Research subjects realized at the Institute

Environment friendly technologies and material

- lead-free soldering,

- silicon solar cells and

- new biomaterials for artificial heart device

Amorphoues, nano- and microcrystalline materials

- amorphous and nanocrystalline Al alloys,

-

electrochemically deposited coatings with superior tribological and anticorrosive properties,

-

metals and alloys with new properties obtained by severe plastic deformation,

-

metallic materials with ultrafine grains for stomatological implantology

Knowledge based functional materials

-

Metallic materials for hydrogen storage,

-

phase transformations and thermophysical properties of functional materials,

-

martensitic and magnetic transformation in alloys based on Huesler'a structure showing shape memory and magnetocalorimetric effect,

-

structure modelling in multilayer materials

Development of research tools and diagnostic techniques

-

Development of advanced research techniques in SEM and TEM like analysis of orientations and misorientations in micro- and nanoscale,

-

Data processing from local measurements of crystallographic orientations and

-

assessment of material degradation during exploitation based on depth pro-file of crystallographic texture and internal stresses in near-surface areas

ENVIRONMENT FRIENDLY TECHNOLOGIES AND MATERIALS

Topic 1: The development and properties of the micro- and nanojoints on the basis of lead-free solders formed by the electrolytic method from the ecological complex plating baths.

Topic leader: Dr hab. Piotr Ozga, prof. PAS.

Aim of the study: The development of theoretical bases of forming of micro- and nano-scale solder areas(pads) and solder objects(wires, particles) using electrolytic methods. The analysis of physico-chemical, microstructural and textural phenomena associated with reducing the dimensions of solder areas, as well as with formation of nanosolders (nanowires, nanoparticles). Explanation of the phenomena during formation of micro and nano-scale solder areas by electrolytic deposition. The designing the electrolytic baths for the deposition of solder suitable for the formation of micro and nanojoints. The determination of the properties of the selected barrier layers on the formation of intermetallic compounds on the border of the solder/substrate. The determination of the corrosion resistance of obtained solder joints. The study will focus on the tin solders and solders on the basis of Sn-Zn alloys deposited electrolytically from the baths based on the environmentally friendly complexing agents.

Research methods: Electrochemical Scanning probe microscopy (EC-SPM) allows the use of AFM and STM techniques (study of electrodeposition in the micro and nano-scale areas, study of the surface topography, electrical forces (EFM), the contact potential difference (KPFM)). Electrochemical techniques potentiostatic, galvanostatic, potentiodynamic and impedance /EIS/ using a rotating disk electrode (kinetics and mechanism of electrolytic deposition). Microscope SEM and TEM (microstructural and phase study) and chemical analysis (EDS) and textural (EBSD). Raman microscopy (μ-RS) with the TERS technique (investigation of formation of oxides and other phases, analysis of the size of nanocrystallites in micro- and nano-scale areas of solder and joints, characterization of structure of graphene (raman mapping). X-ray diffraction (phase composition, grain size). Resistance measurement using four-points method and impedance measurement using impedance spectroscopy method. UV-VIS (nanoparticle size, aging of electrolytic bath). Chemical analyzes of deposits (XRF). Solderability (spreading tests).

Expected results of research: The explanation of the physical and chemical, microstructural and textural phenomena associated with reducing of solder areas(pads), as well as processes during the electrolytic deposition of layers and solder micro- and nano-objects. The development of theoretical bases of technology of formation of nanojoints by a electrolytic method using environmentally friendly complexing agents (citrates, EDTA, etc.).

Exploitation of research results: In modern technologies of production of soldering joints based on Pb-free solders (μ-BGA technology, sets packed electronic circuits using the third dimension / 3D packaging technologies / etc.). The technology for producing of nanosolders (1D nanosolders - nanowires-based solders, etc.). The technology of graphene (combining of the graphene structures, the production of joints with graphene, etc.). As part of the COST Action MP1407 (e-MINDS).

Task in 2016: The development and properties of the solder layers from lead-free Sn-Zn alloys formed by the electrolytic method from citrate plating baths on the graphene covered copper substrates.

