Department of Nanomaterials and Nanotechnology
Tomsk Polytechnic University

MASTER PROGRAMME SYLLABUS

No.	Title	Volume of hours				Credits	Type of control
		Total	Type of classes				
			LC	PW	SM		
1 semester							
ОС.В.1.0	Philosophical and methodological problems sciences and engineering	96.0	16.0		16.0	3	test
ОЦ.В.1.0	Modern methods of structural analysis in material sciences	192	8.0	32.0	24.0	8	exam
ОЦ.В.3.0	Principal directions of development of materials sciences	112	16.0		16.0	3	test
ПЦ.Б.1.0	Computer and information technologies in science and engineering	144	16.0	48.0		4	exam
ПЦ.Б.3.0	Professional foreign language	64			32	2	test
ПНИР.2.	Pedagogical practice	96				3	test
ПНИР.1.	Research in the semester	160				3,5	test
2 semester							
ОЦ.Б.2.0	Modern problems of materials and processes sciences	128	16.0		32.0	4	test
ОЦ.В.2.0	Materials diagnostics	160.0	8.0	16.0	24.0	8	test
ОЦ.В.4.0	Technological processes of nanostructured materials fabrication for branches of the nanoindustry	160.0	8.0	16.0	24.0	4	exam
ПЦ.Б.2.0	Materials science and technologies of modern and advanced materials	160.0	8.0	16.0	24.0	4	exam
ПНИР.1.	Research work in semester	192				4,5	test
М3.	Scientific training	200				8	test
3 semester							
ПЦ.В.3.1.0	Nanomaterials and environment: applications and risk assessment	144.0	8.0	32.0	8.0	4	exam
ПЦ.В.3.2.	Fabrication technology of bulk nanomaterials	176.0	8.0	32.0	24.0	6	exam
ПЦ.В.3.3.	Methods for testing operating characteristics of nanomaterials	144.0	8.0		40.0	4	exam
ПЦ.В.3.4.	Diffraction, spectroscopy and probe methods and equipment for diagnostics of nanomaterials structure and properties	176.0	8.0		56.0	6	test
ПНИР.1.	Research work in semester	224				6	test
4 semester							
М3.	Scientific training	480				18	test
М4	Master thesis	240				15	
	Total						

LC – lectures
PW – practical work
SM – seminars

Philosophical and methodological problems of science and engineering

The main philosophical problems of science and scientific cognition. Classification of sciences and its importance for scientific cognition. Specificity of natural sciences. Specificity of technical sciences. Philosophy and science: forms and perspectives of interaction.

Modern methods of structural analysis in material sciences

1. X-ray structural analysis. Use of X-ray analysis for the study of materials. Determination of solution type. Study of state diagrams. Phase analysis: quantitative and qualitative.

2. Neutron diffraction analysis. Comparative characteristics of the method regarding tot X-ray diffraction method. Advantages and disadvantages. Application areas.

3. X-ray spectral analysis. Application areas. Methods of X-ray spectral analysis: application areas. Methods of X-ray spectral analysis: emission, absorption, fluorescent. Quantitative and qualitative spectral analysis.

4. Electron microscopy. Interaction between electrons and matter. Acquisition of images and diffraction patterns in electron microscope. Preparation of samples for electron microscopy, comparison of various methods. Indexing electron diffraction patterns. Scanning electron microscope. Image acquisition in scanning electron microscope. X-ray micrography. X-ray image acquisition.

5. Nuclear gamma resonance spectroscopy of crystallites. Interaction between gamma irradiation and matter. Bases of the gamma resonance method. Application areas and method scopes.

Principal directions of development of materials sciences

Modern material science. Tasks and content. Metal materials. Ceramics. Polymers. Composition materials. Nanostructured materials. Strengthening of the surface. Coatings.

Computer and information technologies in science and engineering

Relational databases. Introduction to SQL. Introduction to HTML. Introduction to RUBY. Framework Ruby On Rails. Database publishing on the internet. Information security problems. Safe working with computers.

Professional foreign language

Abstract writing. International Conferences. Business letter writing. Lay out of a business letter. Letter of application Offer, Inquiry, Claim. Job hunting. Advertisement analyzing. CV writing. Job interview. Internet surfing for the latest achievements in the speciality. Presentation of the course work. Recent Developments in Science & Engineering in XXI century. Synopsis preparation. Candidate degree examination preparation. Contract and its clauses. Art of negotiation. International grants.

Pedagogical practice

Preparation of methodological course books for classes, experiment plan for educational and research work of a student. Attendance of the classes assisted by the leading department teachers. Carrying out classes. Participation in supervision of educational and research work of students. Participation in workbook and tutorial development. Preparation of reports on all types of activities, presentation of work results for the final validation.

Modern problems of materials and processes sciences

Main notions of physical material sciences. Computer technologies in material sciences. Behavior of materials under mechanical loading and mesomechanics.

Materials diagnostics

Classification of non-destructive control methods. Radiography. Acoustic control methods. Magnetic control methods. Capillar control methods. Tomography. Combined acoustic-optical non-destructive control methods. Other control methods.

