Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

APPROVED
Head of the Phystech School of Aerospace Technology
S.S. Negodyaev

Work program of the course (training module)

course:	Program Orientation Course/Введение в специальность
major:	Applied Mathematics and Physics
specialization:	Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии
	Phystech School of Aerospace Technology
	Chair of Logistics Systems and Technologies
term:	1
qualification:	Master

Semester, form of interim assessment: 2 (spring) - Pass/fail exam

Academic hours: 15 AH in total, including:
lectures: 0 AH.
seminars: 15 AH.
laboratory practical: 0 AH.

Independent work: 30 AH.

In total: 45 AH, credits in total: 1

Author of the program: M.N. Vasilev, doctor of technical sciences, full professor

The program was discussed at the Chair of Logistics Systems and Technologies 09.02.2022

Annotation

The course familiarizes students with the master program subject. The training course syllabus is illustrated by preliminary discussion of the most important problems of plasma physics, plasma chemistry and plasma technology as well as by presentations of real beam-plasma systems in operation. Under the personal tutor guidance every student prepares individual research project on the basis of seminar demonstration demonstrations and information found and selected by the student himself in books, papers and other sources. The training course ends with student's presentation on the individual project results.

1. Study objective

Purpose of the course

To acquaint students with the technique of electron-beam plasma generation, methods for studying its properties and with the electron-beam plasma main applications in industrial and aerospace technologies.

Tasks of the course

- Demonstration to students of the operation of beam-plasma systems available at the Department of Logistics Systems and Technologies;
- Familiarization of students with the directions of proposed research and educational practices;
- Presentation of individual and group projects general ideas to be implemented during the study on the master's program “Beam-plasma systems and technologies.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of physical and mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of physical and mathematical sciences
	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional settings
Gen.Pro.C-2 Acquire an understanding of current scientific and technological challenges in professional settings, and scientifically formulate professional objectives	Gen.Pro.C-2.1 Assess the current state of mathematical research within professional settings
	Gen.Pro.C-2.2 Assess the relevance and practical importance of research in professional settings
	Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form within professional communication

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- general information about principles of operation and designs of beam-plasma setups;
- basic methods of work on beam-plasma facilities, features of their operation and maintenance;
- methods for measuring the main parameters that characterize the operating modes of beam-plasma setups and properties of electron-beam plasma;
- main parameters and target characteristics of technological beam-plasma systems.

be able to:

- apply in practice the basic concepts used in the analysis and synthesis of beam-plasma systems;
- choose the optimal method for setting up experiments on beam-plasma facilities;
- numerically estimate in order of magnitude the beam-plasma key characteristics;
- formulate the problem statement of the experimental study of the properties of electron-beam plasma and its application in industrial and aerospace technologies;
- determine (clarify) methods for solving problems of experimental study of the properties of electron-beam plasma and its application in industrial and aerospace technologies;
- master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of beam-plasma systems.

master:

- the skills of mastering a large amount of interdisciplinary information;
- a culture of setting goals in the beam-plasma systems design and application;
- basic skills of working on beam-plasma facilities.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	The principle of electron-beam plasma generation, typical beam-plasma setups design		2		2
2	The main operation parameters of beam-plasma setups and methods for their measurement. Control methods for beam-plasma facilities		2		2
3	Methods used for measuring physical values characterizing the electron-beam plasma properties		2		2
4	Experiments arrangement to study the beam-plasma effect on matter		2		4
5	Experiments arrangement on the electron-beam plasma flows generation in relation to aerospace technologies		2		4
6	Problems statement for system analysis and modeling of beam-plasma systems. Beam-plasma systems optimization		2		4
7	Discussion of the topics and content of individual and group projects to be carried out within the framework of educational practices		3		12
AH in total			15		30
Exam preparation		0 AH.			
Total complexity		45 AH., credits in total 1			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 2 (Spring)

1. The principle of electron-beam plasma generation, typical beam-plasma setups design

Introduction. Subject, goals and objectives of the course. Technique for generating electron beams. Methods for electron beams injection into dense gaseous media. Injection windows. Systems and components of beam-plasma setups. Concentrated electron beams propagation in a dense gaseous medium. Gas ionization and excitation by an electron beam

2. The main operation parameters of beam-plasma setups and methods for their measurement. Control methods for beam-plasma facilities

Electron guns characteristics, electron beams formation in vacuum. Control of the accelerating voltage and current of the. Faraday cups, collectors, probes, calorimetric methods for measuring the electron beam current. Injection windows characteristics. Coefficient of the electron beam transmission through the injection window and its dependence on the pressure of the plasma generating gas. Controlling the an electron beam energy release in a gas, the electron beam scanning after injection into a dense gas. Regulation and maintenance of the plasma generating gas pressure. Bremsstrahlung generation during the beam-plasma setups operation and methods for its measurement.

