GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Applications of molecular electronics, PG_00039463		
Field of study	Zastosowania elektroniki molekularnej		
Date of commencement of studies	February 2026	Academic year of realisation of subject	2025/2026
Education level	second-cycle studies	Subject group	Obligatory subject group in the field of study Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	1	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Physics of Electronic Phenomena -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr Małgorzata Franz	
	Teachers		

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	15.0	15.0	0.0	0.0	45

E-learning hours included: 0.0

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	45	6.0	24.0	75

Subject objectives

The aim of the course is to familiarize students with issues related to the physical basis of the operation of electronic elements built of molecular materials and their production technology. The lecture consists of three parts, the first presents the properties of molecular materials, the charge carriers transport and generation and recombination processes. In the second part description of the processes taking place at the junctions is described. In the third part, for selected devices, the fabrication, the principles of operation, basic characteristics and parameters are represented.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_U03] has enhanced laboratory work experience	can carry on experiment, analyze the measurement data and make a report	[SU1] Ocena realizacji zadania
[K7_U05] can plan and conduct theoretical calculations, experimental research and computer simulations, critically analyze their results, draw conclusions and form reasoned opinions	can use the knowledge of the physical basis of the operation of molecular electronics elements for solving the problems and analysing experimental results	[SU3] Ocena umiejętności wykorzystania wiedzy uzyskanej w ramach przedmiotu
[K7_W02] has enhanced, theoretically-founded, detailed knowledge of selected field of physics, and sufficient knowledge of related fields of science or technology	is able to describe qualitatively and quantitatively the processes occurring in molecular electronics devices	[SW1] Ocena wiedzy faktograficznej

Subject contents	Course content – lecture LECTURE: Electrical and magnetic properties of molecules, Intermolecular interaction, Molecular crystals and molecular structures, Charge carriers generation and recombination processes: ways of charge carriers generation, geminate and bimolecular recombination, Langevina model, Charge carriers injection: contact phenomena, metal-molecular material junction, p-n junction, heterojunction, thermal, optical, excitonic and tunnel injection, Mechanisms of charge carriers transport in molecular materials: diffusion model, Einstein's formula, charge carriers mobility, Methods of thin films production and basic stages of the device manufacturing process: vacuum evaporation, methods of producing layers from the solution, printing methods, LB layers, layered structures of devices, electrodes of various geometry, Fundamentals of OLEDs operation: single-layer diode, multilayer diodes, characteristics and OLED parameters, applied strategies to improve OLED performance, OSC basics: principle of OSC operation on the example of a single-layer cell, current-voltage characteristics and basic cell parameters, cell performance, multilayer cells, Organic field-effect transistor: construction, operating principle, current-voltage characteristics, transistor operation parameters, effective mobility of charge carriers, characteristics of selected molecular materials used to build transistors, exemplary characteristics of transistors based on molecular materials, operational and environmental stability of devices, Detection of materials using organic field effect transistors: OFET as gas sensors, OFET as chemical and biological sensors, ion-selective organic field effect transistor (ISOFET), selected applications OFET sensors, electronic nose, electronic skin, intelligent textiles, Selected elements of molecular electronics based on single molecules: rectifier diodes, molecular switches, molecular memory, molecular transistors, Perspectives of molecular electronics development. EXERCISES: Electrical properties of molecules. Magnetic properties of molecules. Interactions between molecules. Electrical conductivity of solids. Child's law. Properties of electron gas. Transport of charge carriers. Electroluminescence. Photovoltaic phenomenon. Organic field-effect transistor. LABORATORY: Quantum efficiency of organic photovoltaic cells.
Prerequisites and co-requisites	Earlier participation in classes in the subject "Molecular electronics" is not required but it is advisable to fully understand and assimilate the presented material

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
passing the exercises	50.0%	30.0%
passing laboratories	50.0%	20.0%
passing the lecture	50.0%	50.0%

Recommended reading

Basic literature	J. Godlewski, Wstęp do elektroniki molekularnej, Wydawnictwo Politechniki Gdańskiej, Gdańsk 2008 A. Köhler i H. Bässler, Electronic Processes in Organic Semiconductors, Willey-VCH Verlag GmbH & Co. KGaA Weinheim, Germany 2015
Supplementary literature	Z. Kleszczewski, Podstawy fizyczne elektroniki ciała stałego, Wydawnictwo Politechniki Śląskiej, Gliwice 2000 P. Atkins i J. de Paula, Chemia Fizyczna, PWN, Warszawa 2016
eResources addresses	

Example issues/ example questions/ tasks being completed	Example of the task which will be solved during exercises: Calculate the interaction energy of two water molecules in the mutual distance r, knowing their dipole moment p. Sample question from a set of questions to pass the lecture: Present the current-voltage characteristics and main parameters characterizing the organic field-effect transistor. Laboratory exercise: Determination of the External Quantum Efficiency (EQE) of a silicon and perovskite cell.
Practical activites within the subject	Not applicable

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