Nano materials Technologies

Syllabus of Curricula

Magnitogorsk State Technical University named after G.I. Nosov (MSTU), Russia

Natalia Koptseva
Marina Polyakova

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Annotation

In the course students will get the notions of nanomaterials and nanotechnology, current state and prospects of development. The foundation for the nanomaterials classification and types of their structures will be considered, as well as the features properties and key directions for the use of nanomaterials. An overview of the main technologies of nanomaterials will be presented.

The attention in the teaching discipline will be paid to the scientific foundation of the creation, processing of ultrafine and nanostructured structural materials for innovative applications in industry, as well as methods of studying their structure and properties with the use of modern research equipment.

Review of the deformation structure refinement methods, including the obteining of bulk ultrafine-grained materials, especially structural steels, will be conducted. Particularly, it is planned to consider the effect of subsequent plastic deformation on the evolution of structure and properties of these steels and their stability under thermal influence. Examples of modern technologies for industrial production of high-strength metal products made of steels with ultrafine-grained (nanoscale) structural elements will be considered.

The practical section of the discipline involves consolidation of theoretical material and includes laboratory work aimed at understanding the features of the microstructure and properties of ultrafine-grained structural steels state formed by methods of deformation and thermal deformation effects. Students should be acquainted with the methods of qualitative and quantitative microanalysis of ultrafine-grained steels, test methods of mechanical properties, as well as using modern research complex Gleeble 3500 for the physical modeling of the processes of deformation and structure refinement study of the structural phase transformations.

It is envisaged writing abstracts on topics of discipline in order to increase the knowledge acquired in the lectures and its presentation and defense of work in front of a group of students.

Aim of the module:
competences foreseen by study programme

-The acquisition of knowledge about modern and promising areas of technological solutions and create effective management structure and properties of nanostructured materials

- Preparing graduates for the scientific research to solve the problems associated with the development of methods for obtaining and processing of nanomaterials

Prerequisites:

- basic knowledge of physics and chemistry
- basic knowledge of material science
- basic knowledge of crystallography
- basic knowledge of mechanical and physical properties of materials
- basic knowledge of theory of phase transformations at thermal and thermal-mechanical treatment
- basic knowledge of heat treatment theory
- basic knowledge of plastic deformation technology

Structure of discipline

ECTS (Credits of the module) – 5
Total students workload hours – 125 h.
Contact hours – 75 h.
Individual work hours – 50 h.

Learning outcomes of module

to know:

-classification of nanomaterials and coatings, theoretical basis of nanostructured state of solids, technology of nanomaterials, particularly their physical-mechanical properties, development trends;

to be able:

-to identify and analyze the mechanical, thermal and electrical characteristics nanostructures and nanostructured materials and coatings;

to possess:

- technological bases of production of nanostructured and nanostructured materials;
- structural methods for the study of nanomaterials;
- methods for determination of mechanical, thermal and electrical properties of nanomaterials and coatings

Assessment

Strategy: final exam
Deadline: 18th week
Criteria: knowledge, comprehension, ability to apply the knowledge

The content of the discipline

Themes	Contact work hours				Time and tasks for individual work	
	Lect.	Practic. works	Laborat. works	**Total**	**Individ. work**	**Tasks**
1. General characteristics of nanotechnologies, nanomaterials and nanostructured materials	2	2	-	4	6	study of theoretical material; preparation of practical work
2. Techniques for synthesis and processing of nanomaterials and nanostructured materials	4	2	-	6	6	study of theoretical material; preparation of practical work
3. Basic research methods of nanomaterials nanostructured materials	6	2	8	16	8	study of theoretical material; preparation of laboratory work
4. Deformation methods of producing bulk nanostructured materials	6	2	-	8	8	study of theoretical material; preparation of practical work
5. Structure and mechanical properties of bulk nanostructured nanomaterials	6	2	8	16	8	study of theoretical material; preparation of laboratory work
6. Stability of bulk nanostructured nanomaterials to thermal influences	6	2	8	16	6	study of theoretical material; preparation of laboratory work
7. Application of nanomaterials and nanostructured materials	6	3	-	9	8	study of theoretical material; preparation of laboratory work
Total	**36**	**15**	**24**	**75**	**50**	

