annotation: Since magnetic particles have unique features, the development of a variety of medical applications has been possible. The most unique feature of magnetic particles is their reaction to a magnetic force, and this feature has been utilized in applications such as drug targeting and as contrast agents for magnetic resonance imaging (MRI). Recently, magnetic nanoparticles have attracted attention because of their potential as heating mediators for cancer therapy (hyperthermia). The aim of PhD work is optimization of synthesis strategy for preparation of magnetic nanoparticles for magnetic hyperthermia as well as study of magnetic, structural and functional properties of magnetic nanoparticles from the perspective of their use in-vivo.

The study of phase transformation of amorphous glasses from amorphous to nanocrystalline structure by TEM and synchrotron based scattering and spectroscopic techniques and image techniques at XFEL.
supervisor: prof. RNDr. Pavol Sovák, CSc.
consultants: RNDr. Štefan Michalik, PhD., Ing. Vladimír Girman, PhD.
study form: full-time
Annotation: The thesis will deal with the preparation of metallic glasses in the form of ribbons and rods by melt-spinning technique and the copper mould casting method. The glassy structure of the as-prepared alloys will be investigated by TEM and synchrotron based scattering and spectroscopic techniques, namely high-energy X-ray diffraction (HEXRD) and X-ray absorption spectroscopy (XAS). The phase transformation from amorphous state to nanocrystalline one will be investigated by TEM and by MID beamline at XFEL in Hamburg.

References
1. Structure and magnetic properties of finement based alloys. Univerzita Pavla Jozefa Šafárika 2008. - 158 s. - ISBN 978-80-7097-719-4.

Novel diagnostic methods base on atomic force microscopy
supervisor: Mgr. Vladimír Komanický, PhD.
consultant: doc. RNDr. Vladimíra Tomečková, PhD.
study form: full time
Annotation: Primary goal of the dissertation thesis is a development of novel diagnostic methods based on atomic force microscopy. Another goal of the thesis is preparation of systems using nanotechnology and nanolithography and PVD methodologies that can be used to prepare sensors used in disease diagnostic. These systems will be prepared in the form of thin films, multilayers and other types of nanostructures.
References
1. Shao M. Electrocatalysis in Fuel Cells, A Non- and Low- Platinum Approach, 2013, XVI, 745, 327 pages.
2. Koper M., Wieckowski A. Fuel Cell Catalysis: A Surface Science Approach, 2009, 720 pages.
3. Wieckowski A., Interfacial Electrochemistry: Theory, Experiment, and Applications, 1999, 966 pages.

Effect of microwave heating on structure and properties of powder soft magnetic materials
supervisor: Ing. Radovan Bureš, CSc. - Institute of Materials Research Slovak Academy of Sciences Košice
study form: full time
Annotation: This work is focused on the study of structural, magnetic and mechanical properties of the soft magnetic composite materials based on powder metallic and non-metallic materials. Microwave heating technology will be used for preparation and compaction of the powder material system. Microwaves possess several characteristics that are not available in conventional processing of materials, including: penetrating radiation, controllable electric field distributions, rapid heating, selective heating of materials through differential absorption and self-limiting reactions. The goal of this work is quantification of the effect of microwave radiation on kinetics of synthesis, annealing and sintering processes in powder soft magnetic materials. Obtained knowledge will be applied in optimization and rationalization of the soft magnetic composite preparation method.
References:
- Jing Sun, Wenlong Wang and Qinyan Yue: Review on Microwave-Matter Interaction Fundamentals and Efficient Microwave-Associated Heating Strategies, Materials 2016, 9, 231
- Katie Jo Sunday and Mitra L. Taheri: Soft magnetic composites: recent advancements in the technology, Metal Powder Report, Volume 72, Number 6, November/December 2017

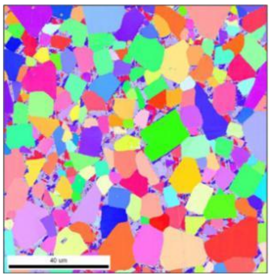


Nanomechanical properties of advanced ceramics materials

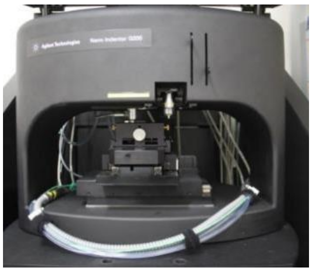
supervisor: prof. RNDr. Ján Dusza, DrSc.- Institute of Materials Research Slovak Academy of Sciences Košice

