GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Applications of molecular electronics, PG_00072272		
Field of study	Technical Physics		
Date of commencement of studies	February 2027	Academic year of realisation of subject	2026/2027
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						
eNauczanie source address: https://enauczanie.pg.edu.pl/2025/course/view.php?id=4650						

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	5.0	25.0	75

Subject objectives

introduce students to issues related to the physical principles underlying the operation of electronic components made of molecular materials and to their fabrication technology. The course covers the properties of molecular materials, processes of charge-carrier generation and decay, mechanisms of charge transport, and phenomena occurring at junctions. It also includes fabrication technologies, operating principles, and selected characteristics and parameters of molecular electronic devices.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_U05] is able, individually or as part of a team (including in a leadership role), to plan and conduct advanced theoretical calculations, experimental studies and computer simulations aimed at solving complex and non-standard scientific and engineering problems, and to critically analyse results and formulate well-founded conclusions	is able to use knowledge of the physical principles underlying the operation of molecular electronic components to solve calculation problems and to interpret experimental results and characteristics of molecular devices.	[SU3] Assessment of ability to use knowledge gained from the subject
[K7_W02] possesses advanced, theoretically grounded knowledge in physics and, to an extent appropriate to professional needs, in related scientific or technical disciplines, including applied computer science, applied physics and photovoltaics.	knows and understands the qualitative and quantitative description of processes occurring in molecular electronic devices, in particular the processes of charge-carrier generation, recombination, injection, and transport.	[SW1] Assessment of factual knowledge
[K7_U03] is capable of conducting advanced laboratory work in physics and related disciplines, selecting and adapting appropriate methods and tools, and critically evaluating existing technical solutions.	is able to plan and conduct an experiment, analyze measurement data, and prepare a report based on the obtained results.	[SU1] Assessment of task fulfilment

<table>
<tr><td>Subject contents</td><td colspan="2">Course content – lecture
Electrical and magnetic properties of molecules. Intermolecular interactions. Crystals and molecular structures. Processes of excess carrier generation and recombination: methods of charge carrier generation, twinning and bimolecular recombination. Charge carrier injection: contact phenomena, metal-molecular material junctions, p-n junctions, heterojunctions, thermal, optical, excitonic, and tunnel injection. Transport mechanisms in molecular materials: the diffusion model, Einstein's formula, charge carrier mobility. Thin film fabrication methods and device fabrication process steps: vacuum vapor deposition, solution-based film deposition methods, printing methods, LB layers, layered device structures, and electrodes with various geometries. Principles of OLED operation: single-layer diode, multilayer diodes, OLED characteristics and parameters, and strategies for improving OLED efficiency. Principle of OSC operation: single-layer cell, current-voltage characteristics and key cell parameters, cell efficiency, multilayer cells. Organic field-effect transistor: structural diagram, principle of operation, current-voltage characteristics, transistor operating parameters, effective charge carrier mobility, characteristics of selected molecular materials used in transistor construction, exemplary characteristics of transistors based on molecular materials, operational and environmental stability of devices. Materials detection using organic field-effect transistors: OFET as a gas sensor, OFET as a chemical and biological sensor, ion-selective organic field-effect transistor (ISOFET), selected applications of OFET sensors, electronic nose, electronic skin, smart textiles. Development prospects for molecular electronics.

Course content – 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.

Course content – laboratory
Determining the external quantum efficiency of silicon and perovskite cells. Investigating an organic photovoltaic cell. Investigating the temperature characteristics of an organic photovoltaic cell. Measuring the spectral characteristics of a white OLED.</td></tr>
<tr><td>Prerequisites and co-requisites</td><td colspan="2">participation in classes in the subject "Molecular electronics" is not required but it is recommended in order to fully understand and assimilate the presented material.</td></tr>
<tr><td>Assessment methods and criteria</td><td colspan="2"><table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td>passing the lecture</td><td>50.0%</td><td>50.0%</td></tr><tr><td>passing laboratories</td><td>50.0%</td><td>20.0%</td></tr><tr><td>passing the exercises</td><td>50.0%</td><td>30.0%</td></tr></table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>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</td></tr>
<tr><td>Supplementary literature</td><td>Z. Kleszczewski, Podstawy fizyczne elektroniki ciała stałego, Wydawnictwo Politechniki Śląskiej, Gliwice 2000

P. Atkins i J. de Paula, Chemia Fizyczna, PWN, Warszawa 2016</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="2">Example of the task which will be solved during exercises: Show that, for single-layer cells, the photovoltaic voltage is directly proportional to the natural logarithm of the ratio of charge-carrier concentrations at the electrodes.

Sample question from a set of questions to pass the lecture: Present a diagram of charge-carrier photogeneration according to the Onsager model.

Laboratory exercise: Determination of the External Quantum Efficiency (EQE) of a silicon and perovskite cell.</td></tr>
<tr><td>Practical activites within the subject</td><td colspan="2">Not applicable</td></tr>
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