3. Methods used for measuring physical values characterizing the electron-beam plasma properties

Probe methods for diagnosing electron-beam plasma. Optical methods for diagnosing electron-beam plasma, optical spectrometers. Mass spectrometers. Temperature measurements in the electron-beam plasma. Pyrometry in beam-plasma setups.

4. Experiments arrangement to study the beam-plasma effect on matter

Heating of solids placed in an electron-beam plasma. Emission of optical and X-ray radiation by solid bodies in an electron-beam plasma. Plasma-chemical processes on the surface of a solid body in contact with an electron-beam plasma. Generation of electron-beam plasma in aerosols.

5. Experiments arrangement on the electron-beam plasma flows generation in relation to aerospace technologies

Generation of electron-beam plasma flows of air and gas mixtures. Measurement of the aerodynamic characteristics of bodies blown by an electron-beam plasma flow. Plasma-stimulated combustion. Aerosols in an electron-beam plasma flows.

6. Problems statement for system analysis and modeling of beam-plasma systems. Beam-plasma systems optimization

Compatibility of the main sub-systems of beam-plasma setups. Ensuring of beam-plasma setups reliable operation, technical maintenance of the main and auxiliary systems. Beam-plasma facilities radiation safety. System assessment of the beam-plasma facilities for various applicationas, efficiency criteria.

7. Discussion of the topics and content of individual and group projects to be carried out within the framework of educational practices

Projects related to the generation and study of the properties of an electron-beam plasmas of various media. Projects related to the study of properties modification and functionalization of various materials in electron-beam plasma. Projects on biomedical applications of electron-beam plasma. Projects related to the conversion of liquid and gaseous hydrocarbons in non-equilibrium plasmas.

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

Experimental complex "Beam-plasma systems and technologies" as part of the ELU-1 and ELU-2 installations, the PPT-2 plasma torch, RF gas-discharge plasma generators, hybrid plasma systems, diagnostic equipment, auxiliary and special technological equipment (room 222 of the UPM building) . Necessary equipment for practical exercises: computer and multimedia equipment (projector, marker board, Internet connection).

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

1) M. Vasiliev, T. Vasilieva. Materials production with Beam Plasmas. In Encyclopedia of Plasma Technology (Ed. J.L. Shohet, Taylor & Francis), 2016
2) Encyclopedia of low-temperature plasma. Chief editor V. Fortov. Moscow. Nauka, 2001. V. XI, sections XI-2, XI-4.9, XI-5.

Additional literature

1) Bychkov, V.; Vasiliev, M.; Koroteev, A. Electron-Beam Plasma: Generation, Properties, Applications; Moscow State Open University Publishers: Moscow, Russia, 1993.
2) M. Vasiliev, Aung Tun Win, I. Pobol. "New applications of the Beam-Plasma Systems for the materials production" Int. J. Nanotechnology. 2014, Vol. 11, Nos 5/6/7/8, P. 660-668
3) M.N. Vasiliev, Aung Tun Win. Generation and Applications of Electron-Beam Plasma Flows // Journal of Physics Conference Series. 2015, V. 591. doi:10.1088/1742-6596/591/1/012051
4) T. Vasilieva, S. Lopatin, V. Varlamov, V. Miasnikov, Aung Myat Hein, M. Vasiliev Hydrolisys of chitin and chitosan in low temperature electron-beam plasma // Pure and Applied Chemistry - – 2016. – V.88, N9 – P. 873-879.

7. List of web resources that are necessary for the course (training module) mastering

Not used

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

Microsoft Office. Internet access.

9. Guidelines for students to master the course

The program of the training course provides for the acquaintance of students with the equipment and instruments used in the experiments, the features of the operation of the main and auxiliary systems of the experimental complex and a number of independent measurements on operating setups.