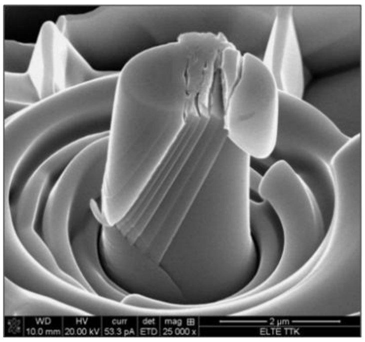
study form: full time

Annotation: A theme of dissertation thesis is aimed to relatively new prospective direction of materials research – nanomechanical testing. The origin of most methods is based on nanoindentation testing, novel nano- and micromechanical methods including compression, tension and bending tests as well as fatigue, creep and fracture experiments performed on a very local scale or on small specimens have been applied to determine mechanical properties and investigation of the effects of size and crystal orientation on the strength and plasticity of materials. Analyzing these behaviour it is possible to acquire new knowledge of fundamental research on deformation mechanisms in advanced ceramics materials, which would be the main expected contribution of dissertation thesis. We are also expected to contribute to the development of new nano-micro-scale testing methods.


Microstructure of WC-Co

FIB-SEM/EDS


nanoindenter Agilent G200


deformed micropillar

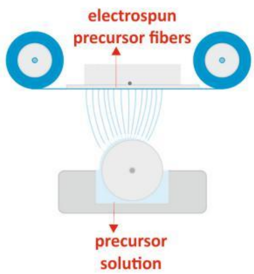
Development of novel electrospun ceramic nanofibres for special technical applications

supervisor: prof. RNDr. Ján Dusza, DrSc. - Institute of Materials Research Slovak Academy of Sciences Košice

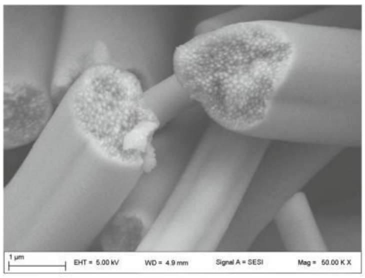
study form: full time

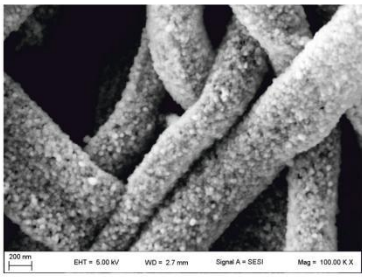
Annotation: Dissertation thesis is oriented to nanofibers systems prepared by relatively novel, low-cost and productive method – needle-less electrospinning, which are expected to have a great potential in the field of solar cell applications, gas sensors, varistors and other special technical applications. The expected contribution of the thesis is to study and explain the relationship between the preparation conditions, the microstructure formation and the selected functional properties of the developed nanofibers and it has all the prerequisites to shift the knowledge about the preparation of the nanofibers towards the real production possibilities. The aim of the thesis is to predict the application possibilities of the studied materials on the basis of the obtained results.

