



# Molecular Nanoelectronics

## Course description sheet

### Basic information

<b>Field of study</b> AGH UST International Courses	<b>Didactic cycle</b> 2023/2024	
<b>Major</b> All	<b>Course code</b> POGJOS.A2000000.4ab603590a809c90bfaa31a6be87bb c1.23	
<b>Organisational unit</b> Generic subjects	<b>Lecture languages</b> english	
<b>Study level</b> any level	<b>Mandatoriness</b> Obligatory	
<b>Form of study</b> Full-time studies	<b>Block</b> General Modules	
<b>Profile</b> General academic	<b>Course related to scientific research</b> Yes	
	<b>USOS code</b> 693-INT-xS-113	
<b>Course coordinator</b>	Konrad Szaciłowski	
<b>Lecturer</b>	Konrad Szaciłowski	
<b>Period</b> Summer semester	<b>Method of verification of the learning outcomes</b> Exam	<b>Number of ECTS credits</b> 2
	<b>Activities and hours</b> Lectures: 15	

## Goals

C1	Zapoznanie studentów z podstawowymi zagadnieniami nanoelektroniki oraz elektroniki molekularnej
C2	Przekazanie wiedzy z zakresu chemii półprzewodników i polimerów przewodzących, szczególnie w kontekście zjawisk związanych z przetwarzaniem informacji
C3	Uświadomienie słuchaczom problemów związanych z fundamentalnymi i technologicznymi ograniczeniami mikroelektroniki

## Course's learning outcomes

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
<b>Knowledge - Student knows and understands:</b>			
W1	Student zna podstawowe właściwości materiałów półprzewodnikowych i polimerów przewodzących		Activity during classes
W2	Znajomość podstaw nanoelektroniki molekularnej		Examination
W3	Podstawowa znajomość teorii pasmowej ciała stałego oraz fizykochemii półprzewodników		Examination
<b>Social competences - Student is ready to:</b>			
K1	Umiejętność rozwiązywania problemów w grupie		Activity during classes

## Student workload

Activity form	Average amount of hours* needed to complete each activity form
Lectures	15
Preparation for classes	15
Realization of independently performed tasks	30
<b>Student workload</b>	<b>Hours</b> 60
<b>Workload involving teacher</b>	<b>Hours</b> 15

\* hour means 45 minutes

## Program content

No.	Program content	Course's learning outcomes	Activities
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1.	<p>Molecular nanoelectronics: The course consists of three parts. The first part deals with basic principles of classical electronics: construction and operational properties of basic active components (diodes, bipolar transistors, FET transistors), structure and fabrication technology of monolithic integrated circuits. Technological and physical limits of classical electronic semiconducting devices are also included in this part. The second part is mostly devoted to synthesis, properties and electronic structure of molecular precursors used in molecular electronics (fullerenes, porphyrins, phthalocyanines, polycenes, tetrathiafulvalenes and carbon nanotubes). Properties critical for applications of these materials in electronics are especially emphasized. The third part of the course discusses techniques used for fabrication and investigation of nanoelectronic structures using single molecules and thin layers. Organic field effect transistors (OFET), organic photovoltaic systems and molecular optoelectronic switches are described in detail.</p>	W1, W2, W3, K1	Lectures
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## Extended information/Additional elements

### Teaching methods and techniques:

Lectures, Discussion, Group work

Activities	Methods of verification	Credit conditions
Lectures	Activity during classes, Examination	

## Prerequisites and additional requirements

Basic knowledge of chemistry and physics

### Rules of participation in given classes, indicating whether student presence at the lecture is obligatory

Lectures: Studenci uczestniczą w zajęciach poznając kolejne treści nauczania zgodnie z sylabusem przedmiotu. Studenci winni na bieżąco zadawać pytania i wyjaśniać wątpliwości. Rejestracja audiowizualna wykładu wymaga zgody prowadzącego.

## Literature

### Obligatory

1. Infochemistry: Information Processing at the Nanoscale Konrad Szacilowski ISBN: 978-0-470-71072-2

### Optional

1. Biomolecular Information Processing: From Logic Systems to Smart Sensors and Actuators Evgeny Katz ISBN:9783527332281

## Scientific research and publications

### Research

1. Nanostrukturalne układy neuromimetyczne

### Publications

1. Towards synthetic neural networks: can artificial electrochemical neurons be coupled with artificial memristive synapses?, E. Wlaźlak, D. Przczyzna, R. Gutierrez, G. Cuniberti, K. Szaciłowski *Jpn. J. Appl. Phys.* 59 SI0801 (2020), <https://doi.org/10.35848/1347-4065/ab7e11> In-materio neuromimetic devices: dynamics, information processing and pattern recognition, D. Przczyzna, P. Zawal, T. Mazur, M. Strzelecki, P. Luigi Gentili, and K. Szaciłowski, *Japanese Journal of Applied Physics* 59, 050504 (2020), <https://doi.org/10.35848/1347-4065/ab82b0> Memristor in a Reservoir System - Experimental Evidence for High-Level Computing and Neuromorphic Behavior of  $PbI_2$ , E. Wlaźlak, M. Marzec, P. Zawal, and K. Szaciłowski, *ACS Appl. Mater. Interfaces* 11, 17009–17018 (2019), <https://doi.org/10.1021/acsami.9b01841> Synaptic plasticity, metaplasticity and memory effects in hybrid organic-inorganic bismuth-based materials, Tomasz Mazur, Piotr Zawal, Konrad Szaciłowski, *Nanoscale* 11, 1080-1090 (2019), <https://doi.org/10.1039/c8nr09413f> Halogen-containing semiconductors: From artificial photosynthesis to unconventional computing, S. Klejna, T. Mazur, E. Wlaźlak, P. Zawal, Han Sen Soo, K. Szaciłowski *Coordination Chemistry Reviews* 415, 213316 (2020), <https://doi.org/10.1016/j.ccr.2020.213316>