Successful mastering of the discipline requires intense student's self tuition. It includes:

- reading the recommended basic and additional literature;
- study of technical descriptions and manuals for the equipment used in experiments;
- preparation of proposals for setting up experiments within the framework of individual and group projects;
- familiarity with publications on the subject of studied topics.

The main indicators of knowledge of the material are the ability to demonstrate knowledge obtained from the materials of lectures and practical classes, as well as recommended literature.

To pass the final test every student must prepare the presentation on one of the studied topic using all available information.

SUPPLEMENT

Assessment funds for course (training module)

major:	Applied Mathematics and Physics
specialization:	Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии Phystech School of Aerospace Technology Chair of Logistics Systems and Technologies
term:	1
qualification:	Master

Semester, form of interim assessment: 2 (spring) - Pass/fail exam

Author: M.N. Vasilev, doctor of technical sciences, full professor

1. Competencies formed during the process of studying the course

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2. Competency assessment indicators

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be able to:

- apply in practice the basic concepts used in the analysis and synthesis of beam-plasma systems;
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- determine (clarify) methods for solving problems of experimental study of the properties of electron-beam plasma and its application in industrial and aerospace technologies;
- master new subject areas, theoretical approaches and experimental techniques related to the analysis, design and application of beam-plasma systems.

master:

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- basic skills of working on beam-plasma facilities.

3. List of typical control tasks used to evaluate knowledge and skills

Examples of individual research projects:

1. Plasma-assisted coating and surface synthesis
• Hydrophilic/hydrophobic properties of surface layers produced in plasmas.
• Biocompatibility of materials produced in plasmas.
2. Plasma treatment of gases and liquids
• Plasma-assisted methane conversion.
• Electron-Beam plasma of liquid aerosol.
3. Dusty plasmas
• Dusty plasma near a wall (of fusion reactor).

- Plasma of solid aerosol (for applications).

4. Hybrid materials synthesis in plasmas

- Carbon-based materials.
- Polymer (or biopolymer)-based materials.

4. Evaluation criteria

1. Principle of electron-beam plasma generation.
2. Methods for electron beams generation in relation to the problem of electron-beam plasma generation.
3. Methods for transport electron beams from a vacuum into a dense gaseous medium. Advantages, disadvantages and limitations of various beam transportation methods.
4. Formation of a plasmagenerating medium in electron-beam plasma generators. Restrictions on the composition and pressure of the plasma-forming medium.
5. Concentrated electron beams propagation in a dense gaseous medium. Scattering, deceleration and absorption of electrons in a gas.
6. Interaction of an electron-beam plasma with a solid body. Processes occurring at the interface between beam plasma and solid body.
7. Electron-beam plasma generators. Main and auxiliary systems of beam-plasma setups.
8. Beam-plasma setups with a solid body inside the plasma volume.
9. Compatibility of beam-plasma setups elements of various types.
10. Methods for measuring the main parameters of electron beams.
11. Basic parameters characterizing the properties of electron-beam plasma and methods for their measurement.
12. Methods for measuring the temperature of a solid body placed in electron-beam plasma.
13. Generation of optical radiations in electron-beam plasma.
14. Bremsstrahlung radiation, X-ray protection of beam-plasma setups.
15. Technologies of thermal materials treatment by electron-beam plasma.
16. Technologies of chemical-thermal materials treatment by electron-beam plasma.
17. Plasma-chemical technologies for processing materials in electron-beam plasma at low temperatures.
18. Technologies for polymers and biopolymers modification in electron-beam plasma.
19. Known electron-beam plasma aerospace applications.

To pass the final test every student must prepare the presentation on individual research project results. When presenting the student is asked 1-2 or more (no more than 5) questions, taking into account the student's activity in the classroom and the assessments of midterm control.

The “pass” mark is given to the student who showed systematized knowledge of the curriculum during the presentation and satisfactorily answered additional questions.

The “fail” mark is given if, during the presentation and answering questions, the student shows that he does not know most of the main content of the curriculum and mistakes in the basic provisions of the discipline being studied.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

Necessary conditions for the “pass” mark are:

- Submission by every student of a presentation with critical analysis of information selected for individual research project.
- Demonstration of the entire course understanding when the presentation discussion.