PROGRAM
Entrance Examination
"Metallurgy"

Master Programs
"Advanced Metallic Materials and Engineering"
"Multicomponent nanostructured coatings. Nanofilms"
"Inorganic-Nanomaterials"

The content of the program:

I. Explanatory Note

The purpose of the entrance examination is to establish upon entering the master's programs the level of the candidate's knowledge of subject-related educational and scientific materials and compliance with the training requirements of the state educational standard of higher education in "Advanced Metallic Materials and Engineering", "Multicomponent nanostructured coatings. Nanofilms" and "Inorganic-Nanomaterials".

Entrance examinations are held in the form of an interview with use of remote technologies.

The duration of the entrance examination is not to exceed 40 minutes.

The maximum score is 100 points and is the combined sum of the scores from the results of the interview component and the score for individual achievement.

The maximum amount of points for the interview component is 60 points. Two questions derived from program content comprise the interview component. Each question is scored from 0 to 20 points. Additionally, the level of knowledge of professional terminology in English is being evaluated from 0 to 20 points. The results of the evaluation interview are the sum of points earned for each question and for the level of knowledge of professional terminology demonstrated in English.

The maximum amount of points for the individual achievement component is 40 points and consists of assessing the following achievements: academic achievement (cumulative grade point average from previous post-secondary institutions of higher education, publications, participation in conferences, scientific achievements, achievements in educational and social activities (certificates, diplomas, etc.) from 0 to 20 points; Statement of Purpose from 0 to 10 points; and letter(s) of recommendation from 0 to 10 points total.

Candidate must earn a minimum of 20 points to be considered eligible for admission.

II. Examination Content Outline

For Master's Program "Advanced Metallic Materials and Engineering"

2.1. Structure of metals.
Metallic crystal structures. Crystallographic directions and planes. Closely-packed crystal structures. Single crystals. Polycrystalline materials. Determination of crystal structures by X-Ray diffraction. Imperfection in metals: point defects, dislocations, interfacial defects, 3-D defects. Microscopic examination.

2.2. Phase transformations in metals.
Diffusion mechanisms. Crystallization. Melting. The kinetics of phase transformation. Isothermal transformation diagrams. Solid solutions. The Gibbs phase rule. Phases. Phase equilibria.

2.3. Binary phase diagrams.
Interpretation of phase diagrams. Binary isomorphous systems. Solubility limit. Lever rule. Development of microstructure in isomorphous alloys. Binary eutectic systems. Development of microstructure in eutectic alloys. Equilibrium diagrams with intermediate phases or compounds. Eutectoid and peritectic reactions. Congruent phase transformations. Mechanical properties of isomorphous alloys.

2.4. The Iron-Carbon system.
The Iron-Iron Carbide (Fe-Fe_3C) phase diagram. Development of microstructure in Iron-Carbon alloys (steels and white cast irons). The Iron-Graphite phase diagram. Development of microstructure in Iron-Graphite Alloys (gray cast irons).

2.5. Mechanical properties.
Stress–strain behavior. Anelasticity. Elastic properties of materials. Plastic deformation of polycrystalline metals. Dislocations slip. Dislocations climb. Tensile properties. Stress and strain. Strengthening mechanisms. Solid solution hardening. Precipitate and dispersion strengthening. Work-hardening. Hardness. Toughness. Impact toughness. Creep and creep fracture. Creep mechanisms. Fatigue failure. Fractographic Studies.

2.6. Heat treatments.
Homogenization annealing. Recovery. Recrystallization. Grain growth. Stress-relief annealing. Full annealing of steel. Normalizing. Quenching of steel. Tempering of steel. Solution heat treatment. Aging.

2.7. Metals and Alloys.
The generic metals and alloys; Iron-based, Copper-based, Nickel-based, Aluminium-based, Titanium-based alloys.

For Master's Programs "Multicomponent nanostructured coatings. Nanofilms" and "Inorganic-Nanomaterials"

2.1. Classification methods for nanopowder preparation. General information on nanomaterials and nanopowders; their properties. Mechanical methods of nanopowder synthesis. Grinding and milling in a planetary centrifugal mill.

2.2. Physico-chemical methods of nanopowder synthesis. Physical properties of the metal powders. Methods for determining of particle size distribution of the metal powders. Morphology of metal powders. Methods for determining the specific surface area of metal powders.

