Teaching materials

Since 2003, the department trains bachelors and masters in the speciality “Physics of solids” with a separate set of students within the field of study "Physics" (15 people at the 25 licensed and accredited persons; accreditation level IV).

BASIC SPECIAL COURSES

Bachelor Program

1. Phase transitions in solids

General points on phase transitions in solids. Questions related to phase equilibrium and first- and second- order phase transitions, crystallization kinetics, polymorphic transitions and their role in the formation of physical properties of materials.

2. Physical materials science

Fundamentals of crystal chemistry, characterization and classification of condensed systems. Thermodynamics of phase transitions, crystallization in a liquid phase, phase transitions in two-component and three-component systems. Classification and analysis of phase diagrams, construction of phase diagrams, thermal treatment of materials and alloys, ways to produce single crystals, fundamentals of metallographic study. Solid solutions, mechanisms of their formation and decay; physics of sintering.

3. Fundamentals of X-rays Structural Analysis

Scattering of X-rays by crystals, the effect of lattice thermal vibrations of atoms on the intensity and geometry of the scattering, the X-rays scattering by solid solutions (formation of long-range and short-range orders), domain size and stacking faults.

4. Methods of X-rays structural analysis

Studying the atomic structure of crystalline solids by means of diffraction methods are discussed. The main attention is paid to X-rays diffraction methods, features of the diffraction patterns obtained by different methods and experimental techniques.

5. Physics of superplasticity

Modern views on structural superplasticity and superplasticity under special conditions; characteristics of structural state and deformation mechanisms of metals and alloys under the conditions of superplasticity; theories of superplasticity. Fundamental and applied aspects of superplasticity.

6. Physics of Biomaterials

Basic physical processes during crystallization (in water solutions and solid-phase reactions), formation, thermal treatment and sintering of nano - and microcrystalline substances based on calcium phosphates (CP; particularly – in hydroxyapatite, HA) which by their characteristics are similar to the main mineral component of bone tissue in vertebrates. Processing methods for single-crystal HA whiskers; ways and mechanisms for toughening by them of ceramic CP materials. Chemical composition, structure, morphology, defective state and physical properties

of functional CP materials. Impurities in CP and possibilities for development of new bioactive materials by ion substitution.

7. Microscopy and spectroscopy of solids

Methods for studying structure, morphology and chemical composition of solids: electron microscopy (replica and transmission techniques); field-emission and auto-ionic microscopy; Auger electron spectroscopy; mass spectrometry; secondary ion mass spectrometry; infrared spectroscopy; X-ray spectrometry; thermogravimetry and differential thermal analysis; special methods of XRD - analysis, high and low energy electron diffraction (electrons diffraction technique). Physical fundamentals, operation scheme and performances for devices are considered. Principal fields and results of applying the presented methods for studying solids are characterized.

8. Diffusion and mechanical properties of metals and alloys

Classification of diffusion. Laws of diffusion. Solution of the second equation of diffusion. Experimental methods of determination of diffusion coefficients. Nuclear mechanisms of self- and heterodiffusion. The laws of diffusion in alloys. The ways of the accelerated diffusion. Mechanical properties: types of deformations and stresses. Elastic and plastic deformation, mechanisms and regularities of deformation development in mono-and polycrystals. Destruction and its species. Heat resistance. Creep, creep types. Mechanical characteristics which are determined by tensile and creep tests. Long-term solidity, fatigue, nature of fatigue destruction.

10. Crystallography and fundamentals of crystal chemistry

Fundamentals of geometric crystallography and crystal chemistry: symmetry in the approximation to continuum and dis-continuum, analytical description of geometric elements of a crystal, classification of crystals, thermal motion and symmetry.

Master Program

1. Physics of solids

Key issues of structural crystallography and methods for the atomic structure of solids, atomic theory and communication properties of different types of chemical bonds, crystal lattice vibrations of atoms and thermal properties of solids, classical, quantum and band electron theory of metals. Modern conceptions on the relationship of defects of crystalline structure with physical properties of real crystals and on governing possibility for physical properties of solids.

2. Problems of modern materials science

Results of current studies on defective structure and mechanism of plastic deformation of solids on different structural scales; in particular – results of the experimental study and computer modeling of structure and physical properties of grain boundaries.

3. New investigation methods in physics of solids

Tunneling and auto-ion microscopies, synchrotron irradiation, neutronography and neutron spectroscopy, nuclear gamma-resonance (Mösbauer - effect), modern methods of spectroscopy and microscopy, microcontac spectroscopy, acoustic spectroscopy.

4. Physics of real crystals

Interatomic ireactions in solids. Classification of solids by the type of chemical bonds. Defects in the crystal structure in real crystals. Dependence of the mechanical properties of crystals on the connection type and defects.

5. Functional properties of biomaterials

Structure and properties of hard tissues, classification and functional properties of biomaterials; requirements for medical biomaterials; possibilities for using ceramics based on hydroxyapatiite and other calcium-phosphate bioactive materials for plastic surgery of bone voids; characterization and testing methods for biomaterials; modern achievements and future tendencies in the field of implants for hard tissue substitution.

6. Computer modeling of physical processes

Fundamental concepts of the computer modeling, digital models of physical processes, a digital experiment, symbolic models for physical processes.

7. Physics of Nanomaterials

Review of nanostructured materials, methods of nanomaterials production, features of their structure, physical, mechanical and functional properties of such materials. The attention is mainly paid to the characterization methods for the structure of nanomaterials and their application in science, engineering and medicine.

Professionally-oriented course for third-year students of Physics faculty

Fundamentals of Structural crystallography

Structural features of crystallography essential in studying structural analysis are presented. Knowledge on macroscopical and microscopical crystallography, structural crystalchemistry and structure of a number of widespread crystals are considered.