GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	X-ray spectroscopy of nanomaterials, PG_00071206		
Field of study	Nanotechnology, Nanotechnology		
Date of commencement of studies	February 2027	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	Subject group	Specialty subject group 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	1	Language of instruction	English
Semester of study	1	ECTS credits	6.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Institute of Nanotechnology and Materials Engineering -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Agnieszka Witkowska	
	Teachers	dr hab. inż. Agnieszka Witkowska	

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	30.0	0.0	0.0	60
	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	60	2.0	88.0	150

Subject objectives	The course introduces students to advanced topics in solid-state spectroscopy, covering both theoretical and practical approaches to spectroscopic methods for material characterization, spectra interpretation, and the application of X-ray spectroscopy in nanomaterials research. The course includes discussions of photoelectron spectroscopy (XPS) and X-ray absorption spectroscopy (XAS) techniques.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W04] has theoretical and practical knowledge of physical and chemical experimental methods in nanotechnology and understands the principles of their application in processes occurring throughout the life cycle of technical systems	During lectures and laboratory exercises, the student acquires theoretical and practical knowledge related to modern spectroscopic instruments and techniques used in the study of nanostructured systems.	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects
[K7_U04] is able to formulate hypotheses, plan and conduct experimental research, critically analyze results, verify hypotheses, draw conclusions, and formulate well-founded opinions within nanotechnology and related physical and natural sciences. Recognizes economic and non-technical aspects of the activities performed	The student has advanced knowledge and skills in laboratory work, including the selection of appropriate spectroscopic methods for the analyzed problem, sample preparation for spectroscopic measurements, expermental set-up preparation and operation, conducting spectroscopic experiments, spectrum analysis, and interpretation of the obtained results.	[SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools
[K7_K01] is able to cooperate and work effectively in a group, assuming different roles depending on changing needs. Adheres to the principles of professional ethics and demonstrates creativity and entrepreneurship. Is capable of self-assessment as well as constructive evaluation of the work of others.	The student performs laboratory tasks (sample preparation, data collection and analysis, and discussion of results) together with the entire group, thereby developing the ability to collaborate and work effectively with others. While preparing the final report for the completed task, the student makes a constructive assessment of both their own work and that of others.	[SK1] Assessment of group work skills [SK3] Assessment of ability to organize work
[K7_U03] has enhanced abilities of using advanced specialist software packages	The student has advanced knowledge and skills in using specialized databases and software for the analysis of spectra collected in spectroscopic experiments.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools

Subject contents

Course content – lecture
1. Introduction to spectroscopic methods
2. Theoretical description of electromagnetic (EM) radiation, atoms, molecules, and solids
3. Interaction of EM radiation with matter
4. Fundamentals of photophysics Jablonski diagram
5. Spectra: parameters and methods of recording
6. X-ray spectroscopy absorption, emission, and photoemission techniques
7. Sources of X-ray radiation
8. X-ray photoelectron spectroscopy (XPS)
9. X-ray absorption spectroscopy (XAS)
10. X-ray emission spectroscopy (XES)

Course content – laboratory

1. **X-ray Photoelectron Spectroscopy (XPS):** Structure and operating principles of an XPS spectrometer; discussion of sample preparation specifics; acquisition and qualitative and quantitative analysis of XPS spectra of samples containing metallic nanoparticles embedded in a glassceramic matrix. The practical sessions are conducted in a specialized XPS spectroscopy laboratory and in a computer laboratory.

2. **X-ray Absorption Spectroscopy (XAS):** Optimization of sample parameters for XAS measurements; analysis of XANES and EXAFS spectra of reduced oxide systems containing heavy metals and metallic nanoparticles. The practical sessions are conducted in a computer laboratory.

Prerequisites and co-requisites

Courses in solid-state physics (physics of materials, nanomaterials), quantum mechanics, inorganic chemistry, and the theoretical foundations of nanotechnology.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Written examination	50.0%	50.0%
Completion of laboratory exercises and preparation of lab reports	100.0%	40.0%
Completion of homework assignments	50.0%	10.0%

Recommended reading

Basic literature	[1] J.M.Hollas, Modern Spectroscopy, John Wiley & Sons, Ltd. [2] D.L.Pavia i in., Introduction to Spectroscopy, Brooks/Cole [3] P.Willmott, An Introduction to Synchrotron Radiation: Techniques and Applications, John Wiley & Sons, Ltd.
Supplementary literature	[4] C.D.Wagner i in. Handbook of photoelectron spectroscopy, Perkin Elmer Corporation [5] G.Bunker, Introduction to XAFS, Cambridge Univ. Press [6] H.Haken, H.Ch.Wolf, "Molecular Physics and Elements of Quantum Chemistry", Springer
eResources addresses	

Example issues/ example questions/ tasks being completed	1. What is spectroscopy and what does it do? 2. What is a spectrum? List and discuss the parameters that characterize a spectral line. 3. List and discuss the main causes of spectral line broadening. 4. State and discuss the Lambert-Beer law. 5. List and characterize the types of molecular orbitals. 6. Discuss the physical basis of photoelectron spectroscopy and present the phenomena accompanying the main photoelectron excitation effect. 7. Discuss the operating principle of an XPS spectrometer. 8. Explain why XPS is a surface-sensitive technique. 9. Discuss the physical basis of X-ray absorption spectroscopy (XAS) and explain the source of fine structure in the spectrum. 10. What kind of information can be obtain from the analysis of the XAFS (X-ray absorption fine structure) spectrum in the region near the absorption edge?
Practical activites within the subject	Possible study visit to NCPS Solaris, Kraków (Polish synchrotron with beamlines dedicated to XAS and XPS spectroscopy).