UNIWERSYTET IM. ADAMA MICKIEWICZA W POZNANIU

# Fabrication and characterization of nanonstructures

Educational subject description sheet

## Basic information

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|---|---|
| **Study programme**<br>Fizyka | **Didactic cycle**<br>2024/25 |
| **Speciality**<br>BIOFIZYKA MOLEKULARNA | **Subject code**<br>04FIZBMOS.22S.03335.24 |
| **Organizational unit**<br>Faculty of Physics and Astronomy | **Lecture languages**<br>English |
| **Study level**<br>Second-cycle programme | **Course type**<br>Elective |
| **Study form**<br>Full-time | **Block**<br>specialty subjects |
| **Education profile**<br>General academic | |

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| **Subject coordinator** | Mateusz Kempiński |
| **Lecturer** | Mateusz Kempiński |

| **Period** | **Activities and hours** | **Number of ECTS points** |
|---|---|---|
| Semester 2 | • Lecture: 30, Exam<br>• Laboratories: 30, Graded credit | 5 |

## Goals

| Code | Goal |
|---|---|
| C1 | Students will be acquainted with experimental techniques utilized in fabrication and analysis of various conducting nanostructures: thin films, wires, dots, pillars and 3D textures, including carbon-based materials. |
| C2 | Students will be acquainted with the basic properties of nanostructured and low-dimensional materials. |
| C3 | Students will be presented with the problems regarding the reading and understanding the experimental data obtained in the presented techniques as well as choosing the techniques relevant to specific applications |

## Subject learning outcomes

| Code | Outcomes in terms of | Learning outcomes | Examination methods |
|---|---|---|---|
| **Knowledge – Student:** | | | |
| W1 | knows the operation principles of the physical and chemical vapor deposition, as well as surface structurization techniques. | FIZ_K2_W01, FIZ_K2_W02, FIZ_K2_W04, FIZ_K2_W05 | Oral exam, Report |
| W2 | knows the operation principles of the analysis techniques from the following branches: - electron microscopy and diffraction, - scanning probe microscopy, - photoelectron spectroscopy, - electronic properties. | FIZ_K2_W01, FIZ_K2_W02, FIZ_K2_W04, FIZ_K2_W06 | Oral exam, Report |
| W3 | knows the most important features of carbon-based nanostructures including specific fabrication methods and analysis techniques. | FIZ_K2_W01, FIZ_K2_W04, FIZ_K2_W05, FIZ_K2_W06 | Oral exam, Report |
| W4 | has practical knowledge on: - operation and maintenance of an ultra-high vacuum chamber, - deposition of thin metallic films with the use of physical deposition techniques. | FIZ_K2_W02, FIZ_K2_W07 | Oral exam, Report |
| **Skills – Student:** | | | |
| U1 | is able to identify and perform basic analysis of images and spectra obtained with the presented techniques | FIZ_K2_U01, FIZ_K2_U03 | Oral exam, Report |
| U2 | is able to choose experimental techniques according to the specific needs, i.e. select the proper fabrication route followed by the most relevant analysis techniques. | FIZ_K2_U01, FIZ_K2_U02, FIZ_K2_U03 | Oral exam, Report |
| U3 | is able to prepare samples and identify apparatus parameters for thin film deposition. | FIZ_K2_U01, FIZ_K2_U03 | Oral exam, Report |
| U4 | is able to perform basic characterization of obtained thin films with the use of AFM technique. | FIZ_K2_U01, FIZ_K2_U03 | Oral exam, Report |
| **Social competences – Student:** | | | |
| K1 | understands the complexity of the presented techniques and the role of qualified technical staff in operating the ultra-high vacuum equipment. | FIZ_K2_K01, FIZ_K2_K02 | Oral exam, Report |
| K2 | is able to cooperate in the fabrication and basic analysis of thin films under supervision of experienced lab technician. | FIZ_K2_K01, FIZ_K2_K02 | Oral exam, Report |

