GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Spectroscopic methods in nanotechnology , PG_00057509		
Field of study	Nanotechnology		
Date of commencement of studies	February 2024	Academic year of realisation of subject	2023/2024
Education level	second-cycle studies	Subject group	Optional 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	4.0
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 dr inż. Leszek Wicikowski	

Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	15.0	0.0	0.0	45
	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	45	2.0	53.0	100

Subject objectives	The aim of the course is to discuss the basic theoretical and practical issues of spectroscopy and presentation of the various types of spectroscopic methods and ways to interpret spectra, with particular attention paid to the possibility of their use in the study of nanostructured systems.

Learning outcomes			
	Course outcome	Subject outcome	Method of verification
	K7_K03	The student laboratory exercices (measurements, data analysis and discussion of results) performs in 2-, 3-person group, thanks to this student reaches the ability to cooperate and work in a group. Preparing the final reports on the realized tasks, he constructively evaluates the effects of his work and others.	[SK4] Assessment of communication skills, including language correctness [SK1] Assessment of group work skills
	K7_W03	During the classes, the student gains the knowledge about development of spectroscopic methods and the latest discoveries related to spectroscopic studies applied on the fields of physics, chemistry and nanotechnology.	[SW1] Assessment of factual knowledge
	K7_W04	During lectures and lab exercises the student learns about modern spectroscopic techniques equipments applied to study of nanostructured systems.	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects
	K7_U05	Students perform extensive laboratory tasks, learn how to prepare a proper samples, how to plan and perform measurements with spectrometer, analyse and discusse the obtained results. In the final report, they comment the experimental details, discuss the results, formulate conclusions and motivated opinions.	[SU1] Assessment of task fulfilment [SU5] Assessment of ability to present the results of task
	K7_U02	The student has skills and knowledge related to the laboratory work, among others with the samples preparation for spectroscopy measurements, preparation and use of the spectroscopy equipment and performing the experiment using various spectroscopic techniques.	[SU1] Assessment of task fulfilment [SU4] Assessment of ability to use methods and tools

Subject contents

Lecture:

1. Introduction to spectroscopy:
2. Theoretical description of electromagnetic radiation (EM);
3. Matter (atom, molecule, solid state);
4. Interaction between the EM radiation and the matter;
5. Photophysics - Jabłoński diagram;
6. Types of spectroscopy, spectrum and ways of its registration;
7. Absorption and emission spectroscopy;
8. Rotational spectroscopy;
9. Vibrational spectroscopy;
10. Rotational-vibrational spectra
11. Raman spectroscopy;
12. Electron spectroscopy, UV-Visspectroscopy;
13. Photoelectron spectroscopy (PES, AES);
14. X-ray absorption spectroscopy (XAS)

Laboratory:
X-ray Photoelectron spectroscopy: spectrometer, sample preparation, XPS spectra registration and qualitative and quantitative XPS spectra analysis (classes in a specialized XPS laboratory and computer laboratory)

Prerequisites and co-requisites

A course in solid state physics (physics of materials), quantum mechanics, nonorganic chemistry and theoretical principles of nanotechnology.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Written exam	51.0%	50.0%
Solving tasks and problems	50.0%	10.0%
Performance of laboratory exercises and laboratory reports preparation	100.0%	40.0%

Recommended reading	Basic literature	[1] J.M.Hollas, Modern Spectroscopy, John Wiley & Sons, Ltd. [2] J.Sadlej, Molecular Spectroscopy, WNT, Warszawa (in Polish) [3] D.L.Pavia i in., Introduction to Spectroscopy, Brooks/Cole [4] P.Willmott, An Introduction to Synchrotron Radiation: Techniques and Applications, John Wiley & Sons, Ltd.
	Supplementary literature	[5] C.D.Wagner i in. Handbook of photoelectron spectroscopy, Perkin-Elmer Corporation [6] G.Bunker, Introduction to XAFS, Cambridge Univ. Press [7] A.Gołębiewski, Elements of quantum mechanics and chemistry, PWN (in Polish)
	eResources addresses	Adresy na platformie eNauczanie:

Example issues/ example questions/ tasks being completed	1. What is a spectroscopy? Describe the types of spectroscopy due to the kind of radiation used. 2. What is a spectrum? Specify and describe the main parameters that characterize the spectral line shape. 3. List and describe the main causes of spectral lines broadening. 4. Define: transmittance, absorbance and absorption coefficient. 5. Formulate and explain Beer-Lambert law and define attenuation length. 6. Describe term symbol which characterize atomic states under Russell-Saunders coupling (Spin-Orbit coupling) condition. 7. Discuss the Hund's rules. 8. Write the selection rules for rotational transitions and define the rotational energy levels in a rigid rotor approximation. 9. How on the basis of rotation spectrum the molecule bond length can be determined (in a rigid rotor approximation)? 10. Write the selection rules for vibrational transitions and define the vibrational energy levels in an harmonic oscillator approximation. 11. Write the selection rules for vibrational transitions and define the vibrational energy levels for real oscillator (anharmonic oscillator). 12. How on the basis of vibration spectrum, bond energy of molecule can be determined? 13. Describe the shape of the vibration-rotation spectrum. 14. Raman spectroscopy: describe the origin and the idea of the phenomenon (e.g. on the basis of Placek polarizability theory) and shape of Raman spectrum. 15. Specify what the complementarity of Raman and IR spectroscopies means. 16. What is the origin of color of the transition metals complexes? 17. Explain the main cause of the line broadening observed in UV-Vis spectrum. 18. What is the auxochrome and how it can change the UV-Vis spectrum? 19. Explain hyperchromic and hypochromic effect, bathochromic and hypsochromic shift. 20. Photoelectron spectroscopy (PES, ESCA): describe the main idea of the technique and present the phenomena which accompanying the effect of the core electron photoexcitation (secondary effects, multi-electron effects). 21. Why photoelectron spectroscopy is a surface sensitive technique? 22. X-ray absorption spectroscopy (XAS): describe the origin of the phenomenon. 23. What kind of information can provide us X-ray absorption spectrum analysis close to absorption edge

	(XANES, X-ray absorption near edge structure)? 24. Explain the origin of the absorption coefficient fine structure observed in the extended energy range of X-ray absorption spectrum (EXAFS). 25. Why EXAFS (Extended X-ray Absorption Fine Structure) analysis is considered as a probe of local structure at the atomic level?
Work placement	Not applicable