COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Materials Characterization Techniques	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: Prof. Gintautas Tamulaitis **Other(s):**	Faculty of Physics

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

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
Auditorium	6 (Spring) semester	English or Lithuanian

Requirements for students	
Prerequisites: General Physics	**Additional requirements (if any):** None

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	128	64	64

Purpose of the course unit (module): programme competences to be developed		
The course is aimed at the development of the basic knowledge, which is necessary to comprehend the principles of the currently most important techniques for materials characterization, the understanding of the advantages and limitations of the techniques, the competencies of assessment and proper use of the results obtained using these techniques, and the experimental skills in applying the general measuring approaches in specific materials characterization techniques.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Dedicated basic knowledge to understand the principles of the main techniques currently in use for structural, electrical and optical measurements (1.1)	Lectures supported by application of the basic knowledge in seminars and laboratory works	Predominantly in mid-term and final exam assessments, partly in assessment of the work in seminars.
Understanding of general approaches used in physical measurements and their applications in specific measurement techniques (1.2)	Lectures supported by detailed examples in seminars and hands-on experience in laboratory works	Predominantly in mid-term and final exam assessments, partly in assessment of the work in seminars and laboratory works.
Understanding of capabilities, advantages and limitations of a wide scope of materials characterization techniques (1.3)	Lectures for basics, seminars for detailed presentation of specific techniques, hands-on experience with a few techniques	Predominantly in mid-term and final exam, partly in assessment of the work in seminars and laboratory works.
Skills in selection of measurement techniques, estimation of their applicability limits, data analysis and interpretation (1.3)	Laboratory works, seminars and self-study work based on the materials presented in lectures	Assessment of seminar activities, laboratory works and individual tasks.
Skills of working as a part of teams exploiting big experimental facilities (4.2)	Laboratory works, interactive observation of big	Assessment of achievements in performing laboratory works

	measurement facilities in action, data processing and analysis as a part of self-study work	supported by self-study 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. Direct and indirect measurements. Measurement errors and mistakes. Contacts and contactless techniques.	1						**1**	**4**	
2. Measurements of electrical parameters: I-V curves; linear four point probe, van der Pauw, Hall effect techniques, capacitance and inductance measurements.	3		1		3		**7**	**5**	Preparation for laboratory works for all students, preparation for seminar presentation for 3 of them (supposing hereon the total number of 24 students, while the hours indicated are in average and substantially increase individually in the week of seminar presentation).
3. Measurements of optical transmittance and absorption coefficient. Optical spectrometers. Determination of optical parameters of transparent and opaque materials. Measurement peculiarities in infrared and deep UV regions. Optical modulation spectroscopy.	4				3		**7**	**5**	Preparation for laboratory works for all students, preparation for seminar presentation for 3 of them
4. Techniques for surface morphology measurements: profilometers, techniques for geometrical parameters of thin films, atomic force microscopy.	2		1		3		**6**	**5**	Preparation for laboratory works completion of the first individual task for all students, preparation for seminar presentation for 4 of them.
5. Luminescence spectroscopy. Photoluminescence, X-ray luminesce, and cathodoluminescence. Light dispersion and detection equipment. Time-resolved photoluminescence spectroscopy (streak camera, up-conversion, time-correlated photon counting technique, measurements in microsecond domain). Spatially-resolved luminescence spectroscopy (micro-luminescence, confocal microscopy, scanning near-field optical microscopy). Characterization of stimulated light emission: variable stripe length and Hakki-Paoli techniques.	5				3		**8**	**5**	Preparation for laboratory works for all students, preparation for seminar presentation for 7 of them.
6. Luminescence efficiency; injection efficiency, internal quantum efficiency, and light extraction efficiency. Measurements with integrating sphere. Ray tracing calculations.	2		1		3		**6**	**5**	Preparation for laboratory works for all students, preparation for seminar presentation for 4 of them.
7. Photocurrent spectroscopy. Photo-induced	2		1				**3**	**5**	Preparation for seminar

transient spectroscopy and deep-level transient spectroscopy.									presentation for 4 students.
8. Techniques based on nonlinear optical phenomena. Pump and probe experiments. Generation of white light continuum. Four-wave mixing. Light-induced transient gratings.	2		1		3		**6**	**5**	Preparation for laboratory works for all students, preparation for seminar presentation for 3 of them.
9. Elastic and inelastic light scattering. Rayleigh, Mie, and Tyndall scattering. Brillouin and Raman scattering. Raman scattering techniques for material characterization.	2		1				**3**	**5**	Preparation for seminar presentation for 3 students.
10. Photoelectron spectroscopy. Angle-resolved photoelectron spectroscopy, X-ray photoemission spectroscopy.	2		1				**3**	**5**	Preparation for seminar presentation for 3 students.
11. Mass spectrometry. Secondary ion mass spectrometry.	1		1		2		**4**	**5**	Preparation for laboratory works for all students, preparation for seminar presentation for 5 of them.
12. X-ray crystallography. X-ray diffraction. Types of experimental techniques, data analysis. X-ray sources for diffractometric measurements.	4				2		**6**	**5**	Preparation for laboratory works and completion of the second individual task for all students, preparation for seminar presentation for 6 of them.
13. Scanning electron microscopy. Transmission electron microscopy.	2				2		**4**	**5**	Preparation for laboratory works for all students, preparation for seminar presentation for 3 of them, completion of the third individual task
Total	**32**		**8**		**24**		**64**	**64**	

Assessment strategy	**Weight ,%**	**Deadline**	**Assessment criteria**
Laboratory works	20	Throughout entire semester	4 hands-on laboratory works and 4 laboratory works via interactive visits of large measurement facilities with subsequent individual data analysis. Completion of all 8 tasks required. Key assessment criteria: ability to properly plan and perform measurements; skills in data analysis and interpretation.
Seminar activities	30	Throughout entire semester	Two presentations (25%-weight each); key assessment criteria: knowledge of the subject presented, good planning, clear and substantiated presentation, suggestibility; participation in discussions (50%-weight each).
Self-study	10	Throughout entire semester	Solution of three specific tasks assigned individually. (The self-study is also indirectly assessed in seminars and laboratory works).
Mid-term exam	20	8^{th} or 9^{th} week of the semester	Answers to five equal-weight open questions in write. Key assessment criteria: understanding of the general approaches, fundamentals of the measurement techniques, and ability to discuss their capacities and applicability.
Final exam	20	Session time	Answers to two equal-weight open questions in write and their oral discussion. Key assessment criteria: understanding of the general approaches, fundamentals of the measurement techniques, and ability to discuss their capacities and applicability.

Author	**Year of**	**Title**	**Issue of a periodical**	**Publishing place and house or web link**

	publication		or volume of a publication	
Compulsory reading				
G. Tamulaitis	Updated annually	Materials accessible via Moodle system		http://vma.esec.vu.lt/
Yang Leng	2013	Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd edition		Wiley-VCH
D. K. Schroder	2015	Semiconductor Material and Device Characterization; 3rd Edition		Wiley-Interscience IEEE Press
Optional reading				
A. Patane, N. Balkan, eds.	2012	Semiconductor Research. Experimental Techniques.	Springer Series in Materials Science 150	Springer
R. P. Campos, A. C. Cuevas, R. E. Muñoz, Eds.	2015	Materials Characterization		Springer