GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

| | | | |
|---|---|---|---|
| Subject name and code | Physical Methods of Materials Investigation, PG_00039809 | | |
| Field of study | Materials Engineering, Materials Engineering, Materials Engineering | | |
| Date of commencement of studies | October 2021 | Academic year of realisation of subject | 2023/2024 |
| Education level | first-cycle studies | Subject group | Obligatory subject group in the field of study<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 | 3 | Language of instruction | Polish |
| Semester of study | 5 | ECTS credits | 2.0 |
| Learning profile | general academic profile | Assessment form | exam |
| Conducting unit | Instytut Nanotechnologii i Inżynierii Materiałowej -> Faculty of Applied Physics and Mathematics | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | dr hab. inż. Agnieszka Witkowska | |
| | Teachers | dr hab. inż. Agnieszka Witkowska | |

**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 | 1.0 | 19.0 | 50 |

**Subject objectives**

The aim of the course is to present the possibilities of modern measurement techniques, along with a description of appropriate measurement systems, methods of analysis of results leading to the determination of structure parameters (macro-, micro- and nanoscopic, as well as at the atomic level) of the studied materials, determination of the chemical composition and physico-chemical and thermal properties.

**Learning outcomes**

| Course outcome | Subject outcome | Method of verification |
|---|---|---|
| K6_K01 | The student is aware of the current technological advancement and progression in the development of research and measurement methods, thus she/ he understands the need to constantly improve professional and personal competences. Being aware of their own limited possibilities of accessing and operating specialist equipment, the student knows when to refer to experts and how to plan the tasks performed by him/herself or others in these circumstances. | [SK2] Assessment of progress of work |
| K6_W06 | Student knows possibilities of the modern measuring techniques, student presents measuring possibilities related to diffraction and spectroscopy techniques, structure imaging and thermal properties of materials. | [SW1] Assessment of factual knowledge |
| K6_W02 | On the basis of the acquired knowledge, the student indicates the possibilities of studying the macro- and micro-world, defines the limits of modern cognition and knows how to select research methods due to the type of the tested substance and the analyzed physico-chemical properties. | [SW1] Assessment of factual knowledge |

| | |
|---|---|
| Subject contents | 1. Introduction - physical methods of material investigation and experiment planning.<br>2. Diffraction methods - theoretical basis:<br>a) X-ray diffraction;<br>- X-ray sources (X-ray tube, synchrotron, synchrotron radiation)<br>- detectors of ionizing radiation<br>- structural X-ray diffraction<br>b) Neutron diffraction;<br>- neutron beam sources<br>- neutron detection<br>- ND vs XRD<br>c) Electron diffraction<br>- electron beam sources and detection<br>- ED vs XRD<br>- LEED, HEED, RHEED<br>3. Spectroscopic methods - introduction and theoretical basis:<br>a) Absorption, emission, photoemission and scattering spectroscopy<br>b) Molecular spectroscopy<br>c) Electron spectroscopy<br>4. Structure imaging methods<br>a) Electron microscopy<br>b) Scanning probe microscopy<br>c) Confocal microscopy<br>d) Spectromicroscopy<br>5. Thermal analysis (DTA, DSC, TGA).<br>6. Adsorption methods: physical adsorption vs chemisorption, study of structural heterogeneity and pore size distribution. |
| Prerequisites and co-requisites | The basics knowledge of material engineering, physics, crystallography and general chemistry |

**Assessment methods and criteria**

| Subject passing criteria | Passing threshold | Percentage of the final grade |
|---|---|---|
| Writting exam | 50.0% | 85.0% |
| Active participation in lectures | 0.0% | 15.0% |

**Recommended reading**

| | |
|---|---|
| Basic literature | [1] A. Oleś, *Metody doświadczalne fizyki ciała stałego*, WNT (in Polish)<br>[2] J.Przedmojski, *Rentgenowskie metody badawcze w Inżynierii Materiałowej*, WNT (in Polish)<br>[3] Z. Kęcki, *Podstawy spektroskopii molekularnej*, PWN, Warszawa (in Polish)<br>[4] A. Kisiel, *Synchrotron jako narzędzie: zastosowanie PS w spektroskopii ciała stałego*, SRNS 5(3) (2006) (in Polish) |
| Supplementary literature | [5] Ch. Kittel, P. McEuen, *Introduction to solid state physics* (9th Ed.), New Jersey: Wiley<br>[6] J.M. Hollas, *Modern Spectroscopy*, John Wiley & Sons, Ltd.<br>[7] P. Willmott, *An Introduction to Synchrotron Radiation: Techniques and Applications*, John Wiley & Sons, Ltd.<br>[8] A. Barbacki (red.), *Mikroskopia elektronowa*, Wyd. Politechniki Poznańskiej (in Polish)<br>[9] P. Atkins, J.de Paula, *Chemia fizyczna*, Rozdz.16 S*pektroskopia 1: widma rotacyjne i oscylacyjne*; Rozdz. 17 *Spektroskopia 2: przejścia elektronowe*, PWN (in Polish) |
| eResources addresses | Uzupełniające<br>Adresy na platformie eNauczanie:<br>Fizyczne metody badań materiałów I - IM1 2023 - Moodle ID: 30985<br>https://enauczanie.pg.edu.pl/moodle/course/view.php?id=30985 |

| | |
|---|---|
| Example issues/ example questions/ tasks being completed | 1. Diffraction methods: physical basis, types and applications.<br>2. X-ray tube: its structure, principle of operation and properties of X-ray obtained using this source.<br>3. What is a synchrotron and how does it work? Describe the basic properties of synchrotron radiation.<br>4. X-ray and electron diffraction - indicate similarities and differences.<br>5. Neutron and electron diffraction - indicate similarities and differences.<br>6. Name and briefly describe two sources of neutron beams used in neutronography.<br>7. Silicon crystallizes in a simple cubic system. A neutron diffraction experiment with a 10-meter detector and angle = 45$^{o}$ reveals that the neutrons reflected from the family of planes (111) have a time of flight of 11200 microseconds. Find the lattice constant of a silicon unit cell?<br>8. List and briefly characterize detectors of ionizing radiation.<br>9. What is a spectrum? Give and discuss the parameters that characterize the spectral line.<br>10. Explain the terms transmittance, absorbance and absorption coefficient. Give the relationship between them.<br>11. Present the idea of the Raman phenomenon and discuss the shape of the Raman spectrum.<br>12. Explain why the XPS technique is a "surface sensitive" technique.<br>13. AFM microscope: describe operating modes and its applications.<br>14. Electron microscopy - list the types of electron microscopes, compare them and determine their applications.<br>15. State what thermal analysis is, its types and possible applications.<br>16. DSC technique (differential scanning calorimetry) - state what kind of thermal properties of materials can be determined using this technique and how.<br>17. Discuss the differences between physical and chemical adsorption.<br>18. Select and provide two of the research techniques you have learned, thanks to which you can determine/ estimate the average size of nanoparticles. Briefly describe how we use these techniques in terms of the mentioned properties of the tested material. |
| Work placement | Not applicable |