GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Physical Methods of Materials Investigation, PG_00059183		
Field of study	Materials Engineering, Materials Engineering, Materials Engineering		
Date of commencement of studies	October 2022	Academic year of realisation of subject	2024/2025
Education level	first-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	3	Language of instruction	Polish
Semester of study	5	ECTS credits	2.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Institute of Nanotechnology and Materials Engineering -> Faculty of Applied Physics and Mathematics		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Agnieszka Witkowska	
	Teachers		

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_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
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

<table>
<tr><td>Subject contents</td><td>1. Introduction - physical methods of material investigation and experiment planning.
2. Diffraction methods - theoretical basis:
a) X-ray diffraction;
- X-ray sources (X-ray tube, synchrotron, synchrotron radiation)
- detectors of ionizing radiation
- structural X-ray diffraction
b) Neutron diffraction;
- neutron beam sources
- neutron detection
- ND vs XRD
c) Electron diffraction
- electron beam sources and detection
- ED vs XRD
- LEED, HEED, RHEED
3. Spectroscopic methods - introduction and theoretical basis:
a) Absorption, emission, photoemission and scattering spectroscopy
b) Molecular spectroscopy
c) Electron spectroscopy
4. Structure imaging methods
a) Electron microscopy
b) Scanning probe microscopy
c) Confocal microscopy
d) Spectromicroscopy
5. Thermal analysis (DTA, DSC, TGA).
6. Adsorption methods: physical adsorption vs chemisorption, study of structural heterogeneity and pore size distribution.</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>The basics knowledge of material engineering, physics, crystallography and general chemistry</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>Active participation in lectures</td><td>0.0%</td><td>15.0%</td></tr>
<tr><td>Writting exam</td><td>50.0%</td><td>85.0%</td></tr>
</table></td></tr>
<tr><td>Recommended reading</td><td><table>
<tr><td>Basic literature</td><td>[1] A. Oleś, Metody doświadczalne fizyki ciała stałego, WNT (in Polish)
[2] J.Przedmojski, Rentgenowskie metody badawcze w Inżynierii Materiałowej, WNT (in Polish)
[3] Z. Kęcki, Podstawy spektroskopii molekularnej, PWN, Warszawa (in Polish)
[4] A. Kisiel, Synchrotron jako narzędzie: zastosowanie PS w spektroskopii ciała stałego, SRNS 5(3) (2006) (in Polish)</td></tr>
<tr><td>Supplementary literature</td><td>[5] Ch. Kittel, P. McEuen, Introduction to solid state physics (9th Ed.), New Jersey: Wiley
[6] J.M. Hollas, Modern Spectroscopy, John Wiley & Sons, Ltd.
[7] P. Willmott, An Introduction to Synchrotron Radiation: Techniques and Applications, John Wiley & Sons, Ltd.
[8] A. Barbacki (red.), Mikroskopia elektronowa, Wyd. Politechniki Poznańskiej (in Polish)
[9] P. Atkins, J.de Paula, Chemia fizyczna, Rozdz.16 Spektroskopia 1: widma rotacyjne i oscylacyjne; Rozdz. 17 Spektroskopia 2: przejścia elektronowe, PWN (in Polish)</td></tr>
<tr><td>eResources addresses</td><td>Adresy na platformie eNauczanie:</td></tr>
</table></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td>1. Diffraction methods: physical basis, types and applications.
2. X-ray tube: its structure, principle of operation and properties of X-ray obtained using this source.
3. What is a synchrotron and how does it work? Describe the basic properties of synchrotron radiation.
4. X-ray and electron diffraction - indicate similarities and differences.
5. Neutron and electron diffraction - indicate similarities and differences.
6. Name and briefly describe two sources of neutron beams used in neutronography.
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?
8. List and briefly characterize detectors of ionizing radiation.
9. What is a spectrum? Give and discuss the parameters that characterize the spectral line.
10. Explain the terms transmittance, absorbance and absorption coefficient. Give the relationship between them.
11. Present the idea of the Raman phenomenon and discuss the shape of the Raman spectrum.
12. Explain why the XPS technique is a "surface sensitive" technique.
13. AFM microscope: describe operating modes and its applications.
14. Electron microscopy - list the types of electron microscopes, compare them and determine their applications.
15. State what thermal analysis is, its types and possible applications.
16. DSC technique (differential scanning calorimetry) - state what kind of thermal properties of materials can be determined using this technique and how.
17. Discuss the differences between physical and chemical adsorption.
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.</td></tr>
<tr><td>Work placement</td><td>Not applicable</td></tr>
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