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Master-degree program at Vilnius University, Faculty of Physics

Semiconductor technology is the key driving force of the technological progress in modern society. The rapid development in electronics and optoelectronics requires an increasing number of specialists with research-based knowledge and technological skills.

This program is aimed at preparing qualified specialists with technological skills in materials science, who have strong background in the physics of inorganic and organic semiconductors and are specialized in frontiers of photovoltaics, novel electronic and optoelectronic devices, semiconductor nanotechnology, solid-state lighting systems and new disruptive technologies enabled by the current development of the state-of-the-art semiconductor science and technology.

The key knowledges and skills of the graduates of the SST study program are focused on the research, development and production of electronic and optoelectronic materials and devices. The graduates of this program are in high demand in global and national high-tech industries, academy, and governmental institutions.

The studies are strongly supported by the access to the state-of-the-art research and technological facilities. To ensure the synergy in acquiring scientific knowledge and experimental skills, a strong emphasis is put on research projects in modern research laboratories throughout the entire study process.

This program is accredited by the Lithuanian national authority, the Centre for Quality Assessment in Higher Education in accordance with the European Quality Assurance Register for Higher Education (EQAR).

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Aims

This program aims at preparing highly-qualified specialists, who will be able to:

- analyze scientific, technological and production issues of semiconductor technologies;
- assess and solve problems, generalize conclusions, suggest and apply scientific and technological innovations, and perform management at technological level, while working at research laboratories, high-tech companies, and public institutions associated with electronics and optoelectronics industries;
- continue their education in semiconductor physics and technologies at PhD level.

Outcomes

Graduates of this program are expected to gain:

- an in-depth understanding of the physics of semiconductors and semiconductor nanostructures, the processes of light-material interaction, the operation principles, variety, advantages and disadvantages of the electronic and optoelectronic devices currently in use and prospective for future development;
- knowledge in materials science, semiconductor technologies, and material characterization techniques;
- ability to use modern investigation techniques to study semiconductor structures and devices and apply up-to-date models for characterization of their properties;
- experience in planning experiments and interpreting their results, and applying mathematical models to describe the processes under study;
- up-to-date outlook of the global trends in semiconductor science, technology and industry based on the close involvement of the Lithuanian, European, and worldwide companies into the study process.

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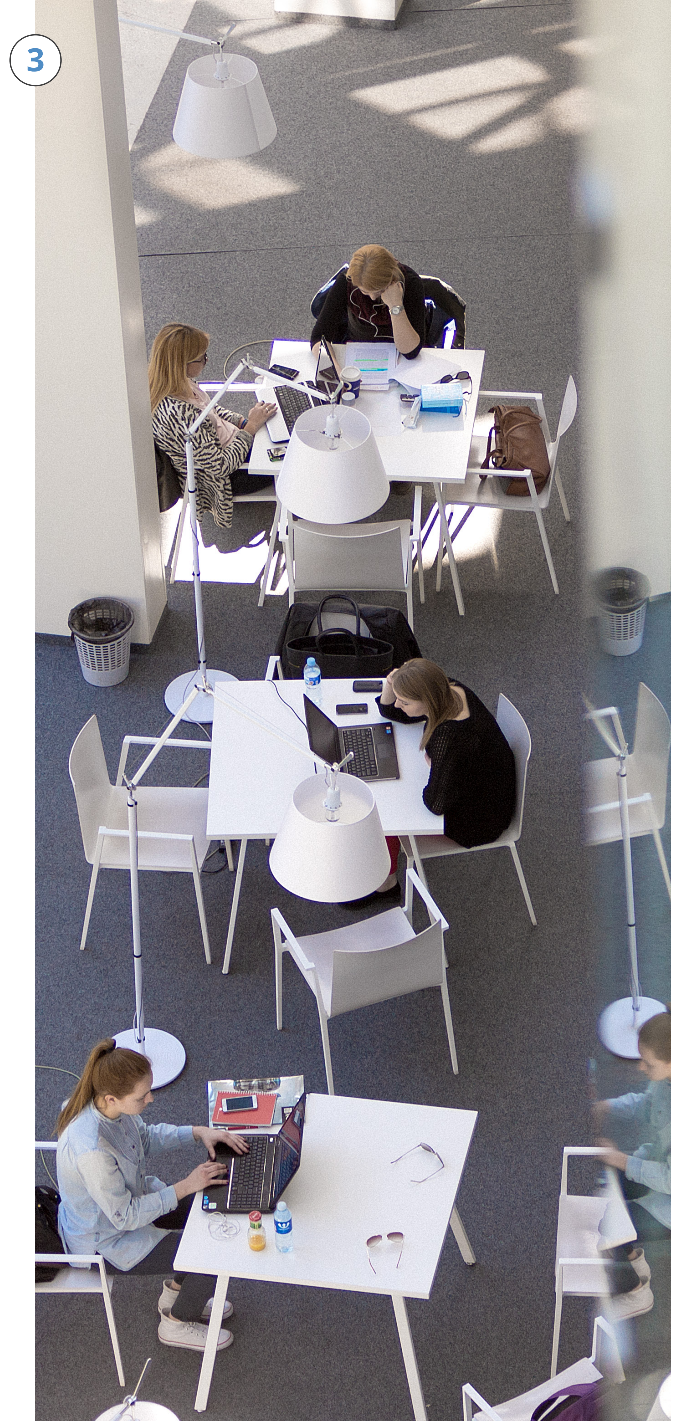