Technological processes of nanostructured materials fabrication for branches of the nanoindustry

1. Nanomaterials and their classification. Classification of substances and materials on th size of particles (grains). Classification on geometric dimensionality: 0 D (zero-), 1 D (one-) 2 D (two-), 3D (three-dimensional) materials. Fractal clusters.

2. Fabrication methods of metal containing nanosized particles. Physical methods for fabrication of nanosized metal particles. Gas phase synthesis (vapor condensation). Plasmachemical synthesis. Deposition from colloidal solutions. Thermal decomposition and reduction. Mechanosyhtesis. Fabrication of nanosized particles by dispersion. Chemical methods for fabrication of nanosized particles. Synthesis of nanosized particles in reduction reactions. Methods of chemical homogenization (co-precipitation, sol-gel method, cryochemical

technology). Electrochemical methods for fabrication of metal nanosized particles.

3. Fabrication of compacted nanocrystalline materials. Interface in compacted materials. Defects. Boundary segregations. Grains, inclusions and pores in consolidated materials. Nanoporous materials. Tubular materials. Semiconductor technology. Hybrid and supramolecular materials. Technology of organic nanolayer compositions by the Langmuir-Blodgett method. Sol-gel technology of nanostructured materials.

Materials science and technologies of modern and advanced materials

Classification of the main types of modern structural and functional inorganic (metallic and non-metallic) and organic (polymer and carbon) materials; composites and hybrid materials; superhard material; intelligent materials and nanomaterials, films and coatings. Fabrication technologies , phase composition and structure of materials with special magnetic, thermal and electrical properties. Fabrication technologies, phase composition and structure of low density materials. Fabrication technologies, phase composition and structure of materials with high elastic properties. Computer software for modeling behavior of materials, assessment and prognostics of their operating properties. Technological properties of production, processing and modification of materials and coatings, parts and articles; equipment, technological tools and devices; systems for control of technological processes.

Nanomaterials and environment: application and risk assessment

Sources of nanoparticles release into environment. Scheme of nanoparticles migration in environment. Mechanisms of interaction of nanomaterials, biological objects and environment. Migration of nanoobjects in the human organism. Mechanisms of penetration of nanoparticles into a cell. Impact of nanoparticles on the soil microbiological activity. Toxicity of nanoparticles regarding to plants. Excretion of nanoparticles from the organism.

Toxicological study of nanomaterials. Characteristics of nanomaterials in toxicology. Physical and physicochemical characteristics. Molecular biological and cytological characteristics. Ecological characteristics. Peculiarities of toxicological study of nanomaterials. Observance of safety rules at work with nanomaterials. Personal protection equipment. Societal risks of nanotechnology development.

Fabrication technology of bulk nanomaterials

1. Compaction technological tasks: minimization of defects, control of shrinkage homogeneity; fast annealing. Agglomerates of particles. Micro and macrostructure of a powder compact. Schemes o assembling by stringing annular molecular structures on the linear ones.

2. Powder technology of nanomaterials compaction. Pressing. Uniaxial compression. Dynamic pressing. Magnetic pulse method. Isostatic pressing. Methods of sintering. Methods of pressure sintering. Plasma discharge sintering (SPS method). Control methods of friction forces during manufacturing articles from nanopowders. Introduction of binding additives into a pressed powder. Matrix lubrication. Collector pressing method. Advantages of the powder collector pressing method.

3. Peculiarities of ultrasound action on solid phase systems. Effects of activation of nanoctructured powders by powderful ultrasoninc action. Impact of ultrasonic action during powder compaction on properties of ceramics.

Methods for testing operating characteristics of nanomaterials

1. Bases of thermal methods of analysis. Thermogravimetric and differential thermogravimetric analysis, differential scanning calorimetric. Interpretation of thermograms. Thermal characteristics of processes of melting, decomposition, formation of binary and complex compounds. Use of thermal analysis for determination of thermodynamic properties of substances

2. Dilatometric method of testing. Determination of the linear expansion coefficient. Study

of phase transformations

3. Assessment of corrosion resistance of materials. General information on corrosion. General characteristics of assessment methods of corrosion resistance. Methodology of accelerated corrosion tests. Electrochemical methods of corrosion resistance assessment. Potentiometry method. Pourbaix diagrams. Corrosion behavior of nanostructured materials.

Diffraction, spectroscopy and probe methods and equipment for diagnostics of nanomaterials structure and propertied

General notions on probe methods for studying nanomaterials structure. Scanning tunnel microscopy. Atomic force microscopy. Electric force microscopy. Magnetic force microscopy. Near- field optic microscopy. Physic bases of scanning tunnel microscopy and atomic force microscopy. Principle of operation of a scanning tunnel microscope (STM). Tunneling. Equipment for STM. Measurement methods of STM. Physical operation principles of an atomic force microscope. Operating modes of an atomic force microscope: contact, contactless, semicontact. Physical bases of electric force (EFM), magnetic force (MFM) and near-field optical microscopy (NFOM). Physical bases of interaction between a probe and a sample in EFM. Equipment for NFOM. Operation principle of NFOM. Methods of NFOM. Configuration of NFOM.