MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION

Federal State Autonomous Education “Ural Federal University named after the first President of Russia B.N. Yeltsin”

Institute of New Materials and Technologies

Signed and Approved

Vice-rector for Research

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ V.V. Kruzhaev

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  COURSE PROGRAM

**METAL SCIENCES AND HEAT TREATMENT OF METALS AND ALLOYS**

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| **The list of information about the work program of the discipline** | **Credentials** |
| **Educational program**  metal sciences and thermal treatment of metals and alloys | **Code of EP** 22.06.01  **Curriculum** № 6386 (version 3) |
| **Direction**  Materials technology | **Code of direction and level of preparation** 22.06.01 |
| **Level of preparation**  Training of highly qualified personnel |
| **FSES** | **Details of the order of the Ministry of Education and Science of the Russian Federation on the approval of the FSES:** № 888 of July 30, 2014, as amended on April 30, 2015 |

**Ekaterinburg**

**2018**

1. **GENERAL CHARACTERISTICS OF THE DISCIPLINE**

**1.1. Annotation of the content of the discipline**

The purpose of the discipline: the deepening and expansion of basic knowledge of metallic materials structure and aspects of their practical use.

Discipline study involves the following tasks:

- formation of professional competencies of a graduate student;

- mastering the theoretical foundations and practical applications of modern treatments of materials in order to obtain the necessary structure and a given level of their physical and mechanical properties;

- the acquisition of practical skills in the use of modern research methods for the analysis of complex multi-level, multicomponent systems.

Discipline studies are the basis for passing the state exam.

**1.2. Language of implementation of the discipline - Russian**

**1.3. Planned learning outcomes of the discipline**

The result of training in the framework of the discipline is the formation of the following competencies:

- the ability to critically analyze and evaluate modern scientific achievements, to generate new ideas in solving research and practical problems, including in interdisciplinary areas (UC-1);

- the ability to design and carry out comprehensive research, including interdisciplinary, based on a holistic system of scientific worldview using knowledge in the field of history and philosophy of science (UC-2);

- the ability and willingness to prove theoretically and optimize the technological processes of obtaining advanced materials and the production of new products from them, taking into account the consequences for society, the economy and the environment (GPC-1);

- the ability and willingness to develop and produce technological documentation for advanced materials, new products and measures of technical quality control of manufactured products (GPC-2);

- the ability and willingness to comply with regulatory requirements that ensure the safety of production and operational activities (GPC-4);

- the ability and willingness to perform theoretical and experimental research as a leading performer using computer technology (GPC-6);

- the ability and willingness to conduct a patent search on research topics, draw up materials for obtaining patents, analyze, systematize and synthesize information from global computer networks (GPC-7);

- the ability and willingness to develop technical specifications and programs of calculations and theoretical work and experimental work (GPC-9);

- the ability to choose instruments, sensors and equipment for conducting experiments and recording their results (GPC-10);

- the ability and willingness to develop technological process, technological tooling, working documentation, route and operational flow charts for the manufacture of new products from advanced materials (GPC-11);

- the ability and willingness to participate in carrying out technological experiments, to carry out technological control in the production of materials and products (GPC-12);

- the ability and willingness to participate in the certification of materials, semi-finished products, products and technological processes of their manufacture (GPC-13);

- the ability and willingness to demonstrate a systematic understanding of the current state and problems of a chosen (professional) branch of scientific knowledge (PC-1);

- the ability and willingness to conduct research in the chosen (professional) branch of scientific knowledge using modern methods and technologies (PC-2);

- readiness to identify, develop problems, using the scientific approach, conduct and implement the results of the study in the chosen (professional) branch of scientific knowledge (PC-3);

- ability to analyze, process and present scientific and professional information (PC-4);

- ability to critically analyze, evaluate and synthesize new ideas in the chosen (professional) branch of scientific knowledge, related fields (PC-6).

As a result of mastering the discipline, a graduate student should:

**Know:**

- the main types, classes of modern and advanced materials and areas of their application; modern problems of theoretical and applied materials science and engineering; basic, special vocabulary and basic terminology in the direction of preparation.

**Be able to:**

- determine the complex of structural and physical characteristics of materials (mechanical, thermal, optical, electrophysical, etc.) corresponding to the goals of their practical use;

- comprehensively assess and predict the trends and implications of the materials science and materials technology development; assess the need and prospects of a material or process.

**Acquire** (demonstrate skills and experience):

- methods of designing advanced materials using multiscale mathematical modeling and appropriate software;

- methods and means of nano-and microstructural analysis;

- methods and means of quality control and technical diagnostics of technological processes of production.