Topic 2: Nanoscale surface functionalization of biomaterials for biomedical circulatory system and the microstructure characteristics and properties of nanostructured composite coatings of biomaterials dedicated to contact with blood.

Topic leader: Dr hab. eng. Roman Major, prof. PAS.

Aim of the study: Surface modification leading to reduce thrombogenicity of the material provided in contact with blood. The aim of the study is to create the conditions of the substrate for the cell repopulation by making a bioactive tissue-based scaffold using a multi-disciplinary engineering and biological techniques.

Expected effects of the tests: The expected results is to understand the cell- material interaction and the influence of the substrate modification on life cellular processes, their activation and differentiation.

Exploitation of research results: Designing cardiovascular implants, preparation of applications for research projects in Poland and abroad in cooperation with a partner from Austria and France, and published the results in leading scientific journals.

Task in 2016: Functional materials with coatings of a special properties dedicated for circulatory system.

Topic 3: The development of new materials and technologies for photovoltaic structures

Topic leader: Prof. Paweł Zięba, PhD, DSc.

Aim of the study: Improvement the electrical performance and reducing the manufacturing costs of crystalline silicon cells and the development of a new type of photovoltaic cells using the materials with the perovskite structure and metallic and semiconductor nanoparticles.

Test Methods: For characterization of materials and structures the following methods will be used: Scanning Electron Microscopy, Transmission electron microscopy (TEM), X-ray diffraction spectroscopy, UV-VIS spectroscopy, Photo- and Electroluminescence Imaging, FTIR, ellipsometry, I-V characteristics and the quantum efficiency measurements. Moreover the technological equipment will be used as for example: belt furnaces, screen printers, diffusion furnace, spin-coater and laser.

Expected results of research: The result of the research will be the efficiency improvement and production costs of silicon and perovskite solar cells decreasing. The processes of junctions formation from liquid sources will be optimized. Another important effect will be good quality and low cost metallic contacts achieving.

Exploitation of research results Publication of results in journals and conferences materials and PhD thesis.

Task in 2016: Optimization of technological processes for silicon solar cells and to investigate the physical properties perovskites for use in photovoltaic cells.

Topic 4: Nanocrystalline metallic and composite coatings produced by electrochemical deposition method.

Topic leader: Prof. Ewa Bełtowska-Lehman, PhD, DSc.

Aim of the study: Design of galvanic baths and the development of electrodeposition process conditions (on steel substrate) of nanocrystalline metallic coatings and composites with Ni-based alloy matrices containing refractory metal (Mo and W) reinforced by ceramic phase, with enhanced functional properties similar to hard chrome. The scope of work includes the determination of the effect of selected parameters of electrodeposition process such as chemical composition and plating bath pH, temperature, sonication and the hydrodynamic conditions on the deposition kinetics, microstructure and physicochemical properties of resulting coatings.

Research Methods: The coatings will be electrodeposited in a system with a rotating disc electrode (RDE) supplied by potentiostat /galvanostat. The kinetics of electrodeposition process will be investigated by means of steady-state polarisation measurements in variable hydrodynamic conditions, complemented by zeta potential determination. Microstructure of the coatings obtained will be characterized by XRD, SEM and TEM techniques. Corrosive characteristics will be determined by electrochemical methods, micromechanical and tribological properties will be evaluated by instrumental indentations and using a ball-on-disc apparatus.

Expected research results: The results of the planned study will enable a better understanding of the processes taking place at the cathode during codeposition of ceramic particles of reinforcement phase and a metallic matrix (from aqueous electrolyte solutions).

The results obtained will help to develop a theoretical base for the production by electrochemical method nanocrystalline coatings with improved mechanical and anti-corrosion properties, which can be a substitute for chromium coatings deposited from toxic electrolytes containing Cr (VI).

Use of test results: The results of the research will be the subject of a number of publications in international scientific journals. They will also allow for the development of an application for funding within the framework of the research project.

Task in 2016: Optimization of the electrodeposition process of composite coatings (of Metal Matrix Composite type) with the Ni-Mo matrix reinforced by nanocrystalline ceramic phase.

