COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Physics and Technology of Inorganics Optoelectronic Devices	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: prof. Gintaras Valušis **Other(s):**	Faculty of Physics, Institute of Photonics and Nanotechnology

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, practice, laboratory works	II (spring) semester	Lithuanian/English

Requirements for students	
Prerequisites: Electricity and Magnetism, Optics, Solid State Physics	**Additional requirements (if any):**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
10	**280**	**96**	**184**

Purpose of the course unit (module): programme competences to be developed
To provide knowledge on modern inorganic electronic and optoelectronic devices and their operational principles, design features and fabrication technologies; develop skills to apply obtained knowledge for design of new materials and their-based devices; to analyse scientific literature on modern devices; apply simple theoretical models to estimate parameters and explain physics behind operation relying on knowledge in general physics, semiconductor physics and optics.

Learning outcomes of the course unit (module)	Teaching and learning methods	Assessment methods
Acquisition of theoretical knowledge required for design and technology on modern electronic and optoelectronic devices; ability to understand the scientific literature on the topic; to exchange information and to present results; ability to understand, interpret and apply knowledge in electronics, optoelectronics and technology fields; acquisition of knowledge required for understanding the operating principles of the devices.	Lectures	Exam in verbal/written form.
Ability to understand scientific literature, exchange the information and to present results obtained by other authors.	Seminars	Evaluation whether student is able to understand independently scientific literature and present results
Ability to apply simple theoretical models to evaluate parameters of devices.	Practice	Evaluation whether student is able to apply independently models to describe operation

		of the studied devices and evaluate their parameters
Ability to use knowledge in experimental investigation of operation of novel devices and determining their parameters.	Laboratory works	Control questions, evaluation of results, reports and conclusions.

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. **Semiconductor parameters for modern devices.** Main semiconductors for modern electronics – silicon, AIII-BV, oxides, organic and magnetic semiconductors; carbon nanocompounds. Semiconductor nanostructures and their growth technologies.	**1**						**1**	**4**	
2. **Modern microwave and hot electron devices** Intro to hot electron physics. Gunn effect. IMPATT diodes. QWITT diodes. High-power sensors. P-i-N diodes. Bigradient diodes. Klystrons. Magnetrons. Back-wave oscillators. Comparison of their parameters.	**4**			**2**	**4**		**10**	**10**	Preparation for laboratory works, practice, reports writing. Repetition for exam.
3. **Frequency multipliers and intro to terahertz physics.** Multiplication in mathematics, Transistors circuits. Solution for microwave and terahertz (THz) ranges. Main parameters of operation. Specifics of THz range in electromagnetic wave scale. THz generation principles. Physics behind THz detection. Semiconductor nanotechnology for compact THz imaging systems.	**4**	**2**		**2**			**8**	**10**	Preparation for laboratory works, practice, reports writing. Repetition for exam.
4. **THz emitters and detectors.** Optoelectronic systems. Air-plasma emitters. Microbolometers. THz QWIPs. Planar THz diodes. THz HEIWIP's.	**3**		**2**		**4**		**9**	**10**	Preparation for laboratory works, reports writing. Repetition for exam.
5. **Modern heterojunctions-based devices and plasmonics.** Modulation-doped structures. High electron mobility transistors, HEMTs and their parameters. Nanoelectronics devices. Ultrafast transistors. Features of HEMT's design. Nanometric field effect transistors. „Shallow water“ instabilities and 2D electron gas in HEMT's. Plasma waves, their dispersion. Frequency and noise properties of HEMT's. Application for THz imaging. Compact plasma electronics.	**4**		**2**	**2**			**8**	**10**	Preparation for practice.