Nanospider NS Lab 200



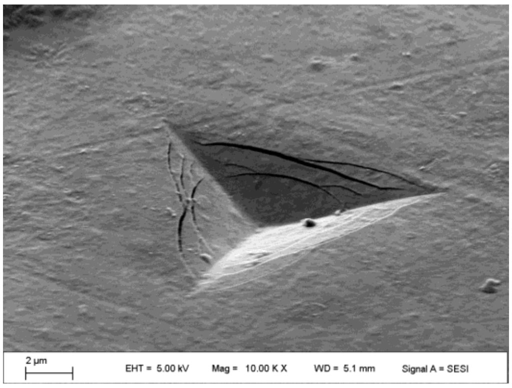
Scheme of needle-less electrospinning


SEM image of electrospun precursor fibers of titania


SEM image of SnO_2 fibers

Highly ionized plasma sputtering of multicomponent high entropy ceramic coatings.
supervisor: doc. RNDr. František Lofaj, DrSc. - Institute of Materials Research Slovak Academy of Sciences Košice
study form: full time
Annotation: The development of magnetron sputtering is oriented toward technologies with high ionization degree of the sputtered material which provides better control of the deposition process as well as better coating properties. The most famous ionized PVD is the High Power Impulse Magnetron Sputtering (HiPIMS) and the relatively new technology High Target Utilization Sputtering (HiTUS) also belongs among these methods. High degree of ionization is achieved in the case of HiPIMS by very short duty cycle impulses with extremely high power density whereas in HiTUS by the power at an independent plasma source. The work should focus on the optimization of the deposition parameters of hard multicomponent carbide, boride and nitride coatings from the viewpoint of the control of their elastic and plastic properties by means of determination of dependencies among the deposition parameters, plasma characteristics, coating structures and their mechanical and tribological properties. The work will be performed on the iPVD systems Cryofox Discovery (Polyteknik, Denmark) and HiTUS C500 (PQL, UK) in combination with the electron microscopy observations (SEM, TEM) and measurements of mechanical properties.





HiPIMS Discovery HiTUS C500 nanoindentation in W-C coating

Quantitative characterization of plasma deposition of ceramic coatings by optical and electron spectroscopy methods.
supervisor: doc. RNDr. František Lofaj, DrSc. - Institute of Materials Research Slovak Academy of Sciences Košice
study form: full time
Annotation: The advanced ceramic coatings for ultrahigh temperature applications consist of high melting point and heavy (Zr, Hf, Ru, W..) metallic elements strongly bonded with light elements (boron, nitrogen, oxygen, carbon with hydrogen) which result in difficulties in quantitative analysis when using conventional chemical methods. Usually, a combination of several analytical methods is necessary to obtain quantitative characterization of both light and heavy elements at the same time in the resulting compounds. However, the control of the coating composition requires also the control of the plasma composition during the deposition. Thus, the *in situ* methods of plasma composition should be combined with the methods applied to the coatings to determine the relationships controlling their chemistry, structure and properties. The work should employ both *in-situ* optical emission spectroscopy for the plasma control with the *ex-situ* glow discharge optical emission spectrocopy (GDOES), Raman spectroscopy as well as energy and wavelength disperse electron spectroscopy (and potentially also X-ray Photoelectron Spectroscopy (XPS) and Secondary Ion Mass Spectrocopy (SIMS)) methods on the carbide and boride based

coatings for quantification of their chemistry to establish the correlations between the plasma characteristics and their structure and properties. The plasma study will be performed on the existing iPVD systems using OES system (Avantes, The Netherlands) and Raman microscope (XploRa, Horiba, France), GDOES (GD2, Horiba, France) as well as on the EDS and WDS (Oxford, UK) attached to the scanning electron microscopes. The introduction of new XPS and SIMS facilities is also anticipated.

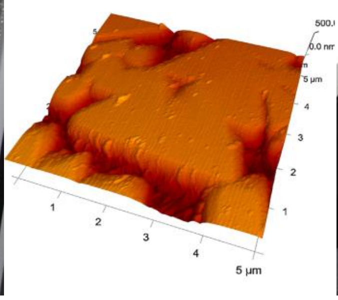

Raman mikroskope GDOES FIB-SEM/EDS

Mapping of the mechanical and tribological properties of ceramic PVD coatings on micro- and nano-level.

supervisor: doc. RNDr. František Lofaj, DrSc. - Institute of Materials Research Slovak Academy of Sciences Košice