AMORPHOUS, NANO- AND MICROCRYSTALINE MATERIALS

Topic 5: Preparation and characterization of high-strength magnesium alloys and composites.

Topic leader: Dr hab. Lidia Lityńska-Dobrzyńska, prof. PAS.

Aim of the study: Development of technology of magnesium alloys and their composites to improve the strength.

Research methods: Magnesium alloys will be prepared by using rapid solidification techniques, ie. suction casting into copper moulds or melt spinning on a rotating copper wheel. These methods lead to refinement of the microstructure and formation metastable phases, which could improve mechanical properties of the alloys. It is planned also to apply intensive plastic deformation (ECAP and Groove Pressing) leading to fine-grained microstructure. Magnesium alloys based composites reinforced by ceramic nanoparticles will be prepared by intensive mixing in the liquid phase.
Microstructural studies will be performed using X-ray diffraction (XRD), scanning electron microscopy (SEM) and by transmission electron microscopy (TEM). Microcalorimetric studies (DSC) will be applied to estimate the stability of the phases forming during rapid solidification. Mechanical properties of alloys and composites will be determined by hardness or microhardness tests and the tensile or compression strength experiments.

Expected results of research: The main objective of the research is to study the effect of applied preparation methods on mechanical properties and microstructure of magnesium alloys and composites compared to the conventional casting. Investigation will be focus on identification of the phases formed during rapid solidification and description of the refinement of the microstructure. In the case of composites, the distribution of introduced nanoparticles will be determined as well as the microstructure of the interfaces between the particle and the matrix.

Use of test results: The results of the research will be presented during the national and international conferences and will be published in international journals. The results will provide a basis for the preparation of proposals for research projects in NCN or NCBiR.

Task in 2016: Influence of solidification rate and intense plastic deformation on the structure and properties of magnesium alloy containing rare earth elements.

Topic 6: The altering of properties of metals and alloys through structure refinement by severe plastic deformation.

Topic leader: Prof. Henryk Paul, PhD, DSc

Aim of the study: The main objective of this research program is to determine the crystallographic relationship between the strongly deformed matrix and areas occupied by plastic flow instabilities in the form of (micro-/macro-) shear bands. The analyzes will be carried out on single- and poli-crystalline metals (including ultra-fine-grained ones) of fcc lattice and with different stacking fault energies. They will aim to elucidate the mechanisms responsible for the appearance of this form of unstable flow and the description of the crystallographic changes that accompany the emergence of new grains during the recrystallization process.

Test Methods: In this study, the methods of the high pressure torsion (HPT) and the equal channel angular extrusion (ECAE) will be used for preliminary samples processing. During secondary straining the samples will be plane strain compressed (PSC) for clear texture control. The transmission and scanning electron microscopes equipped with high resolution systems for local orientation measurements will be used for detailed crystallographic and morphological characterization of the deformed samples, whereas the micro calorimetric methods will be used for thermal effects measurements during annealing.

Expected results of research: As a result of the work it is expected to make the full description of the changes that accompany the formation of (macro-/micro-) shear bands, in particular, in extremely fine-grained fcc metals and explain the crystallographic determinations of this process as well as the description of the ‘way' by which the global texture of the deformed state is ‘modified' by a shear bands. Moreover it is expected the detailed description of the mechanisms of the texture transformation during the early stages of recrystallization. In this part the crystallographic description of new grains nucleation during recrystallization will be at the heart of interest.

Use of test results: The texture transformations during the recrystallization is one of the last still unresolved 'metallurgical problems'. Thus, the ongoing work is of fundamental nature. Nevertheless, a clear description of the mechanism of the shear bands formation and in particular a description of the crystallographic interrelations between orientations identified inside the shear bands and the orientations of new grains that appears during annealing (inside the shear bands) is essential for industrial practice; this opens the possibility of a 'conscious' control of manufacturing processes of thin sheets during rolling and annealing.

Task in 2016: Plastic flow instabilities formation in fine-grained structure of polycrystalline nickel.

Topic 7: Hexagonal metallic materials with a microstructure modified by complex strain in the application as biomaterials.

Topic leader: Prof. Krzysztof Sztwiertnia, PhD, DSc.

