COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Functional and Smart Materials	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: Assoc. prof. T. Šalkus **Other(s): Assoc. prof. I. Zamaraitė**	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	English

Requirements for students	
Prerequisites: 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	130	60	70

Purpose of the course unit (module): programme competences to be developed		
Students will get familiar with Functional materials. They will have insight in a broad range of current and future important types of functional material. Also student will understand the possibilities in applications as for example in telecommunication, memory devices or even displays. Also they will develop abilities to relate the properties of functional materials to their structure, phase.		
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 (3.1, 4.1)	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 (5.1, 5.2)	Cross-discussion	Presentation, analysis of the particular case
Students will understand the principal of new technologies using the knowledge of general physics and solid-state physics for projecting of prototypes (9.2, 12.1)	Problem lectures, explaining	Oral questioning, written quiz
They will be able to perform standart laboratory work procedures, to analyse compounds, to apply knowledge in technological steps (13.1)	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 and Brief history. Crystallography. Crystal structure. Symmetry operations. Properties Associated with Noncentrosymmetric Materials. Polarization. First and second order phase transition. Paraelectric, ferroelectric phase. Dielectric anomalies. Curie–Weiss law.	4		0				**4**	**4**	Repetition for exam.
2. Perovskites. Hexagonal Manganites. Piezoelectricity. Pyroelectricity. Ferroelectricity. Origin of ferroelectric domains. Anti-ferroelectricity. Second-Harmonic Generation.	2		2		8		**12**	**12**	Preparation for seminar. Repetition for exam.
3. Device application of polar materials. Ferroelectric memory. Strain sensor and accelerometers, Ultrasound generation. Infrared detection using pyroelectric devices. Ferroelectric field effect transistors FeFETs.	4		2				**6**	**6**	Preparation for seminar. Repetition for exam.
4. Light propagation in materials. Electro – optic effect. Electro – absorption modulation. Electro – optic modulators. Interferroelectric modulators.	2		4				**6**	**6**	Preparation for seminar. Repetition for exam.
5. Magnetic materials. Physical basis for magnetic properties. Diamagnetic, paramagnetic ferromagnetic, anti-ferromagnetic effect. Supercoducting materials: first and second type Superconductivity. Conventional theories	2		4				**6**	**8**	Preparation for seminar. Repetition for exam.
6. Quantum interference devices. SQUID magnetometers. Cooling by demagnetization. Magneto-optic modulators. Magnetic recording. Giant magnetic resistence devices.	4		2				**6**	**6**	Preparation for seminar. Repetition for exam.
7. Point defects. Ionic diffusion and conductivity in solid state. Crystal structures of solid electrolytes. Phase transitions in solid electrolytes.	*4*				4		**8**	**8**	Repetition for exam.
8. Lithium-ion conductors. Oxygen ion conductors. Proton conductors. Mixed electronic – ionic conductors.	*2*		2				**4**	**4**	Preparation for seminar. Repetition for exam.
9. Applications of solid electrolyte materials: fuel cells, batteries, sensors, ionistors, electrolyzers, oxygen pumps, electrochromic displays, memristors.	*4*						**4**	**8**	Repetition for exam.
10. Technological processing of functional materials: single crystal growth methods, ceramics processing, thick film processing, thin film growth.	*4*						**4**	**10**	Repetition for exam.
Total	**32**	**0**	**16**	**0**	**12**	**0**	**60**	**70**	

Assessment strategy	**Weight,%**	**Deadline**	**Assessment criteria**
Laboratory work rating	10*	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)	60	During the exam session	10 open questions. Assessment of answer particularity, consistency and mistakes.

Autorius	**Leidimo metai**	**Pavadinimas**	**Periodinio leidinio Nr. ar leidinio tomas**	**Leidimo vieta ir leidykla ar internetinė nuoroda**
Privaloma literatūra				
Rainer Waser	2005	Nanoelectronics and information technology : advanced electronic materials and novel devices	2	ISBN: 352740542
Bruce, Duncan W., O'Hare, Dermot, Walton, Richard I.	2010	Inorganic Materials Series : Functional Oxides (1)		ISBN: 9781119972945
Papildoma literatūra				
T. Kudo, K. Fueki	1990	Solid State Ionics		ISBN-10: 3527281665 ISBN-13: 978-3527281664
Jasprit Singh	2005	Smart Electronic Materials Fundamentals and applications		ISBN-13:978-0-521-85027-4 ISBN-10:0-521-85027-4]
J.F. Scott	2000	Ferroelectric Memories		ISBN:3540663878