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Novel Materials and Technologies

The goal of this course is to introduce both conventional and novel material technologies, with special emphasis on thin film deposition and micro- and nanoelectronics engineering. The students are expected to acquire thorough understanding and practical skills in the modern technologies of crystal growth, deposition of thin films and multilayers, formation of nanostructures, as well as skills in processing techniques of importance in solving problems in the field of development and manufacture of semiconductor-based devices.

Semiconductor Optics

This is an in-depth course on semiconductor optics. The course introduces the basics of quantum mechanics and the fundamentals of semiconductor physics. A special emphasis is put on the quasiparticles in solid state matrices, which exhibit practically prospective optical properties ranging from THz to UV. The knowledge and understanding of dispersion curves, optical transitions, and the peculiarities of light interaction with semiconductor materials and structures will be developed. The course also focuses on optical properties of low-dimensional structures.

Modern Microelectronic Devices

The course will start from the fundamental principles of modern microelectronic devices. Modern crystalline and organic materials for the fabrication of such devices will be analyzed from the point of view of different applications. A comprehensive analysis of the operation principles of different classes of semiconductor devices will be presented and numerous devices and their applications will be analyzed.

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Modern Electronic and Optoelectronic Devices

The course introduces the principles of the operation and trends in development of the modern electronic and optoelectronic devices. A brief overview of the key materials for electronics and optoelectronics and their design and growth technologies is provided; the peculiarities of carrier transport in artificially fabricated materials are discussed. The course covers the physics behind the operation of modern hot-carrier based devices, plasma-wave electronics, terahertz electronics and optoelectronics, meta-materials, spintronics, graphene-based devices, different types of laser diodes, semiconductor optical amplifiers, fiber optics communication systems, trends in their application and technology. In seminars and laboratory works, the students discuss the design of modern devices, techniques for estimating their parameters, get practical training in modern scientific labs, and acquire skills in sharing their knowledge on the topics relayed to the modern electronic and optoelectronic devices.

Nanotechnologies

After a short historical overview of nanotechnology evolution, the course introduces the key techniques for the formation of semiconductor nanostructures and their characterization. An emphasis is put on carbon nanotubes and nanocarbon materials, graphene and Van der Waals structures, molecular beam epitaxy and the techniques for fabrication of photonics crystals and their applications. Students will gain a deeper understanding of the modern nanotechnology via seminars dedicated to discussions on the featured papers published in highly-ranked scientific journals.

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Energy-Saving Semiconductor Technologies

The currently most important semiconductor technologies for energy saving are introduced. The main attention is paid to the development and applications of light-emitting diodes (LEDs), photovoltaics, and smart grids. A background will be developed in understanding of the key issues in energy production and consumption, and in up-to-date semiconductor technologies of interest for energy saving.

Photonics and Adaptive Optics

In this course, the focus is set on the modern branches of photonics. Localization of light, Brillouin zone for photons, photonic crystals, dimensionality-dependent properties, impact of defects and surface states are introduced. Research of modeling, construction, structural and optical properties, application of photonic crystals is discussed. Interaction with nanophotonics, plasmonics, hybrid devices are reviewed. The subjects of wave front optical phase conjugation in quantum electronics, semiconductor devices and nonlinear spectroscopy of semiconductors are also discussed.

Solar Cell Technologies

The purpose of the course is to gain knowledge in the frontiers of photovoltaics research and modern solar cell production technologies. After the completion of this course, the students will be familiar with the major solar cell production technologies used today, the key factors determining their applicability, the expected future trends of photovoltaics. They also will be able to critically evaluate the existing technologies and future achievements within the context of material availability, financial feasibility and other limiting factors of importance in the progress to terawatt-scale use of photovoltaics.

Curriculum

Course title	ECTS credits	Professor
First Year, First Semester		
Novel Materials and Technologies	10	Assoc. Prof. R . Butkutė
Semiconductor Optics	10	Assoc. Prof. T . Malinauskas
Microelectronic Devices	5	Prof. V. Kažukauskas
Research Project I	5	Individual advisors
First Year, Second Semester		
Modern Electronic and Optoelectronic Devices	10	Prof. G. Valušis
Nanotechnologies	5	Prof. G. Valušis
Energy -Saving Semiconductor Technologies	5	Prof. G. Tamulaitis
Research Project II	10	Individual advisors
Second Year, First Semester		
Photonics and Adaptive Optics	5	Prof. R. Tomašiūnas
Solar Cell Technologies	5	Prof. V. Tamošiūnas
Organic Optoelectronics	5	Prof. S. Juršėnas
Electronics and Photonics Marketing	5	Prof. G. Tamulaitis
Research Project III	10	Individual advisors
Second Year, Second Semester		
Master's Thesis	30	Individual advisors

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Organic Semiconductors

Soft organic materials replace conventional semiconductors in electronics and photonics technologies. The organic optoelectronic device market is one of the most rapidly growing. This course will provide the basic knowledge of the physical processes in organic materials and the organic optoelectronic device technologies. The course will provide practical skills for fabrication of simple organic devices and will prepare for adaptation of the coming organic semiconductor devices and technologies.