Purpose of research: The aim of the research is to optimize the microstructure and texture of the material used for the manufacture of implants or parts of them and to develop theoretical basis of proper microstructures and textures analysis of materials with a strong grain refinement - as after deformation by the equal-channel angular pressing (ECAP), hydrostatic extrusion (HE) or extrusion with forward-backward rotating die (KoBo). There are provided tests of hexagonal materials that apply on implants such as biocompatible titanium and titanium alloys, zinc and zinc alloys with magnesium as well as magnesium and its alloys. In parallel research of structures lightweight composite biomaterials, such as sea shells and wood, will aim at understanding the correctness of material solutions shaped by Nature.

Research Methods: At each stage of the studies a wide range of mechanical strength tests (including research anisotropy), microstructural measurements using the latest techniques (as orientation microscopy in scanning and transmission electron microscopes, SEM and TEM) and X-ray diffraction will be provided. Computer data processing based on our own software (as KikSpot, Tarsius, ODYS) will be further developed.

Expected results of research: Supplementing knowledge concerning the advantages and stability of the hexagonal material properties with heavily modified microstructure and lightweight composite biomaterials (such as shells, wood). Explanation of a strong crystallographic texture impact - appears in materials extruded by ECAP, HE and KoBo - on the anisotropy of mechanical, corrosion and biological properties. Explanation of technological problems, as for example limitations of ECAP and KoBo methods on processing appropriate quality materials (especially titanium). Computer research of the data allows a more accurate characterization of the microstructures (eg. internal stresses or orientation and misorientation characteristics) compared to those obtained using commercial software.

Application of studies: Improvement of properties (especially mechanical and biological) based on a modification of the microstructure and chemical composition. Replacement of Ti grade 5 (i.e. Ti-6Al-4V alloy) and Ti-grade 4 by titanium of high purity (eg. Ti grade 2) with a modified microstructure which mechanical and biological properties will be better than the properties of used in implantology Ti grade 5. Production of semi-finished products (rods) for new generation implants (eg. dental) as well as bioresorbable implants. On the other hand, knowledge of the structure of natural biomaterials facilitate the search for biomimetic solutions in the field of light, functionally graded materials.

Task in 2016: Zinc as a biomaterial for the purpose of bioresorbable implants. The study of microstructures of natural composite biomaterials part I.

Topic 8. Evolution of microstructure, thermal stability, phase composition and thermo-mechanical properties of the chosen multicomponent alloys, amorphous and micro-crystalline, involving melt-quenched nano-crystals.

Topic leader: Dr hab. Tomasz Czeppe, prof. PAS.

Aim of the Study: determination of the mutual relation between thermally controlled phase transformations, evolution of microstructure, thermo-mechanical and thermo-physical properties of multi-component alloys initially amorphous or partially crystalline, containing melt-quenched nano- or micro-crystals. In the first place it is planned to investigate alloys with the Ni- and Cu- matrix like Ni-Zr-X, Ni-Al-X and Cu-Zr-X. This alloys, under equilibrium conditions crystallize involving many types of phases as well as intermetallic particles frozen from the liquid phase. The next step will be investigation of the possible improvement of the mechanical properties of the amorphous or microcrystalline matrix resulting from participation of the crystalline fraction inherited from the liquid phase or introduced by proper thermal treatment. The thermodynamic modeling (the CALPHAD strategy) will be used to determine thermal stability of the phases in the relevant sections of the equlibrium phase diagrams. The particular additions to the investigated alloys will be planned in the annual tasks.

Research methods: the alloys will be made by levitation or cold crucible levitation followed by rapid cooling or the copper mould suction methods. The specific microstructure will be obtained with use of the methods used for the bulk metallic glasses preparation, i.e. by rapid cooling from the liquid state. In spite of the high solidification rates the structures commonly incorporate nanocrystals frozen in from the liquid phase. Microstructure and phase composition will be determined by XRD, SEM, TEM and HREM. Thermo-physical properties like: Cp, elastic modulus, density, enthalpy and kinetics of the phase transformations will be measured by the methods of thermal and thermo-mechanical analysis. The foresight of the crystalline phases most probable for crystallization will be carried out by the modeling of the phase diagrams cross-sections using Thermocalc and/or Dictra programs.

