



Subject card

Subject name and code	, PG_00052077						
Field of study	Nanotechnology						
Date of commencement of studies	October 2021	Academic year of realisation of subject			2022/2023		
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	2	Language of instruction			Polish		
Semester of study	4	ECTS credits			2.0		
Learning profile	general academic profile	Assessment form			assessment		
Conducting unit	Instytut Nanotechnologii i Inżynierii Materiałowej -> Faculty of Applied Physics and Mathematics						
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Marcin Łapiński					
	Teachers	dr inż. Marcin Łapiński					
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	2.0	18.0	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_W07	Student acquires a wide knowledge in the field of methods of analyzing the physical properties of materials and nanomaterials. Learns both the theoretical principles (main phenomena, laws and relations) as well as technical and application aspects of the research methods under discussion.			[SW1] Assessment of factual knowledge		
	K6_W10	Student is able to analyze the research problem, select a research method and plan a physical experiment in order to solve this problem. Is aware of the limitations related to the use of certain experimental methods.			[SW1] Assessment of factual knowledge		
	K6_U02	Student has an extended theoretical knowledge in the field of research methods and techniques used in nanotechnology and materials engineering. He is able to choose an appropriate experimental method to solve a given research problem.			[SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject		

Subject contents	1. Introduction; 2. Diffraction methods - theoretical basis: - X-ray diffraction; - Neutron diffraction; - Electron diffraction. 3. EM radiation sources; 4. Detectors of ionizing radiation; 5. Synchrotron, synchrotron radiation and its application. 6. Spectroscopic methods - introduction and theoretical basis: - Molecular spectroscopy (microwave, IR, Raman, UV-Vis); - Photoelectron spectroscopy (PES) and Auger electron spectroscopy (AES); - X-ray absorption spectroscopy (XAS). 7. Structure imaging methods: - Electron microscopy (SEM, TEM, STEM); - Scanning probe microscopy (STM, AFM); - Confocal microscopy. 6. Thermal analysis (DTA, DSC, TGA). 7. Methods of testing material porosity (mercury porosimetry, gas porosimetry, micro-CT)											
Prerequisites and co-requisites	The basics knowledge of physics, crystallography, general chemistry and materials engineering,											
Assessment methods and criteria	<table border="1" data-bbox="448 573 1487 678"> <thead> <tr> <th data-bbox="448 573 794 611">Subject passing criteria</th> <th data-bbox="794 573 1141 611">Passing threshold</th> <th data-bbox="1141 573 1487 611">Percentage of the final grade</th> </tr> </thead> <tbody> <tr> <td data-bbox="448 611 794 645">Active participation in lectures</td> <td data-bbox="794 611 1141 645">0.0%</td> <td data-bbox="1141 611 1487 645">15.0%</td> </tr> <tr> <td data-bbox="448 645 794 678">Writing exam</td> <td data-bbox="794 645 1141 678">50.0%</td> <td data-bbox="1141 645 1487 678">85.0%</td> </tr> </tbody> </table>			Subject passing criteria	Passing threshold	Percentage of the final grade	Active participation in lectures	0.0%	15.0%	Writing exam	50.0%	85.0%
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Active participation in lectures	0.0%	15.0%										
Writing exam	50.0%	85.0%										
Recommended reading	Basic literature	[1] A. Oleś, <i>Metody doświadczalne fizyki ciała stałego</i> , WNT (in polish) [2] J.Przedmojski, <i>Rentgenowskie metody badawcze w Inżynierii Materiałowej</i> , WNT (in polish) [3a] J. Sadle, <i>Spektroskopia molekularna</i> , WNT, Warszawa (in polish) [3b] Z. Kecki, <i>Podstawy spektroskopii molekularnej</i> , PWN, Warszawa (in polish) [4] A. Kisiel, <i>Synchrotron jako narzędzie: zastosowanie PS w spektroskopii ciała stałego</i> , SRNS 5(3) (2006) (in polish)										
	Supplementary literature	[5] Ch. Kittel, P. McEuen, <i>Introduction to solid state physics</i> (9th Ed.), New Jersey: Wiley [6a] W. Moebis, S.J. Ling, J.S. Sanny, University Physics, OpenStax, Volume 2 [6b] W. Moebis, S.J. Ling, J.S. Sanny, University Physics, OpenStax, Volume 3 [7] J.M. Hollas, <i>Modern Spectroscopy</i> , John Wiley & Sons, Ltd. [8] P. Willmott, <i>An Introduction to Synchrotron Radiation: Techniques and Applications</i> , John Wiley & Sons, Ltd. [9] A. Barbacki (red.), <i>Mikroskopia elektronowa</i> , Wyd. Politechniki Poznańskiej (in polish) [10] P. Atkins, J.de Paula, <i>Chemia fizyczna</i> , Rozdz.16 <i>Spektroskopia 1: widma rotacyjne i oscylacyjne</i> ; Rozdz. 17 <i>Spektroskopia 2: przejścia elektronowe</i> , PWN (in polish)										
	eResources addresses	Adresy na platformie eNauczenie:										

<p>Example issues/ example questions/ tasks being completed</p>	<ol style="list-style-type: none"> 1. List and briefly characterize detectors of ionizing radiation. 2. Silicon crystallizes in a simple cubic system. A neutron diffraction experiment with a 10-meter detector and angle = 45° 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? 3. What is a synchrotron and how does it work? Describe the basic properties of synchrotron radiation. 4. What is a spectrum? Give and discuss the parameters that characterize the spectral line. 5. Explain the terms transmittance, absorbance and absorption coefficient. Give the relationship between them. 6. Present the idea of the Raman phenomenon and discuss the shape of the Raman spectrum. 7. Explain why the XPS technique is a "surface sensitive" technique. 8. Electron microscopy - list the types of electron microscopes, compare them and define the scope of applications. 9. Determine what thermal analysis is and what the types are. 10. Discuss the differences between physical and chemical adsorption.
<p>Work placement</p>	<p>Not applicable</p>