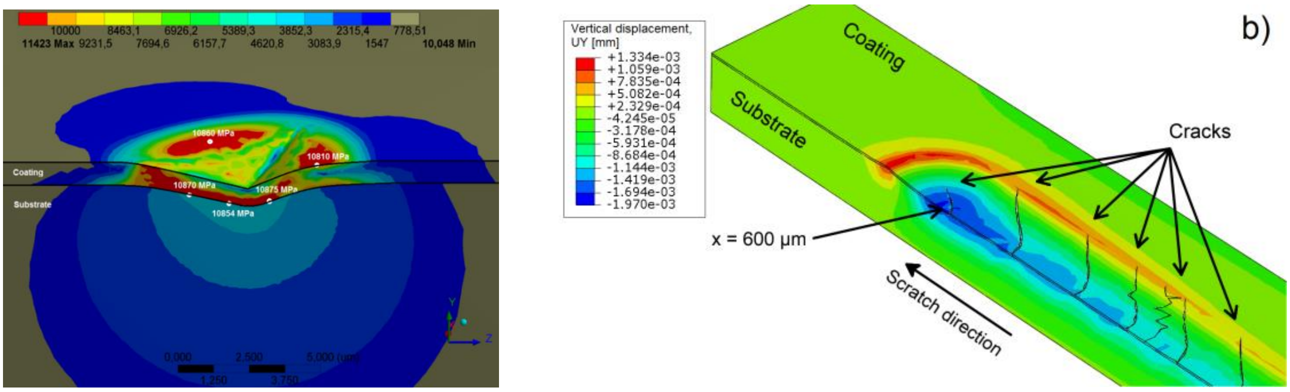
study form: full time

Annotation: The development of MEMS is bound to the development of the technologies for their preparation and characterization of the mechanical properties, reliability and lifetime at nano-level. The development of this field resulted from the development of corresponding imaging and testing methods at nano-level. The most famous methods involve atomic force microscopy (AFM), nanoindentation incl. *in-situ* nanoindentation in scanning electron microscope and nanolitography. AFM combines imaging capabilities in various modes with the modes related to the measurement of physical, mechanical, tribological and other properties down to atomic level. The aim of the work is mapping of the mechanical and tribological properties of different types of PVD coatings at micro- and nano-level by means of a combination of different AFM modes in AFM (Dimension Icon, Bruker, USA) with the nanoindenter (G200, Agilent, USA), eventually, also by an in-situ nanoindentation in a scanning electron microscope.



AFM - Dimension Icon nanoindenter Agilent G200

Mathematical modelling of the processes during nanoindentation, scratch testing and tribological tests in
supervisor: doc. RNDr. František Lofaj, DrSc. - Institute of Materials Research Slovak Academy of Sciences Košice
study form: full time
Annotation: The work is focused on a detail study of the processes of stress and deformation states during instrumented nanoindentation, scratch and tribological tests in the coated composite systems using finite element modelling (FEM) externded FEM (xFEM) and Cohesive Zone Model (CZM) methods and subsequent experimental verification. The work will be performed on thin coatings on substrates with different mechanical properties. The aim is to understand the details of damage mechanisms in coatings in dependence on the loading conditions as well as the optimization of the conditions for the measurement of the mechanical properties and tribological properties of the studied coatings.



Stress distributions during nanoindentation and scratch test

Thermal and non-thermal phase transitions induced by short-wavelength lasers in various materials
supervisor: Ing. Karel Saksl, DrSc. - Institute of Materials Research Slovak Academy of Sciences Košice, PF UPJŠ Košice
consultant: Ing. Libor Juha, CSc. (IoP-CAS and IPP-CAS, Praha)
Annotation: Short-wavelength lasers working in extreme ultraviolet (XUV), soft x-ray (SXR) and x-ray spectral ranges provide high fluxes of energetic photons. In these spectral ranges, a single photon carries an energy ranging from tens of eV to several keV. Such photon energy is high enough to break any covalent bond; it also exceeds a band gap energy even of an ionic crystal and a cohesive energy of any crystal lattice. Therefore XUV/x-ray laser beams can cause not only thermal phase transitions but also non-thermal modifications of solids. Various materials - insulators (e.g., organic polymers and ionic crystals), semiconductors (both elemental and compound ones) and metals (e.g., Ni, Cr, Au, and Pt) irradiated by focused beams of XUV/x-ray lasers of a different kind, both plasma- and electron-beam-based - will be investigated by advanced instrumental analytical techniques. These analytical methods provide information on phase transitions that occurred on surfaces and in near-surface layers of illuminated materials. In collaboration with theory, thermal and/or non-thermal character of the material modification will be estimated.

Impedance spectroscopy and dielectric properties of magnetoelectric ceramics
supervisor: RNDr. Vladimír Kovaľ, PhD. - Institute of Materials Research Slovak Academy of Sciences Košice
study form: full time
Annotation: The dissertation will be focused on investigation of the dielectric properties of polycrystalline multifunctional materials in a wide temperature and frequency range by a complex impedance spectroscopy technique. In course of research work, theoretical and experimental approaches such as synthesis of experimental materials, structural XRD analysis, scanning and transmission electron microscopy and analytical modelling of dielectric response of the prepared magnetoelectric structures will be carried out.