Expected results of research: characteristics of microstructural, thermo-physical and thermo-mechanical properties, characterization of the nano-crystallization processes from the liquid or glassy phase and its influence on the properties of the alloys. The assessment of the usefulness of the microstructures obtained in the range of the amorphous phase deformability or of catalysis.

Use of results of the research: scientific publications and conference presentations, also as a base for the research projects applications.

Task for the 2016 year: Production of the rapidly crystallized Ni based alloys with additions of Nb, Sn and V and investigations of their microstructure, thermal stability, phase composition and thermo-mechanical properties, in the amorphous or microcrystalline state.

FUNCTIONAL MATERIALS

Topic 9: Metallic materials for energy and hydrogen storage.

Topic leader: Prof. Władysław Gąsior, PhD, DSc.

Topic 9/1: Thermodynamic properties of ternary alloys Li-Sb-Pb and Li-Ag-Sb.

Topic leader: Dr hab. eng. Przemysław Fima, prof. PAS.

Aim of the study: The measurement of lithium activity and enthalpy of mixing of the Li-Sb-X liquid ternary alloys, where X is Ag or Pb, developing properties of the liquid phase and the phase diagrams calculation.

Research methods: It is planned to use two experimental methods for the measurement of thermodynamic data. The enthalpy of mixing will be studied by drop calorimetry (for each of the ternary systems measurements will be performed for several sections). The research of activity of lithium will be carried out by measuring the electromotive force of concentration cell for alloys with a constant ratio of Sb / Pb and Sb / Ag (2-3 for each system). Both the colorimetric and electromotive forces measurements conducted in a wide range of concentrations and temperatures will provide information on the liquidus in the systems Li-Sb-X.

Expected results of research: The main result of the research will be thermodynamic data for the studied systems, for which neither the phase diagrams, nor their thermodynamic properties have not yet been investigated.

Use of test results: It is planned to present the results on the most important national and international conferences devoted to the thermodynamics of alloys, as well as publication in leading journals indexed by the Journal Citation Reports. In particular, the data collected can be used to develop the thermodynamic description of systems investigated and the calculation of phase diagrams. The proposed topic is basic research, so the results can be the basis for future applications for research projects proposed to the National Science Centre and the European Research Council. The data collected can also be used to explain the phenomena that occur during the charge and discharge of cells in which one of the electrodes is made of an alloy which is the subject of the proposed research.

Task in 2016: Thermodynamic properties of ternary Li-Sb-X alloys.

Topic 9/2: Studies of hydrogen sorption by magnesium, charcoal, coal nanotubes and physicochemical studies of Pb-Sb and Pb-Sb-Li alloys.

Topic leader: Prof. Władysław Gąsior, PhD, DSc.

Aim of the study: Determination of the surface tension, density and viscosity of binary Pb-Sb and Li-Pb-Sb liquid solutions under high purity argon flow and investigations of the sorption of hydrogen by magnesium, magnesium nitride, charcoal and carbon nanotubes.

Research Methods: The physicochemical properties study will be conducted using the apparatus built in the Institute and the sorption studies applying the professional apparatus by ISOCHEMIA.

Expected results of research: Determination of the temperature dependence of surface tension, viscosity and density, confronting experimental data with the values from the modeling and determination of optimal conditions (temperature, pressure) absorption and desorption of hydrogen for the materials cited.

Use of test results: The results will be published in journals cited by the JCR and will be presented at international and national conferences. In addition, the measured data of physicochemical properties will be entered into the SURDAT database successively modified at the Institute.

Task in 2016: Studies of hydrogen sorption by magnesium and measurements of surface tension, viscosity and density of liquid Pb-Sb alloys.

Topic 10: Structural aspects of martensitic transformation in Heusler based functional materials.

Topic leader: Dr hab. eng. Wojciech Maziarz, prof. PAS

Aim of the study: Optimization of functional properties (magnetic cooling, magnetic shape memory) of Heusler based alloys through modification of chemical composition, crystalline structure and microstructure.

