COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Modern semiconductor devices – physics and technology	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: dr. Algirdas Mekys **Other(s): dr. Nerijus Nekrašas**	Faculty of Physics

Study cycle	Type of the course unit (module)
Second (Master studies)	Compulsory

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
Lectures, seminars, laboratory works	I (autumn) semester	Lithuanian/English

Requirements for students	
Prerequisites: General physics – electricity and magnetism, solid state physics, higher mathematics, differential equations, quantum mechanics, or similar advanced courses.	**Additional requirements (if any):**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	140	64	76

Purpose of the course unit (module): programme competences to be developed		
To provide knowledge about main fundamental physical principles of modern microelectronic devices, materials they are made of; and ability to efficiently analyze information in literature sources about modern microelectronic devices and the way they are functioning on the level of semiconductor physics; to explain the operation of microelectronics circuit(s); apply theoretical knowledge when analyzing and designing circuits with modern semiconductor devices.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Gained theoretical knowledge about main fundamental physical principles of modern microelectronic devices and materials they are made of; and ability to efficiently analyse information in literature sources about modern microelectronic devices and the way they are functioning on the level of semiconductor physics; explain the operation of microelectronics circuit(s); apply theoretical knowledge when analysing and designing circuits with modern semiconductor devices.	Lectures	Oral exam
Ability to find the necessary specific scientific information in published literature and/or internet, analyse, comprehend and present it.	Seminars	Evaluation, if student is able to find the necessary specific scientific information, analyse, comprehend and present it.
Ability of the student to apply theoretical knowledge for the investigation of properties of microelectronic devices and electronic circuits; ability to analyse the experimental results basing on the fundamental physical principles; ability	Experimental classes (laboratory works)	Control questions, evaluation of results, reports and conclusions.

understand the causes of the problems and solution possibilities.		

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. Materials of modern microelectronics. Crystalline semiconductors: from classical ones towards the wide- and narrow-gap semiconductors. Disordered structures: micro- and polycrystalline, amorphous materials. Organic semiconductors. Technology of modern microelectronics.	3						**3**	**4**	Repetition for exam.
2. Physics of surfaces and interfaces. Crystal structure of surfaces. Phase and structural transitions. Quaziparticles at surfaces. Main principles and methods of surface analysis. Electronic states at surfaces and interfaces. Theory of potential barrier. Carrier transport phenomena at surfaces and interfaces. Laboratory work: Investigation of p-n structure or Investigation of metal, oxide and semiconductor structure.	5		2		2		**9**	**11**	Preparation for laboratory works and seminar presentations, Repetition for exam.
3. Contact theory. Metal-semiconductor junction. Energy band models, space charge regions, formation of potential barriers. Accumulation and depletion layers. Rectifying junction, ohmic junction. Space-Charge-Limited-Currents (SCLCs). Laboratory work: Investigation of metal, oxide and semiconductor structure.	4		2		2		**8**	**10**	Preparation for laboratory works and seminar presentations, Repetition for exam.
4. p-n junctions. Homo- and heterojunctions. Blocking, injecting, ohmic contacts. Effects, limiting current flow. Carrier injection, accumulation, exclusion and extraction. p-i-n diodes. Laboratory work: Investigation of p-n structure or Breakdown phenomena in semiconductor structures.	4		2		2		**8**	**9**	Preparation for laboratory works and seminar presentations, Repetition for exam.
5. Bipolar transistors and related devices. Theory, band structure, analysis of Current-Voltage dependencies. Laboratory work: Investigation of bipolar transistor and its transient properties.	4		2		2		**8**	**9**	Preparation for laboratory works and seminar presentations, Repetition for exam.
6. Three-junction bipolar devices. Dynistors, thyristors, diacs. Requirements, characteristic features, energy band structure and principles of operation. Laboratory work: Investigation of Thyristor.	2		2		2		**6**	**8**	Preparation for laboratory works and seminar presentations, Repetition for exam.
7. MOSFETs, MESFETs and related devices. Theory, band structure, analysis of Current-Voltage dependencies. Memory devices. Laboratory work: MOSFET.	3		2		2		**7**	**8**	Preparation for laboratory works and seminar presentations, Repetition for exam.
8. High frequency devices. Microwave diodes, quantum-effect and hot-electron devices. Single electron devices. Spin-effect devices. Giant magnetoresistance (GMR) devices. Z2-FET transistors. Laboratory work: Transient properties of	4		2		2		**8**	**9**	Preparation for laboratory works and seminar presentations, Repetition for exam.

semiconductor diodes or Frequency dependences of transistors.									
9. Photonic light emitting and light-harvesting devices. Photodiodes, Solar cells, LEDs. Screens and monitors based on microelectronic structures: LCD (twisted nematic – TN, in plane switching – IPS, other modifications). CFL LCD, LED LCD. Passive matrix, active matrix. OLED, AMOLED. Laboratory work: Investigation of optron or LED.	3		2		2		**7**	**8**	Preparation for laboratory works and seminar presentations, Repetition for exam.
Total	**32**		**16**		**16**		**64**	**76**	

Assessment strategy	**Weight,%**	**Deadline**	**Assessment criteria**
Oral exam	75	During the exam session	The student needs to answer to 2 questions of the total 40 from the whole course and additional questions concerning the presented statements. Assessment of answer particularity, consistency and mistakes.
Laboratory work rating	15	All course	Ability to answer theoretical questions, understanding of the measurement principles and circuitry, quality of the work description, ability to explain the results basing on the fundamental physical principles. It is obligatory to finish all laboratory works.
Assessment of the presentations during the seminars.	10	All course	Understanding of the analyzed topics, quality of oral and visual presentations.

Author	**Year of publication**	**Title**	**Issue of a periodical or volume of a publication**	**Publishing place and house or web link**
Compulsary reading				
S.M. Sze	2007	Physics of semiconductor devices		Wiley Interscience (available at the University library).
Kwok K. Ng	2010	Complete Guide to Semiconductor Devices		https://onlinelibrary.wiley.com/doi/book/10.1002/9781118014769
V. Kažukauskas	2008	Šiuolaikiniai puslaidininkių mikro-elektronikos prietaisai. Fizika ir technologija.		Progretus, Vilnius (available at the University library)
V. Kažukauskas	2002	Elektriniai reiškiniai puslaidininkio paviršiuje. Vadovėlis.		VU, Vilnius (available at the University library)
Optional reading				
V. Kažukauskas.	1998	Krūvininkai puslaidininkių paviršiuose, kontaktuose ir pn sandūrose. Uždavinynas.		VU, Vilnius (available at the University library)
S. Sze.	2001	Semiconductor Devices: Physics and Technology, 2nd Edition.		Wiley (available at the University library)
K. Seeger.	2002	Semiconductor Physics. An Introduction. 8th ed.		Springer, Berlin (available at the University library)