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|   | **Course Syllabus** |

**1.** **Course Title:**

Introduction to Micro- and Nanofabrication Technology

**2. Academic Level:**

Master

**3. ECTS Credits:**

5 ECTS

**4. Semester:**

2, spring semester

**5. School/Department:**

Institute of Nanotechnologies, Electronics and Equipment Engineering / Department of Nanotechnology and Microsystems Technology

**6. Location:**

Taganrog Campus, 2 Shevchenko St., Taganrog

**7. Instructor:**

English

Prof. Alexey Kolomiytsev, PhD, email: askolomiytsev@sfedu.ru, Prof. Oleg Ilin, PhD, email: oiilin@sfedu.ru

**8. Language of Instruction:**

**9. Course Description:**

The course is designed to give an advanced introduction into micro- and nanofabrication technology, such as optical and electron beam lithography, atomic force and scanning probe microscopy, scanning electron microscopy and technology of focused ion beam, technology of carbon nanotubes and graphene structures formation.

**10. Course Aims:**

- to obtain theoretical and practical knowledge about micro- and nanofabrication technology, such as optical and electron beam lithography, atomic force and scanning probe microscopy, scanning electron microscopy and technology of focused ion beam, technology of carbon nanotubes and graphene structures formation.

- to develop communicative competences in English.

**11. Specific entry requirements (if any):**

English B1. Basic knowledge of the electronic structure of atoms and molecules along with the bachelor’s level knowledge selected fields of general physics, chemistry, solid state physics and mathematics.

**12. Course Content:**

Unit 0: IC History and Semiconductor Fundamentals. History of IC and semiconductor fabrication technology, basis of p-n junction diode (JD), p-n-p and n-p-n bipolar junction transistor (BJT), device application of p-n junction (photodetector, solar cell, LED, laser diode).

Unit 1: Technology of cleaning and etching of semiconductor wafers.Technology of cleaning semiconductor and dielectric wafers as well as physical principles and technology of etching wafers by RIE and wet etching. Practical skills in the plasma chemical etching STE ICPe68 equipment.

Unit 2: Technologies of formation of thin films. Physical processes of film formation by thermal and magnetron sputtering, laser ablation, molecular beam epitaxy and plasma-chemical deposition. Plasma chemical deposition with STE ICPd81 and LPCVD PlasmaLab 100 equipment, laser ablation PLD Pioneer 180, magnetron sputtering Auto500.

Unit 3: Technology lithographic processes. Moore's law, basics of lithographic processes such as photolithography, electron beam lithography, probe lithography and focused ion beams technology. MJB4 alignment and exposure equipment during photolithography and skills in technology of focused ion beams on Nova Nanolab 600 equipment.

Unit 4: Technology of growing carbon nanotubes. Technology of chemical vapor deposition for creation arrays of carbon nanotubes. Basics of the process that affects growth, orientation and properties of carbon nanotubes. PECVD equipment for growing aligned arrays of vertically aligned carbon nanotubes.

Unit 5: Methods for control and modification of surfaces with micro- and nanometer spatial resolution

Physical basis of probe microscopy. Techniques applied in the analysis of surface with micro- and nanometer resolution, methods of probe nanolithography. Probe microscope Solver P47 Pro. Scanning electron microscopy at the surface of the object visualization. Scanning electron microscope with an ion column Nova Nanolab 600.

**13. Intended Learning Outcomes:**

Knowledge: features of English for special purposes; basic principles of preparation and design of presentations and reports; basic communication techniques.

Abilities: to present reports in English on a topic in area of micro- and nanofabrication technology, to prepare presentations; to use basic methods and techniques of communication in English to solve different problems of professional activities.

Skills: to think abstractly, to analyze, to synthesize the information received in English.

**14. Learning and Teaching Methods:**

**Passive:** lecture-visualization using presentation material, oral questioning.

**Active:** independent work with literature, scientific, educational and reference digital resources, performance of analytical tasks, creation of reproductive individual works (essays, scientific reports), independent production of texts with new settings.

**Interactive:** lab sessions and project work. The course can be carried out partly or as a whole using electronic and distant educational system of University.

**15. Methods of Assessment/Final assessment information:**

Assignments: 5 projects, midterm and final assessment, term paper, presentation.

1. JD/BJT Project: one week after the end of a unit 10%

2. Photolithography Project: one week after the end of a unit 10%

3. AFM/STM Project one week after the end of a unit 10%

4. In Class Midterm Assessment 20%

5. FIB/SEM Project one week after the end of a unit 10%

6. CNT Project one week after the end of a unit 10%

7. Presentation in class 10 min pres. and 5 min Q&A 10%

8. Term Paper 20%

A 10% per day late penalty will be applied to all assignments. 100%

**16. Reading List:**

1. R.C. Jaeger. Introduction To Microelectronics Fabrication (2nd. ed.). 2002, Prentice Hall.
2. R. F. Pierret. Semiconductor Device Fundamentals. 1996, Addison Wesley.
3. K. Suzuki, B. W. Smith. Microlithography: science and technology (2nd. ed.). 2007, New York: CRC Press. 846 p.
4. Helbert J.N. Handbook of VLSI microlithography. Principles, technology, and applications. 2001, New York: Noyes Publications. 1024 p.
5. Bruus H. Introduction to nanotechnology. Lyngby: Department of Micro and Nanotechnology. 2004.105 p.
6. Franssila S. Introduction to microfabrication. 2004. New Jersey: Wiley. 422 p.