The main content of the theoretical section

1. General characteristics of nanotechnologies nanomaterials and nanostructured materials. Defining nanomaterials. Nanostructured materials and nanotechnology. Classification of nanomaterials. Pecularіyies of the structure of nanocrestalline materials. Properties of nanomaterials
2. Techniques for synthesis and processing of nanomaterials and nanostructured materials. Vapor-phase synthesis. Liquid phase synthesis. Sol-gel technique. Solid-state phase synthesis. Precipitation from solutions. Consolidation of nanopowders
3. Basic research methods of nanomaterials and nanostructured materials. X-Ray diffraction for nanomaterials characterization. Electron microscopy. X-Ray spectruscopy. Scanning prob microscopy. Surface analysis methods
4. Deformation methods of producing bulk nanostructured materials. Torsion under high pressure. Equal-channel angular pressing. Screw extrusion. Comprehensive forging. Other methods based on large plastic deformation
5. Structure and mechanical properties of bulk nanostructured nanomaterials. Typical nanostructures and mechanism of structuring. Experimental methods for measuring grain growth. Peculiarities of mechanical properties formation in structural carbon steel in the process ECAP
6. Stability of bulk nanostructured nanomaterials to thermal influences Behaviour of nanomaterials and the nanostructured materials when heating. Structural-phase transformations in low and medium carbon steel with UFG structure formed by the method ECAP.
7. Application of nanomaterials and nanostructured materials

Laboratory works

Laboratory work № 1. "The evolution of the structure and mechanical properties of the structural carbon steels during deformation nanostructuring by method of equal-channel angular pressing“

Laboratory work № 2. The evolution of the structure and mechanical properties after annealing of the structural ultrafine grained steel, nanostructured by method of equal-channel angular pressing“

Laboratory work № 3. "Modern diagnostics of the structure and properties and fisical modelling obteining of UFG structure in steels".

Sample topics of abstracts

1. Perspective directions of modern methods development of deformation nanostructuring
2. The traditional and upgraded schemes of equal channel angular pressing. Advantages and limits of technology
3. Peculiarities of technological equipment for the reception and processing of nanostructured materials
4. Peculiarities of the research equipment for the diagnostics of the nanostructured materials structure and properties
5. Integration problems of nanostructuring deformation processes in the current production of metallurgical enterprises

et al.

Literature

Compulsory literature:

1. Гусев А.И. *Наноматериалы, наноструктуры, нанотехнологии* М.: Физматлит, 2005. – 416 с.
2. Валиев Р.З., Александров И.В. *Объемные наноструктурные металлические материалы. Получение, структура и свойства*. М.: Академкнига, 2007. – 398 с.
3. Zhen Guo, Li Tan. *Fundamentals and Applications of Nanomaterials .* Artech House, 2009. – 268 p.
4. Koch C.C., Ovid'ko I.A., Seal S., Verper S. Structural Nanocrystalline *Materials. Fundamentals and Applications* Cambridge University Press. 2007. – 380 p.

Additional literature:

1. *Bulk Nanostructured Materials*. Editor(s): Michael J. Zehetbauer, Yuntian Theodore Zhu2009. – 736 p. Willey Online Library*/*
2. Андриевский Р. А., Рагуля А.В. *Наноструктурные материалы*. Уч. пособие. М.: Издательский центр «Академия», 2005. – 187 с.
3. Анищик В.М., Борисенко В.Е., Жданок С.А., Толочко Н.К., Федосюк В.М. *Наноматериалы и нанотехнологии*. Мн.: БГУ, 2008. – 375 с.
4. Чукин М.В., Копцева Н.В., Ефимова Ю.Ю., Емалеева Д.Г., Барышников М.П., Полякова М.А. *Структура и свойства наноструктурированных углеродистых конструкционных сталей*: Учебное пособие. Магнитогорск: ГОУ ВПО «МГТУ», 2011. – 122 с.

Contacts

Magnitogorsk State Technical University named after G.I. Nosov (MSTU), Russia

Metallurgy, Materials Science and Metal Working Institute

Teachers:

Natalia Koptseva,
coordinating, *Foundry and Materials Science Department,*

e-mail:
kopceva1948@mail.ru

Marina Polyakova,
Mechanical and Metallurgical Process Engineering Department,

e-mail:
m.polyakova-64@mail.ru

Thank you for attention