

GDAŃSK UNIVERSITY

Subject card

Subject name and code	Spectroscopy methods in nanotechnology, PG_00052031							
Field of study	Nanotechnology							
Date of commencement of studies	October 2022		Academic year of realisation of subject		2022/2023			
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	2		ECTS credits		6.0			
Learning profile	general academic profile Asses		Assessmer	nt form		exam		
Conducting unit	Zakład fizyki układów nieuporządkowanych -> 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	Lesson type	Lecture	Tutorial	Laboratory	Project		Seminar	SUM
of instruction	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		85.0		150
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			
	к7_коз	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	During lectures and lab exercises the student learns about modern spectroscopic techniques equipments applied to study of nanostructured systems.	[SW1] Assessment of factual knowledge			
	K7_U03	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_U05	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_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			
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 (UV-Vis); 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 - 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 (phys theoretical principles of nanotechnol	sics of materials), quantum mechanic ogy.	s, nonorganic chemistry and			

and criteria Isboretory exercises estation 100.0% 40.0% 40.0% and laboritary cryster separation 50.0% 10.0% 50.0% Recommended reading Basic literature [1] J.M.Hollas, Modern Spectroscopy, John Wiey & Sons, Ltd. Recommended reading Basic literature [1] J.M.Hollas, Modern Spectroscopy, John Wiey & Sons, Ltd. Supplementary literature [4] C.D. Wagner I.n. Handbuck of photoelectron spectroscopy, Perdix-Einer Corporation Supplementary literature [4] C.D. Wagner I.n. Handbuck of photoelectron spectroscopy, Perdix-Einer Corporation Example issues/ example questions/ tasks being completed 1. What is a spectroscopy? Description to XAFS. Cambridge Univ. Press 1. What is a spectroscopy? Description to XAFS. Cambridge Univ. Press [8] H.Haken, H.Ch.Waft. "Molecular Physics and Elements of Quantum Chemistry". Springer Example issues/ example questions/ tasks being completed 1. What is a spectroscopy? Description to Spectroscopy and photoer 2023 - Moodel ID: 27232 Mits // Amazanie. Spectroscopy and photoer 2023 - Moodel ID: 27232 Mits // Amazanie. Spectroscopy and photoer 2023 - Moodel ID: 27232 Mits // Amazanie. Spectroscopy and photoer 2023 - Moodel ID: 27232 Mits // Amazanie. Spectroscopy and photoer 2023 - Moodel ID: 27232 Mits // Amazanie. Spectroscopy and the Mit of anatomistic and elements of Quantum Chemistry and photoer 2023 - Moodel ID: 27232 Mits // Amazanie. Spectroscopy and the Mit of anatomist and elements of Quantum Chemistry. Springer	Assessment methods	Subject passing criteria	Passing threshold	Percentage of the final grade	
Solving the homework problems 50.9% 10.9% Recommended reading Selving the homework problems 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. Wilmott, An Introduction to Spectroscopy, Brooks/Cole [3] P. Wilmott, An Introduction to Spectroscopy, Brooks/Cole [3] P. Wilmott, An Introduction to Spectroscopy, Brooks/Cole [3] G. Durker, Introduction to SAFS, Cambridge Univ. Press [6] G. Bunker, Introduction to XAFS, Cambridge Univ. Press [6] G. Bunker, Introduction to XAFS, Cambridge Univ. Press [6] H.Haken, H.Ch. Wolf, "Molecular Physics and Elements of Quantum Chemistry". Springer eResources addresses Acresy na platformie eNauczanie: Spectroscopy due to the kind of radiation used. example questions/ tasks being completed 1. What is a spectroscopy? Describe the types of spectroscopy due to the kind of radiation used. * Units is a spectroscopy? 1. What is a spectroscopy due to the kind of radiation used. * Units is a spectroscopy? 2. Sectoscopy due to the kind of radiation used. * Units is a spectroscopy? 2. Sectoscopy due to the kind of radiation used. * Units is a spectroscopy due to the kind of radiation used. 2. Sectoscopy due to the kind of radiatin us	and criteria	Laboratory exercises realization		<u> </u>	
