COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Nano- and microstructure technologies	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: Doc. R. Butkutė **Other(s): dr. I. Reklaitis,** dr. M. Malinauskas	Faculty of Physics

Study cycle	Type of the course unit (module)
First cycle	optional

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
	VI (spring) semester	Lithuanian/English

Requirements for students	
Prerequisites: Knowledge of general physics, solid-state physics, growth technologies of semiconductors, background of chemistry	**Additional requirements (if any):**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	150	64	86

Purpose of the course unit (module): programme competences to be developed		
Students will get familiar with the micro- and nano-materials and structures. They will gain fundamental principles of nano-technologies including formation, characterization and possible applications. Develop abilities to shape micro-structures and characterize their properties.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Students will be able to understand the scientific literature published in english, and to accomplish the projects working in international teams (4.3)	Team discussion, debates	Presentation, theme
Students will be able to find the relevant scientific literature in the internet, scientific journals and handbooks, to learn and critically evaluate its content and systematically present (2.2)	Cross-discussion	Presentation, analysis of the particular case
Students will understand the principal of new technologies using the knowledge of general physics, semiconductor for projecting of prototypes (3.3, 3.4, 4.4)	Problem lectures, explaining	Oral questioning, written quiz
They will be able to perform standard laboratory work procedures, to synthesize compounds, to apply knowledge of chemistry in technological steps (2.3)	Project	Research work

Content: breakdown of the topics	Contact hours	Self-study work: time and assignments

	Lectures	Tutorials	Seminars	Exercises	Laboratory work	Internship/work placement	**Contact hours**	**Self-study hours**	**Assignments**
1. Introduction. Brief history of nano-technologies. Top-down and bottom-up design concepts. 0D, 1D, 2D, 3D quantum confinement. Applications of nano-technologies.	1		1				**2**	**5**	Preparation for seminar. Repetition for exam.
2. Basics of physical chemistry basics. Surface energy. Chemical potential. Electrostatic and polymeric nanoparticles stabilization.	2		1				**3**	**5**	Preparation for seminar. Repetition for exam.
3. 0D nanostructures. Nanoparticles. Synthesis of metal, semiconductor, and oxide nanoparticles. Nanoparticles insertion in solid-state materials methods. Practical use of 0D nanostructures.	2		2				**4**	**10**	Preparation for seminar. Repetition for exam.
4. Self-assembling approach. Bottom-up nano-structures formation methods (rapid thermal annealing, chemical vapour deposition, molecular beam epitaxy and other methods).	2		2				**4**	**5**	Preparation for seminar. Repetition for exam.
5. 1D nanostructures, nanowires. Fusion methods: nanowires size control principles. Self-organization of molecules and nanostructures. Self-assembled structures growth and control techniques Self-organizing in organic electronics: advantages and disadvantages in applications of self-organizig molecules, layer fabrication, Langmuir-Blodgett layers, self-organizing in volume, organic solar cells and FETs.	2		2		2		**6**	**10**	Preparation for seminar. Repetition for exam.
6. 2D nano-materials engineering. Basic quantum wells fabrication principles. Semiconductor nano-structures engineering and analysis examples, the peculiarities and commonalities.	3		2				**5**	**5**	Preparation for seminar. Repetition for exam.
7. Top-down nano-structures formation methods (reactive plasma etching, quantum sheets epitaxy technologies, quantum dots formation from bulk materials, etc.). Laboratory work on top-down nano-structures formation technology.	3		2		2		**7**	**11**	Preparation for seminar and laboratory works. Repetition for the exam.
8. Direct 2.5D structures formation with the nano-resolution (focused ion beam method, chemical vapour deposition by electron beam, etc.).	3		2				**5**	**5**	Preparation for seminar. Repetition for exam.
9. Nano-darinių tyrimo metodai (optiniai, elektronų mikroskopija, katodoliuminescencija, atominės jėgos mikroskopija, spektroskopija su mikro skyra). Optinės litografijos pakartojimas, elektronų pluoštelio, jonų pluoštelio litografijos, nano-įspaudimo litografija. Elektronų litografijos laboratorinis darbas, nano-darinių charakterizavimo laboratorinis darbas.	2		2		2		**6**	**15**	Preparation for seminar and laboratory works. Repetition for the exam.

Nano-structures characterization methods (optical and electron microscopies, cathodoluminescence, atomic force microscopy, micro-spectroscopy, etc.). Repetition of optical lithography, electron beam, ion beam lithography, nano-imprint lithography. Electron lithography laboratory work, nano-structures characterization laboratory work									
10. Introduction to photonic devices (photonic crystals, photonic band structure, applications, future trends).	2		2				**4**	**5**	Preparation for seminar. Repetition for exam.
11. Direct laser writing, interference lithography, soft lithography, stereolithography, variaties of 3D printing, photoreduction.	5		3		2		**10**	**5**	Preparation for seminar. Repetition for exam.
12. Metamaterials. Mezo-scale (multidimensional) and composite (multimaterial) structures formation (4D printing). The demand and possibilities in today's life, its prevalence in Lithuania and the world. Examples and future prospects.	5		3				**8**	**5**	Preparation for seminar. Repetition for exam.
Total	**32**		**24**		**8**		**64**	**86**	

Assessment strategy	**Weight,%**	**Deadline**	**Assessment criteria**
Laboratory work rating	30*	All course	Preparation to answer theoretical questions, quantity of errors in circuit connection, the quality of the work description, ability to describe the results. Evaluation in 10 scores system, the final score is multiplied by the weight coefficient. * It is obligatory to finish all laboratory works.
Seminars rating	30	All course	Ability to understand and accomplish the tasks during the seminars
Exam (written form)	40	During the exam session	5 open questions. Assessment of answer particularity, consistency and mistakes.

Author	**Year of publication**	**Title**	**Issue of a periodical or volume of a publication**	**Publishing place and house or web link**
Compulsary reading				
Bhushan, Bharat	2010	Handbook of nanotechnology	3	Berlin : Springer Science+Business Media ISBN 978-3-642-02525-9
Hawkes, P., Spence, J.C.H.	2007	Science of Microscopy	1	ISBN-13: 978-0387497624
Bharat B.	2010	Springer Handbook of Nanotechnology	1	ISBN-13: 978-3642025259
Optional reading				
Murty, B.S., Shankar, P., Raj, B., Rath, B.B., Murday, J.	2013	Textbook of Nanoscience and Nanotechnology	1	ISBN-13: 978-3642280306
	2010-2016	Materials Today		