**2. CONTENT OF THE DISCIPLINE**

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| **Code of sections, topics** | **Section, topic of the discipline** | **Content** |
| **Р1** | **The structure of metals and alloys** | Scale levels of structure. Macrostructure Microstructure Submicrostructure. Types of crystal lattices. Anisotropy of crystal properties. Defects of the crystal structure. Intercrystalline boundaries (low-angle, high-angle, special). Solid solutions of substitution, introduction and subtraction. Ordered solid solutions. Multiphase materials. Interphase boundaries. Natural and artificial composite materials. Electronic structure of metals. Types of bonds between atoms in solids. Electronic connections. |
| **Р2** | **Structural and phase transformations of metals**  **and alloys in the solid state** | Diffusion in solids. Basic equations of diffusion theory. Atomic migration mechanisms. Elastic deformation. The main modes of plastic deformation. Structural changes during plastic deformation. Texture of materials. Return and polygonization. Recrystallization. Border Migration. Classification of phase transformations. Phase equilibrium diagrams. Shift (diffusionless) and normal (diffusion) transformations. Intermediate (bainite) transformation. Mechanisms of shear and normal transformations. Phase transformation diagrams (thermokinetic, isothermal, etc.). Ordering solid solution. Far and near order. |
| **Р3** | **Heat treatment of metals and alloys** | Classification types of heat treatment. Homogenization annealing. Pre-recrystallization and recrystallization annealing. Phase transformations when heated. Structural heredity. Hardening without polymorphic transformation. Hardening with polymorphic transformation. Critical cooling rate during quenching, hardenability. Isothermal hardening. Age-hardening. Drawing-back. Reversible and irreversible temper brittleness. High-temperature and low-temperature thermomechanical processing. Chemical heat treatment. Nitriding, cementation, carbonitriding, aluminizing, chrome plating, boration, sulphidation, siliconizing. Refining CTU. Hydrogen treatment. Equipment for hardening, annealing, tempering, chemical-thermal and other types of heat treatment of steels and alloys. Continuous annealing and hardening units. Ways to achieve high rates of heating and cooling products during heat treatment. Heat treatment defects. |
| **Р4** | **Methods of research and control of the structure and properties of metals** | Methods for the study of microstructure. Light microscopy. Electron microscopy X-ray diffraction and electron-graphic analysis. X-ray microanalysis analysis. Methods for measuring physical properties (thermal analysis, calorimetry, dilatometry, density measurement, resistometry, magnetic analysis, etc.). Methods for the determination of corrosion properties. Mechanical properties of metals and alloys. Methods for measuring them. Static and dynamic tests. Tests for creep, long-term strength and stress relaxation. Fatigue testing. |

**6.3.5. The list of indicative questions for the exam**

1. Types of crystal lattices. Anisotropy of crystal properties. Defects of the crystal structure. Intercrystalline boundaries (low-angle, high-angle, special).

2. Solid solutions of substitution, introduction and subtraction. Ordered solid solutions.

3. Multiphase materials. Interphase boundaries.

4. Natural and artificial composite materials.

5. Electronic structure of metals. Types of bonds between atoms in solids. Electronic connections.

6. Classification of types of heat treatment. Homogenization annealing. Pre-recrystallization and recrystallization annealing.

7. Phase transformations during heating. Structural heredity. Hardening without polymorphic transformation. Hardening with polymorphic transformation.

8. Critical cooling rate during quenching, hardenability. Isothermal hardening.

9. Age-hardening. Drawing-back. Reversible and irreversible temper brittleness.

10. High-temperature and low-temperature thermomechanical processing. Chemical heat treatment.

11. Nitriding, cementation, carbonitriding, aluminizing, chrome plating, boration, sulphidation, siliconizing.

12. Equipment for hardening, annealing, tempering, chemical-thermal and other types of heat treatment of steels and alloys.

13. Units of continuous annealing and hardening.

14. Ways to achieve high rates of heating and cooling products during heat treatment. Heat treatment defects.

15. Methods for studying microstructure. Light and electron microscopy.

16. X-ray diffraction and electron graphic analysis. X-ray microanalysis analysis.

17. Methods for measuring physical properties (thermal analysis, calorimetry, dilatometry, density measurement, resistometry, magnetic analysis, etc.).

18. Methods for the determination of corrosion properties.

19. Mechanical properties of metals and alloys and methods for their measurement.

20. Static and dynamic tests. Tests for creep, long-term strength and stress relaxation. Fatigue testing.

**7. TRAINING-METHODOLOGICAL AND INFORMATION SUPPORT OF THE DISCIPLINE**

**7.4. Databases, information and reference and search engines**

Zonal Scientific Library of the Ural Federal University, the section "Young Scientists" [Official site]. URL: <http://lib.urfu.ru/course/view.php?id=144>

Electronic catalog of the Ural Federal University [Official site]. URL: <http://lib.urfu.ru/course/view.php?id=76>

Electronic catalog of periodicals of the Ural Federal University [Official site]. URL: <http://lib.urfu.ru/course/view.php?id=80>

Electronic Library Systems of the Ural Federal University [Official site]. URL: <http://lib.urfu.ru/mod/resource/view.php?id=2330>

Electronic resources by subscription of the Ural Federal University [Official site]. URL: <http://lib.urfu.ru/course/view.php?id=97>

Free electronic resources of the Ural Federal University [Official site]. URL: <http://lib.urfu.ru/course/view.php?id=75>

Libraries, including digital (electronic) libraries, providing access to professional databases, information and reference and search engines, as well as other information resources:

- universal:

1. Academic Search Complete, EBSCO publishing;
2. eBook collection Oxford Russia Fund;
3. eLibrary ;
4. InCites, Web of Science;
5. Journal Citation Reports, Web of Science;
6. Oxford University Press;
7. ProQuest Digital Dissertations and Theses vol. A & B, ProQuest;
8. Sage, Sage Publications Ltd;
9. Science, AAAS;
10. ScienceDirect Freedom Collection, Elsevier;
11. Scopus, Elsevier;
12. SpringerLink, Springer;
13. Web of ScienceTM Core Collection, Web of Science;
14. Wiley, Wiley Online Library;
15. MARS ABRIKON;
16. Russian platform of archives of scientific journals (Archive NEICON);
17. EBS University Library Online, «Direct-Mediа»;
18. Electronic library of dissertations of the RSL, Russian State Library;

- support systems:

1. EBSCO Discovery Service, EBSCO publishing;
2. EndNote Web, Web of Science;
3. Zotero;
4. Antiplagiat.