2.3. Sintering of powder compounds. Liquid phase and solid state sintering. Mechanisms of mass transfer at solid state sintering: via gas transfer, surface diffusion, bulk diffusion in a solid. Effect of parameters of sintering on material properties.

2.4. Methods of coating deposition at atmospheric pressure. Row materials for coatings. Thermal spraying. Plasma spraying. Arc spraying. Detonation spraying. Flame spraying. Plasma and laser welding. Electrospark alloying.

2.5. Vacuum methods of coating deposition. Physical and chemical vapor deposition technologies. The interaction of ions with the surface of a solid. Magnetron sputtering. Cathodic arc evaporation.

2.6. Structure of crystals. The symmetry of the crystal lattice. Amorphous materials. Defects in the crystal structures. Crystallization. Homogeneous and heterogeneous nucleation of crystals in the melt. Mechanisms of crystal growth.

2.7. Phase equilibrium in multicomponent systems. Chemical Equilibrium. Equilibrium constant for chemical reaction. The main types of phase diagrams of binary systems. Classification of phase transformations.

2.8. General classification of coating types. Physical and chemical characteristics of coatings. Methods for determining the thickness of coatings. Methods for determining the chemical and phase composition of coatings.

2.9. Inorganic nanomaterials. Physical and chemical methods of their synthesis. Application of inorganic nanomaterials.

2.10. Classification of ceramics and cemented carbides. Hard alloys based on WC-Co. Application of cemented carbides.

2.11. Types of chemical bonds. Crystal lattice. Potential energy surface. Types of atomistic simulation methods. Lennard-Jones 12-6 potential. Tersoff potential. Molecular dynamics.

2.12. The mechanical properties of materials. Mechanical testing. Hardness and microhardness. Plasticity and elasticity of solids.

2.13. Physical properties of solids. Methods of investigation of the physical properties of materials. Microscopic probe methods and materials research. Basic methods of X-ray analysis. Electron

diffraction and neutron diffraction. The notion of spectroscopic methods of investigation. Basics of scanning and transmission electron microscopy.

III. Recommended Reading

For Master's Program "Advanced Metallic Materials and Engineering"

1. William D. Callister, David G. Rethwisch. Fundamentals of Materials Science and Engineering: An Integrated Approach, 4th Edition. Wiley. 2012.
2. Ashby, M. F. and D. R. H. Jones, Engineering Materials 1, An Introduction to Their Properties and Applications, 3d edition, Elsevier, Oxford, 2005.
3. Ashby, M. F. and D. R. H. Jones, Engineering Materials 2, An Introduction to Microstructures, Processing and Design, 3d edition, Elsevier, Oxford, 2006.
4. ASM Handbook, Volume 4, Heat Treating. ASM International. 2002
5. ASM Handbook, Volume 8, Mechanical Testing and Evaluation. ASM International
6. ASM Handbook, Volume 9, Metallography and Microstructures. ASM International. 2004

For Master's Programs "Multicomponent nanostructured coatings. Nanofilms" and "Inorganic-Nanomaterials"

1. Charles Kittel. Introduction to Solid State Physics. Wiley, New York, 8 edition, November 2004.
2. Andrew R. Leach. Molecular Modelling. Principles and Applications. Prentice Hall, 2 edition, April 9, 2001.
3. M.S. Blanter, I.S. Golovin, H. Neuhauser, H. R. Sinning, Internal Friction in Metallic Materials A Handbook, Springer-Verlag, Berlin Heidelberg, 2007, p. 540.
4. Materials Science and Engineering: An Introduction, W.D. Callister, Jr., David G. Rethwisch, 9-th edition, John Wiley and Sons, Inc., 2014.
5. Nanostructured Materials: Selected Synthesis Methods, Properties and Applications. Edited by P. Knauth and J. Schoonman. 2004, 180 p.
6. A. Fridman, L. Kennedy. Plasma physics and engineering. Taylor& Francis, NY, 2004
7. Comprehensive Hard Materials, Elsevier Science and Technology, Editor-in-Chief V. Sarin, 2014.
8. William D. Callister, David G. Rethwisch. Fundamentals of Materials Science and Engineering: An Integrated Approach, 4th Edition. Wiley. 2012.
9. G. Kreimer. Strength of Hard Alloys, Consultants Bureau, NY, 1968.
10. Springer handbook of nanotechnology. Edited by Bharat Bhushan, Spinger Verlag, 2010, 2012 p