COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Semiconductors growth technologies	

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

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

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

Requirements for students	
Knowledge of general physics, solid-state physics, 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		
To provide the knowledge about classical and modern technologies of growth of bulky semiconductors and thin layers, to acquire the practical skills in the field of fabrication of semiconductor-based nano- and micro-devices		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Student will be able to use theoretical knowledge for interpretation of problems and find possible technological solution (1.1-1.3)	Problem lectures	Oral questioning, written quiz
Will be trained to work in team, organize and solve the given problems and provide a summary of main results (2.1, 3.2, 3.4, 4.2)	Cross-discussion	Analysis of the particular case
Will be able to discuss with the specialists of the field	Team discussion, debates	Presentation, essay
Will manage to find, understand and apply the knowledge from the internet sources, publications and literature (5.1)	Individual work	Presentation
Will understand the principles of engineering of new technologies using basic knowledge (3.2, 3.4)	Problem lectures, explaining	Oral questioning, written quiz
Will gain skills necessary for construction of	Problem lectures	Oral questioning, written

semiconducting electronic and optoelectronic devices(1.3, 3.1)		quiz
Will be able to select and perform standard technological operations for preparation and growth of semiconductor compounds (2.2, 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.Physical background of heteroepitaxial growth. Phase diagrams and kinetics. Bulk crystals. Growth methods: Czochralski, Bridgeman-Stokbarger, Kyroupolos, Verneil, Float zone. Physical chemistry. Pecularities of growth of single and multicomponents materials. Doping, diffusion, Lows of Fick	2						**2**	**10**	Repeating the information, solving the tasks
2. Growth technology of semiconductors, dielectrics and metals, layer growth mechanism, epitaxial, polycrystalline and amorphous layers. Physical layer deposition methods: thermal evaporation, magnetron sputtering, laser ablation MBE. Condensation process, Amorphous, polycrystal, monocrystalline layers. Vapour and liquide phase deposition.	3	2		1	2	4	**12**	**10**	Repeating the information, preparation for the growth procedures
3. Deffects in thin films, recrystallization of layers, annealing by laser.	2			1			**3**	**5**	Preparation for the discussion on thin film growth methods.
4. Chemical deposition techniques of semiconductors. Thermodynamics. Equilibrium conditions. Binary, ternary, quaternary systems. Doping. Surface reconstruction, surface diffusion.	3						**3**	**5**	Repeating the information, solving the tasks.
5. Kinetics of chemical reactions. Physical processes on the surface adsorption, desorbtion, chemisorption. Homogeneous and heterogeneous chemical reactions. Precursors. Hydrodynamics and mass transport. Plasma physics. High frequency plasma.	3			1			**4**	**10**	Repeating the information, solving the tasks.
6. Chemical vapour deposition (CVD). Metalorganic chemical vapour deposition (MOCVD). Chemical beam epitaxy (CBE). Hot wire chemical vapour deposition (HWCVD). Plasma enhanced chemical vapour deposition	2	2		1	2	4	**11**	**10**	Preparing for technological research work. Repeating the information for

(PECVD). Liquid delivery systems of precursors.									examination.
7. Characterization of thin films: XRD, SEM, AFM, optical characterization methods.	2						**2**	**5**	Preparation for the discussion on thin film characterization methods.
8. Introduction. Brief history of semiconductor circuits formation. Optical lithography. Mask-less lithography (laser, electron beam, ion beam, etc.).	3						**3**	**5**	Preparation for laboratory works. Repetition for exam.
9. Wet chemical etching, rapid thermal annealing, metal evaporation technologies (thermal, laser, electron beam evaporation), contact formation principles. Contacts formation laboratory work.	3		2		2		**7**	**10**	Preparation for seminar and laboratory works. Repetition for exam.
10. Plasma technologies (plasma enhanced chemical vapour deposition, ion implantation, reactive ion etching, plasma cleaning, magnetron sputtering, etc.). Plasma technologies laboratory work.	3		2		2		**7**	**10**	Preparation for seminar and laboratory works. Repetition for exam.
11. Finishing technologies (diamond and laser scribing, cleaving, dicing, laser lift-off, die soldering, wire bonding, encapsulation, etc.). Lithography laboratory work.	3				2		**5**	**3**	Preparation for seminar. Repetition for exam.
12. Study of semiconductor device manufacturing examples (silicon p-n diode, gallium nitride light-emitting diode, gallium arsenide laser diode, etc.).	3				2		**5**	**3**	Preparation for seminar. Repetition for exam.
Total	**32**	**4**	**4**	**4**	**12**	**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**
Compulsory reading				
David A. Glocker	2010	Handbook of thin films process technology	2 leidimas	Taylor & Francis ISBN: 0750306955 9780750306959
T. Markvart, L. Castañer	2005	Solar cells: materials, manufacture and operation	2 leidimas	Elsevier Advanced Technology ISBN: 9780123869647

John B. Hudson	1998	Surface Science: an introduction		John Wiley&Suns ISBN 0-471-25239-5
Jong-Hee Park	2001	Chemical Vapor Deposition		ASM International ISBN 0-87170-731-4
Gerald B. Stringfellow	1999.	Organometalic Vapor-Phase Epitaxy: Theory and practice		Academic Press ISBN 0-12-673842-4
Hwaiyu Geng	2005	Semicondutor manufacturing handbook	1	ISBN-13: 978-0071445597
Yoshio Nishi, Robert Doering	2007	Handbook of Semiconductor Manufacturing Technology	2	ISBN-13: 978-1574446753
Optional reading				
Stephen A. Campbell	2001	The science and engineering of microelectronic fabrication	2	Oxford University Press ISBN 0-19-513605-5
Michael A. Lieberman, Alan J. Lichtenberg	2005	Principles of Plasma Discharges and Materials Processing	2	ISBN-13: 978-0471720010
Stephen A. Campbell	2012	Fabrication Engineering at the Micro- and Nanoscale	4	ISBN-13: 978-0199861224
Gary S. May, Costas J. Spanos	2006	Fundamentals of Semiconductor Manufacturing and Process Control	1	ISBN-13: 978-0471784067