Electronics and Photonics Marketing

The course is aimed at revealing the long way for a scientific idea to become a product. The personal and institutional capabilities important for the development of new products in photonics and electronics as well as the most important materials, devices and markets are discussed. The key issues are illustrated by historical examples, current developments and future trends. Students will gain experience tracking the progress in science and technology from practical applications to the level of market products.

Research Projects

The curriculum of each semester contains a research project, which is carried out in scientific or industrial research laboratories under individual guidance by a supervisor at the laboratory. The project in the first semester is focused predominantly on development of skills in applying measurement techniques or using semiconductor growth or processing techniques. The second project develops predominantly analytical skills, while the third project covers all the basic aspects of research work, including data acquisition and assessment, generalization and interpretation, and making of scientific conclusions. The projects prepare the students for their work on master's thesis.

Master's Thesis

The last semester is dedicated entirely to preparation of the master thesis. The thesis conclude the research carried out in research laboratories under individual supervision. Usually but not obligatory, the work on the thesis is a continuation of the research projects carried out in the first three semesters. The master's thesis in this study program usually results in a research paper published before or after graduation.

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Facilities

Students of this program have access to a wide range of state-of-the-art technological and research facilities on campus.

The facilities for growing thin films, thick layers and nanostructures of inorganic semiconductor include Molecular Beam Epitaxy (MBE) system for the growth of III-V semiconductor layers and heterostructures, Metal-Organic Chemical Vapor Deposition (MOCVD) reactor, magnetron sputtering and thermal evaporation physical vapor deposition systems.

The organic semiconductor facilities are equipped for fabrication of OLEDs, solar cells, transistors, sensors in fully fledged chemical laboratories and cleanrooms.

The equipment for surface processing and device prototyping encompass photolithography, laser lithography and assemblage equipment, a vacuum deposition system with an electron beam for making metallic contacts, electrochemical system for modification and formation of surface structures, reactive ion and plasma etching facilities.

The key facilities for structural characterization are:

high resolution X-ray diffractometers (XRD), atomic-force microscopes (AFM), scanning electron microscope (SEM), cold-field emission SEM, and high resolution transmission electron microscope (TEM).

The key facilities for study of optical properties and carrier dynamics are based on photoluminescence spectroscopy with time resolution down to picosecond domain and spatial resolution on submicrometer scale using confocal microscopy and scanning near field optical microscopy (SNOM), nonlinear optical techniques including free carrier absorption, light-induced transient grating technique, etc. The facilities are equipped with a large variety of lasers, including femtosecond and picosecond lasers with fixed and tunable wavelengths, and cryosystems enabling measurements in the temperature range from 8 to 500 K.

All the research facilities are located on campus, at the National Center for Physical Sciences and Technology, in close proximity to the Faculty of Physics and University Library.

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Cooperation

This program is supported by national and international cooperation with academic and industrial research centers.

The key academic partners are research laboratories at the following universities and other research institutions:

- European Organization for Nuclear Research (CERN), Geneva, Switzerland
- Center for Organic Photonics and Electronics Research (OPERA), Kyushu University, Japan
- National Institute of Advanced Industrial Science and Technology (AIST), Japan
- National Taiwan University, Taiwan
- Rensselaer Polytechnic Institute (RPI), Troy, New York, USA
- Swinburne University of Technology, Melbourne, Australia
- Ghent University, Ghent, Belgium
- Inter-university Micro-Electronics Centre (IMEC), Leuven, Belgium
- University of Durham, United Kingdom
- Fraunhofer Institut für Silicatforschung, Germany
- Technical University of Berlin, Germany
- University of Rome, Italy
- University of Helsinki, Finland

The key partners in national industry are: Brolis Semiconductors, Solitek, Precizika, Protechlab, Ledigma, Workshop of Photonics, Nano-Avionics, Metsolar, Standa, Hortiled, Teravil, Vilniaus Ventos Puslaidininkiai.

The key partners in global high-tech industry include: Sensor Electronic Technology Inc. (USA), OSRAM Opto Semiconductors GmbH (Germany), TopGaN Ltd. (Poland), Aixtron SE (Germany), Consortium "Umicore" (Belgium), Compound Semiconductor Technologies Global Ltd. (UK), Picosun Oy (Finland).

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SEMICONDUCTOR SCIENCE AND TECHNOLOGY (SST)

MASTER'S DEGREE STUDY PROGRAMME