6. **Mesoscopic devices.** Mesoscopic structures. Mesoscopic “signatures” in electrical characteristics. Conductance of one-dimensional wire. Quantum contact. Coherent/incoherent transport. Carbon nanotubes. Carbon nanoelectronics. Ballistic transport. Coulomb blockade. Quantum Hall effect.	**2**		**2**				**4**	**10**	Repetition for exam.
7. **Spintronics devices.** Spintronics materials. Anisotropic and giant magnetoresistance. Spin transport and scattering. Electrical and optical spin injection. Spin-Hall effect. Growth of spintronic materials. Spin memory. Spin field effect transistors.	**2**						**2**	**10**	Repetition for exam.
8. **Ultrafast processes and coherent transport-based devices**. Ultrafast phenomena and their investigation. Dephasing times. Coherent transport. Quantum beats in quantum wells. Superlattices. Bloch oscillations. Quantum cascade lasers. Bloch laser.	**3**	**2**		**2**	**4**		**11**	**16**	Preparation for laboratory works, practice, reports writing. Repetition for exam.
9. **Meta-electronics and its devices.** Metamaterials and their properties. Lens and superlens. Modulators. Filters. Design principles. Technologies of meta-electronics devices.	**2**		**2**				**4**	**10**	Repetition for exam.
10. **Graphene-based electronic devices.** Graphene and its features. Peculiarities of carrier transport in graphene. Hall and quantum Hall effect in graphene. Bilayers. Graphene electronics devices. Silicene.	**2**	**2**	**2**				**6**	**10**	Repetition for exam
11. **Main optoelectronic materials.** Semiconductors application. Structures and contacts. Heterostructures, epilayers, diluted semiconductors. Structures of confined dimensions.	**2**		**2**	**2**			**6**	**10**	Repetition for exam
12. **LEDs and laser diodes**: principles of operation, spectra of LEDs and laser diodes, their dynamical and modulation features. Novel devices and features. Single-mode lasers. Lasers with quantum structures. Quantum cascade lasers.	**6**		**2**				**8**	**14**	Repetition for exam
13. **Semiconductor optical amplifiers.** Optical fibres amplifiers. Types of amplifiers. Usage in optical communications. Nonlinear optical devices with optical amplifiers.	**2**	**2**					**4**	**10**	Repetition for exam
14. **Photodetectors**. Main characteristics. Ramo theorem. Photoresistance. Photodiodes. PiN and UTC photodiodes.	**2**			**2**			**4**	**10**	Repetition for exam
15. **THz and infrared optoelectronics devices.** Their parameters. Modern bolometers and their design. QWIP‘s. Sensitivity and noise equivalent power. Quantum dots detectors. Comparison of parameters.	**2**		**2**	**2**	**4**		**10**	**10**	Preparation for laboratory works, practice, reports writing. Repetition for exam.
16. **Integrated optics and optoelectronics**. Light	**3**			**2**			**5**	**20**	Repetition for

modulators, electrooptic Mach-Zehnder modulators. Quantum confined Stark effect. Charge coupled devices. CCD ir CMOS image arrays.									exam
17. **Future optical communication systems**. Fiber communication systems. Data transfer principles and multiplexing.	**2**		**2**				**4**	**10**	Repetition for exam
18. **Trends of development of optoelectronics technologies.** Last lecture, which contents is defined by the latest scientific news in the topic.	**2**								
Total	**48**	**8**	**16**	**16**	**16**			**184**	

Assessment strategy	**Weight,%**	**Deadline**	**Assessment criteria**
Exam (verbal/written form)	50	During the exam session	3 open questions. Assessment of answer particularity, consistency and mistakes.
Laboratory work rating	10*	All course	Preparation to answer theoretical questions, the quality of the work description, ability to describe the results. * It is obligatory to finish all laboratory works.
Seminars	20	All course	Ability to understand and accomplish the tasks during the seminars.
Practice	20	All course	Ability to apply independently models to describe operation of studied devices and evaluate their parameters.

Author	**Year of publication**	**Title**	**Issue of a periodical or volume of a publication**	**Publishing place and house or web link**
Compulsary reading				
1. S. M. Sze	2002	Semiconductor devices: Physics and technology		John Willey & sons, MKIC – section of Technological Sciences.
2. P. Bhattacharya.,	1997	Semiconductor Optoelectronic Devices,		Prentice Hall MKIC – section of Technological Sciences.
Optional reading				
1. W. J. Stillman and M. S. Shur, Journal of	2007	Closing the Gap: Plasma Wave Electronic Terahertz Detectors,	vol. 2, 2009-221	Nanoelectronics and Optoelectronics, e-version.