Research methods: A range of characterization techniques will be employed in order to examine structure and microstructure of Heusler based alloys produced by various technologies, which display functional properties (magnetocaloric effect, magnetic shape memory) near room temperature. It is planned to conduct examination of polycrystalline alloys derived by conventional metallurgy, powder metallurgy and rapid solidification as well as single crystalline alloys grown by the Bridgman method. The temperature range of the forward and reverse martensitic transformation will be determined by calorimetric measurements (DSC). Crystalline structure, the degree of atomic order of the austenite phase and the crystallographic relations between martensite variants and different types of boundaries will be determined with the use of x-ray diffraction (XRD) and electron backscatter diffraction (EBSD) techniques. Transmission electron microscopy (TEM) will be used for the analysis of grains' type and size, micro segregation, precipitation processes as well as crystalline structure in micro and nanoareas.

Expected results of research: The main outcome will be the determination of the mutual relationship between structure and functional properties of Heusler alloys based materials. In particular it is expected that the studies will provide the answer to the question regarding the influence of the ordering process on martensitic transformation and the magnitude of the magnetocaloric effect in polycrystalline materials. In connection to single crystalline materials it is planned to determine the role of the training process of metamagnetic alloys in obtaining single variant martensite state and the possibilities of employing such alloys as substitutes for Ni-Mn-Ga alloys.

Use of test results: The research results will be disseminated at the main scientific national and international conferences dedicated to this subject as well as in peer reviewed journals. Since this topic shares both fundamental and applicable research nature the obtained results will be used as a base for future research proposal both at National Science Centre and National Centre for Research and Development.

Task in 2016: The influence of thermos-mechanical treatment on magnetocaloric properties of Heusler Ni-Mn-Sn single crystal.

Topic 11: Preparation and properties of Ni-P and Ni-Re-P electroless deposited coatings and their reactivity with lead-free solders.

Topic leader: Dr hab. Joanna Wojewoda-Budka, prof. PAS

Aim of the study: The optimization of chemical composition of Ni-P and Ni-Re-P electroless coatings deposited on copper based on the complex characteristics of interconnection resulting from the reaction of these coatings with the lead-free solder (microstructural characterization, chemical composition and mechanical properties).

Research Methods: The electroless plating technology will be optimized in order to receive the Ni-P and Ni-Re-P coatings on copper with different phosphorus and rhenium contents. These works will be performed within already ongoing cooperation with the Jerzy Haber Institute of Catalysis and Surface Chemistry of the Polish Academy of Sciences. The optimization of the electroless plating process will be based on both homogeneity of the chemical composition of the coatings and their morphology (lack of cracks and discontinuities). Microstructural characteristics will be performed using scanning and transmission electron microscopy, while the examination of the chemical and phase composition will be carried out using X-ray energy dispersive spectroscopy, X-ray and electron diffraction, which will determine the nature of the obtained coating (amorphous / nanocrystalline). The thermal stability of Ni-P and Ni-P-Re layers will be determined by the crystallization temperature carried out with differential scanning calorimetry technique. The reaction of the electroless coatings with the lead-free solder material will be described in terms of their quality, microstructure changes at the Ni-P-Re/SAC interfaces and the changes after subjecting them to a series of thermal cycles in accordance with standard procedures in the electronics industry. Interconnections subjected to thermal shocks will be examined by scanning electron microscopy and, if this is necessary, transmission electron microscopy. In addition, for a given composition of the coatings, the microhardness and shear tests will be carried out to enrich substantially knowledge on the crack propagation and to allow for the indication of the optimal composition of the coating.

Expected results of research: Currently, coatings Ni-P/Au (Electroless Nickel Immersion Gold - ENIG) find widespread application in surface mounting electronics industry. Despite many advantages they also have a number of drawbacks (porous gold, brittle gold and the so-called black pad phenomenon). To resolve the existing problems one of the possible solution seems to be the modification of the coating composition. Previous studies on the reactivity of the Ni-P coatings with solders indicated a significant influence of phosphorus on the amount and type of forming undesirable phases of NixPy type. Literature reports suggest that rhenium reduces the phosphorus content in the coating, which should preferably affect the quality of the joints. However, so far no studies on the reactivity of solder with the coatings Ni-P with the addition of rhenium was reported, that is why the proposed research is innovative.

