GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

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|---|---|---|---|
| Subject name and code | Molecular electronics, PG_00048742 | | |
| Field of study | Materials Engineering, Materials Engineering, Materials Engineering | | |
| Date of commencement of studies | February 2022 | Academic year of realisation of subject | 2022/2023 |
| Education level | second-cycle studies | Subject group | Optional subject group<br>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 | 2 | ECTS credits | 3.0 |
| Learning profile | general academic profile | Assessment form | exam |
| Conducting unit | Department of Physics of Electronic Phenomena -> Faculty of Applied Physics and Mathematics | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | dr Małgorzata Franz | |
| | Teachers | dr Małgorzata Franz | |

**Lesson types and methods of instruction**

| Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
|---|---|---|---|---|---|---|
| Number of study hours | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30 |

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 | 30 | 10.0 | 35.0 | 75 |

**Subject objectives**

The aim of the lecture is to familiarize students with the basic issues of molecular electronics. In particular, students learn the basic physicochemical properties of molecular materials, phenomena of generation, recombination and transport of charge carriers in such materials and the basics of electronic components built on their basis.

**Learning outcomes**

| Course outcome | Subject outcome | Method of verification |
|---|---|---|
| K7_U01 | Student is able to acquire information on issues of molecular electronics from foreign language literature, and is able to subject these messages to critical analysis. | [SU4] Assessment of ability to use methods and tools |
| [K7_K82] is equipped to participate actively in lectures, seminars and laboratory classes conducted in foreign language | By reading English-language books on molecular electronics, the student acquires the skills of fluent communication in this language. | [SK4] Assessment of communication skills, including language correctness |
| K7_W04 | Student is able to describe the physicochemical properties of molecular materials, processes of generation, recombination and transport of charge carriers in such materials and the basic operation of molecular electronics devices. | [SW1] Assessment of factual knowledge |

<table>
<tr><td>Subject contents</td><td>Introduction to the subject: miniaturization of electronic devices, inorganic and organic materials in electronics, conductive polymers, basic electronic elements: OLED, OPV, OFET and their presence in commercial electronic devices. Electrical and magnetic properties of molecules. Molecular solid state: types of crystal bonds with particular emphasis on van der Waals interaction. States of electronic excitation in molecular systems: excitons, diffusion model of exciton migrations, exciton processes. Injection of charge carriers for molecular materials: contact phenomena, metal-molecular interface, injection mechanisms: thermal injection, optical injection, exciton and tunnel injection. Currents of charge carriers of one sign: currents limited by electrode injection, Schottky phenomenon, currents limited by spatial charge, photoenhanced currents. Currents of charge carriers of two characters: thermal generation, injection of charge carriers from electrodes to molecular material, photogeneration of charge carriers in volume, Onsager model. Electroluminescence: bimolecular recombination, Langevin model, principle of operation, characteristics and parameters of the light emitting diode (OLED). Photovoltaic effect: the principle of a photovoltaic cell (OSC) on the example of a single-layer cell, current-voltage characteristics and basic cell parameters, cell performance, multilayer cells. Organic field effect transistor: operation principle of an organic field effect transistor (OFET), current-voltage characteristics, transistor operation parameters, selected applications OFET. Summary: perspectives for the development of molecular electronics</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>Student defines basic terms concernig structure of matter. Student lists basic types of electronics. Student uses basic physical terms.</td></tr>
<tr><td>Assessment methods and criteria</td><td><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Lecture (written form)</td><td>50.0%</td><td>100.0%</td></tr>
</table></td></tr>
<tr><td>Recommended reading</td><td><table>
<tr><td>Basic literature</td><td>1. J. Godlewski, Wstęp do elektroniki molekularnej, Politechnika Gdańska, 2008 2. 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>1. M. Pope, C.E. Swenberg, Electronic Processes in Organic Crystals and Polymers, Oxford, Clarendon Press, 19991. 2. K.C. Kao, W. Hwang, Electrical Transport in Solids, Oxford, Pergemon Press, 1981 3. J. Kalinowski, Organic Light-Emitting Diodes, Marcel Dekker, New York, 2005 4. A. Chełkowski, Fizyka dielektryków, PWN, W-wa, 1976 5. H. Haken, H.C. Wolf, Atom i kwanty, Wprowadzenie do współczesnej spektroskopii atomowej, PWN, W-wa 1997 6. H. Haken, H.C. Wolf, Fizyka molekularna z elementami chemii kwantowej, PWN, W-wa 1998 7. J. Godlewski, Własności optyczne i elektryczne molekularnych ciał stałych, Politechnika Gdańska, 1996 8. A. Graja, Niskowymiarowe półprzewodniki organiczne, WNT, W-wa, 1989 9. W. Przygodzki, A. Włochwicz, Fulureny i nanorurki, WNT, W-wa, 2001</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
</table></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td>Sample questions from a set of questions for a written exam: What is the polarization of a molecule? Present a diffusion model of exciton migration in a molecular solid body. Derive the formula for the concentration of singlet excitons. Present current-voltage characteristics and main parameters characterizing the organic field-effect transistor.</td></tr>
<tr><td>Work placement</td><td>Not applicable</td></tr>
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