## Study content

| No. | Course content | Subject learning outcomes | Activities |
|---|---|---|---|
| 1. | Basic issues of physics of conductors; electric transport and localization phenomena; metal-insulator transitions; conducting nanostructures. | W1, W2, W3 | Lecture |
| 2. | Physics of vacuum, vacuum technologies (pumps, gauges, etc.). | W1, W2, W4, U1, U2, K1, K2 | Lecture, Laboratories |

| No. | Course content | Subject learning outcomes | Activities |
|---|---|---|---|
| 3. | Vapor deposition techniques (PVD, CVD, ALD, MBE). | W1, W3, W4, U1, U2, U3, K1, K2 | Lecture, Laboratories |
| 4. | Surface structurization techniques (IBS, GLAD, thermal reconstruction). | W1, U2, K1 | Lecture |
| 5. | Introduction to electron microscopy (TEM, SEM), spectroscopy (EDS) and diffraction (LEED, RHEED). | W2, U1, U2, K1 | Lecture |
| 6. | Introduction to scanning probe microscopy (STM, AFM and related techniques). | W2, W3, U1, U2, U4 | Lecture, Laboratories |
| 7. | Photoelectron spectroscopy (XPS, UPS, Auger). | W2, W3, U1, U2, K1 | Lecture |

## Additional information

| Activities | Teaching and learning methods and activities |
|---|---|
| Lecture | Lecture with a multimedia presentation of selected issues, Laboratory method, Demonstration and observation |
| Laboratories | Lecture with a multimedia presentation of selected issues, Laboratory method, Demonstration and observation |

| Activities | Credit conditions |
|---|---|
| Lecture | Student must answer the questions regarding at least three different topics that were discussed during the lectures.<br>The final grade will be determined based on the answers.<br>Basic knowledge of the topic-related keywords and definitions will be rated as 3.<br>Basic knowledge plus the ability to explain the details of the topic-related phenomena will be rated as 4.<br>Detailed knowledge on the given topic, with the ability to answer the problem questions will be rated as 5.<br>Final grade will be the established as the average of all student's answers. |
| Laboratories | Student must present the lab report comprising the basic info about all the methods used during the lab classes, as well as the obtained results.<br>The report is required to approach the exam. |

## Literature

**Obligatory**

1. Roth, A. "Vacuum technology North Holland publishing co." Amsterdam-New York-Oxford (1976).

## Calculation of ECTS points

| Activities | Activity hours* |
|---|---|
| Lecture | 30 |
| Laboratories | 30 |
| Report preparation | 10 |

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|---|---|
| Preparation for the exam | 30 |
| Reading the indicated literature | 15 |
| Preparation for classes | 10 |
| | |
| **Student workload** | **Hours**<br>125 |
| **Number of ECTS points** | **ECTS**<br>5 |

* academic hour = 45 minutes

## Efekty uczenia się dla kierunku

| Kod | Treść |
|---|---|
| FIZ_K2_K01 | The graduate is ready to critically evaluate own knowledge and received content |
| FIZ_K2_K02 | The graduate is ready to recognize the importance of knowledge in solving cognitive and practical problems and seeking expert opinion (also from other scientific disciplines) to overcome difficulties during independent problem solving |
| FIZ_K2_U01 | The graduate can use their knowledge to formulate and solve complex and unusual problems in the field of physical sciences; select and apply appropriate methods and tools necessary to solve a given problem (including advanced IT techniques), as well as adapt existing methods and tools or develop completely new ones |
| FIZ_K2_U02 | The graduate can find the necessary information in the professional literature, databases and other sources, in particular in scientific journals basic to physics, and perform critical analysis, synthesis and creative interpretation of the collected information |
| FIZ_K2_U03 | The graduate can formulate and test hypotheses related to simple research problems in physics (plan and perform observations, experiments, theoretical calculations or computer simulations and critically evaluate and discuss the results obtained) |
| FIZ_K2_W01 | The graduate knows and understands in-depth selected facts, phenomena, concepts and theories specific to physics and complex relationships between them (constituting advanced general knowledge in the field of physical sciences and representing both key and other selected issues in the field of advanced detailed knowledge in this discipline) |
| FIZ_K2_W02 | The graduate knows and understands in-depth selected research methods and tools as well as mathematical models used in physics |
| FIZ_K2_W04 | The graduate knows and understands main development trends in the discipline of physical sciences |
| FIZ_K2_W05 | The graduate knows and understands the role of physical sciences in the context of fundamental dilemmas and challenges of modern civilization |
| FIZ_K2_W06 | The graduate knows and understands basic concepts and principles in the area of industrial property protection and copyright |
| FIZ_K2_W07 | The graduate knows and understands workplace health and safety principles to the extent that allows independent work in the research workplace |