Use of test results: The results are planned to be presented at the most important national and international conferences related to the subject, and will also be published in renowned scientific journals. The proposed theme has both the nature of basic research and application, therefore the obtained results can be used as a starting point for the research projects both at the National Science Centre and the National Centre for Research and Development.

Task in 2016: Optimization of electroless plating process parameters of Ni-P and Ni-Re-P coatings on copper substrate.

DEVELOPMENT OF RESEARCH TECHNIQUES AND TOOLS

Topic 12: Analysis of crystallographic orientations, elastic strains of crystal lattices and grain boundaries in polycrystalline materials.

Topic leader: Dr hab. Adam Morawiec, prof. PAS.

Aim of the study: The aim of the task is the development of theoretical and numerical methods of analyses of crystallographic textures, orientations of individual crystallites, orientation relationships, and grain boundaries in polycrystalline materials. Part of the work will concern the determination and analysis of elastic strains of crystal lattices.

Research methods: theoretical and numerical methods.

Expected results of research: Development of theoretical and numerical methods related to crystallite orientations will improve the determination and analysis of single crystal orientations, crystallographic textures, orientation maps and relationships between orientations of crystallites of different phases.

Use of the results: Research results will be published.

The task in 2016: Rodrigues parameters in non-Cartesian coordinate systems.

Topic 13: Development of spectroscopic and diffraction analytical methods as well as in-situ analyses in SEM.

Topic leader: Professor Marek Faryna, PhD, DSc.

Aim of the study: The aim of the task is to expand research capabilities of advanced analytical methods in a high-resolution scanning electron microscope.

Research methods: High Resolution Scanning Electron Microscopy.

Expected results of research: Improving the efficiency of wavelength dispersive X-ray spectrometer. Expanding the limits of physical and effective resolution of electron backscatter diffraction analysis by use of transmission Kikuchi diffraction (TKD). The development of EBSD in-situ measurements by use of heating stage.

Use of test results: The obtained results will be presented during the conferences, domestic and international, and will be published in peer review journals. The obtained results will be also used as a basis for applying for research projects sponsored by Polish National Science Centre.

Task in 2016: Quantitative evaluation of contaminated carbon on ferritic steel surface by use of wavelength dispersive X-ray spectrometry and improvement of physical spatial resolution by use of Transmission Kikuchi Diffraction (TKD) in SEM applied to highly deformed samples.

Topic 14: Observation of phase transformation during in-situ TEM heating.

Topic leader: Prof. Jerzy Morgiel, PhD, DSc.

Aim of the study: Description of the mechanism of phase transitions in selected materials to optimize their functional properties.
Research Methods: The study will focus on a comprehensive characterization of the microstructure of materials using advanced techniques of transmission microscopy such as analytical (HAADF/EDS) and High Resolution (HREM) microscopy. These experiments are carried out using a newly purchased holder for heating samples in a transmission electron microscope and allowing for simultaneous observations of phase transformation. The holder water cooling system improves image stabilization necessary for recording observed changes in the microstructure. The in-situ experiments are backed with observations of microstructure of the ex-situ (vacuum furnace) heat treated samples.

Expected results of research: The main objective of the study is a description of the mechanism of phase transitions in newly developed functional materials, like in Si nanorods, HfTiO oxide coatings, CFC coated with Cr/CrN coating and reactive multilayers. These observations should allow to optimize the final properties of the tested materials. In particular, the question of the mechanism of reaction between Si nanorods and nickel, grain size control in oxide coatings intended for photovoltaic applications, phase transformations in CFC coated fibers.

Use the results of research: Conducted experiments should complement and link the research conducted in the laboratory DN-3, and the results of the research will be presented during the symposiums and conferences, as well as will be published in journals covering phase transformation and microstructure. The experiences gained will form the basis for the preparation of applications for research projects funded by NCN.

Task in 2016: Observation of phase transformation during in-situ TEM heating (Si nanorods/ nickel, HfTiOx coatings, CFC/Cr/CrN).