GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Spectroscopy methods in nanotechnology, PG_00063688		
Field of study	Nanotechnology		
Date of commencement of studies	October 2024	Academic year of realisation of subject	2024/2025
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	2	ECTS credits	5.0
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	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	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	5.0	60.0	125

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_U05] can plan and conduct experimental and critical research and analyze their results, draw conclusions and formulate reasoned conclusions – within their specialization.	Students perform a few experiments, learn how to prepare a proper samples, how to 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 [SU2] Assessment of ability to analyse information [SU5] Assessment of ability to present the results of task
[K7_U03] has enhanced abilities of using advanced specialist software packages	The student has extended knowledge and skills in the use of professional databases and softwares for the analysis of data collected in a spectroscopy experiment.	[SU2] Assessment of ability to analyse information [SU4] Assessment of ability to use methods and tools
[K7_K03] can cooperate and work as part of a team, adopting different roles. Can self-evaluate, and give constructive feedback on the work of others.	The student laboratory taks (measurements, data analysis and discussion of results) performs with the whole goup, thanks to this student reaches the ability to cooperate and work effectively with others. Preparing the final reports on the realized tasks, he constructively evaluates the effects of his work and others.	[SK3] Assessment of ability to organize work [SK4] Assessment of communication skills, including language correctness [SK1] Assessment of group work skills
[K7_W04] has practical and theoretical knowledge of physical and chemical experimental methods of nanotechnology.	During lectures and lab exercises the student learns about modern spectroscopic techniques equipments applied to study of nanostructured systems.	[SW1] Assessment of factual knowledge

Subject contents	Lecture: 1. Introduction to spectroscopy; 2. theoretical description of electromagnetic radiation (EM), matter (atom, molecule, solid state); 3. Interaction between the EM radiation and the matter; 4. Basics of photophysics - Jabłoński diagram 5. Spectrum: its parameters and ways of registration; 6. Rotational spectroscopy; 7. Vibrational spectroscopy (IR); 8. Rotational-vibrational spectra; 9. Raman spectroscopy; 10. Electron spectroscopy (UV-Vis); 11. Photoemission spectroscopy (UPS, XPS, AES); 12. X-ray absorption spectroscopy (XAS). Laboratory: 1. FTIR spectroscopy: presentation of measurement modes used in infrared spectroscopy, discussion of the details related to the preparation of solid and liquid samples, FTIR spectra collection and analysis e.g. to examine microplastics present in seawater or the composition and purity of selected pharmaceuticals - classes conducted in a specialized laboratory of molecular spectroscopy and in a computer laboratory; 2. UV-Vis spectroscopy: presentation of the measurement technique, samples preparation, study of the quantum size effect through measurements and analysis of emission UV-Vis spectra - classes conducted in a specialized laboratory of molecular spectroscopy and in a computer laboratory; 3. Photoelectron spectroscopy: XPS spectrometer, discussion of the details related to the samples preparation, collection and qualitative and quantitative analysis of XPS spectra of samples containing metallic nanoparticles embedded in a glass-ceramic matrix - classes conducted in a specialized laboratory of XPS spectroscopy and in a 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
Laboratory exercises realization and laboratory reports preparation	100.0%	40.0%
Solving the homework problems	50.0%	10.0%
Written egzam in theory	51.0%	50.0%

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	Adresy na platformie eNauczanie: Spectroscopy Methods in Nanotechnology - 2025 - Moodle ID: 44055 https://enauczanie.pg.edu.pl/moodle/course/view.php?id=44055 Spectroscopy Methods in Nanotechnology, laboratory - 2025 - Moodle ID: 44057 https://enauczanie.pg.edu.pl/moodle/course/view.php?id=44057

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

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