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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. Wilmott, An Introduction to Spectroscopy, Brooks/Cole [3] P. Wilmott, An Introduction to Synchrotron Radiation: Techniques and Applications, John Wiley & Sons, Ltd. [2] D.L. Pavia i In, 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 Acreary na platformic eNauczanic: Spectroscopy Methods in Nanotechnology 2023 - Moodle 10: 27232 https://mauczanie.gp.gdu.phmcollecourseview.php?die/27232 bisetions/ tasks being completed 1. What is a spectroscopy/ Deschare the spectral line shape. 1. Unit is a spectroscopy of Deschare the spectral line shape. 3. List and describe the main caracse spectral lines thradening. 2. What is a spectroscopy activity of describe the main caracse spectral lines thradening. 3. Define: transmitance. Bisorbance and absorption ceefficient. 5. Formulate and replane Bert-Lamber I wand define the rotational energy levels in an approximation. 3. Write the selection rules for rotational transitions and define the vibrational energy levels for real oscillator, income and thesprestromaphic and t					
2) D.L.Pavia i in., Introduction to Spectroscopy, Brooks/Cole 3) P.Wilmott. An Introduction to Synchrotron Radiation: Techniques and Applications, John Wiley & Sons, Ltt. 3) Supplementary literature 4) C.D.Wagner i in. Handbook of photoelectron spectroscopy, Perkin- Emer Corporation 5) G.B.unker, Introduction to XAFS, Cambridge Univ. Press (5) G.B.unker, Introduction to XAFS, Cambridge Univ. Press (6) H.Haken, H.Ch.Wolf, "Molecular Physics and Elements of Quantum Chemistry", Springer eResources addresses Adresy na platformic eNauczanie: Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232		· · ·			
Example issues/ eResources addresses Adresy na platformie eNauczanie: Spectroscopy Methods in Nandechnology 2023 - Moodle ID: 27232 https://neuczanie.ge.du.plinoodler.comserview.php?id=27232 Spectroscopy Methods in Nandechnology 2023 - Moodle ID: 27232 https://neuczanie.ge.du.plinoodler.comserview.php?id=27232 2. What is a spectrors:Oper/yand describe the main parameters that characterize the shape. 3. List and describe the main causes of spectral lines broadening. 4. Office: transmittance, absorbance and absorption coefficient. 5. Formulate and explain Beer-Lambert law and define the rotational energy levels in a rigid rotor approximation. 9. If Nor on the selection rules for rotational transitions and define the rotational energy levels in an harmonic oscillator, approximation. 11. 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 in an harmonic oscillator, and parkation spectrum. 12. How on the basis of Vibration spectrum. 13. Spectrib the shape of the vibration appedrum. 14. Raman aspectroscopy / Kastion spectrum. 15. Spectry what the complementiaty of Raman and IR spectroscopies means. 16. What is the dation of the vibration media complexes? 17. Explain the main cause of the line transition media complexes? 18. What is the dation of the shape of Raman and R. Spectroscopies means. 19. What is the apper of the vibration media complexes? 10. Write the transition reget of the core electron photoexcitation (secondary effects, multi- lectors	Recommended reading	[2] D.L.Pavia i in., Introduction to Spectroscopy, Brooks/Co			
Image: Spectroscopy Methods in Nanotechnology 2023 - Moodle ID: 27232 https://enauczanie.ge.du.pl/moodle/course/view.php?ld=27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 https://enauczanie.ge.du.pl/moodle/course/view.php?ld=27232 Spectroscopy Methods in Nanotechnology 2023 - Model ID: 27232 https://enauczanie.ge.du.pl/moodle/course/view.php?ld=27232 What is a spectroscopy? Describe the types of spectroscopy due to the kind of radiation used. What is a spectroscop? Describe the types of spectroscopy due to the kind of radiation used. Berne transmittance, absorbance and absorption coefficient. 5. Formulate and explain Beer-Lambert law and define attenuation length. 6. Describe tim 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. 1. Write the selection rules for vibrational transitions and define the vibrational energy levels for real oscillator (anharmonic oscillator). 1. Bescribe the shape of the Vibration spectrum. 1. Write the selection rules for vibration rules for paperoximation. </td <td></td> <td>Supplementary literature</td> <td colspan="3">Elmer Corporation [5] G.Bunker, Introduction to XAFS, Cambridge Univ. Press [6] H.Haken, H.Ch.Wolf, "Molecular Physics and Elements of Quantum</td>		Supplementary literature	Elmer Corporation [5] G.Bunker, Introduction to XAFS, Cambridge Univ. Press [6] H.Haken, H.Ch.Wolf, "Molecular Physics and Elements of Quantum		
 example questions/ tasks being completed 2. What is a spectrum'? Specify and describe the main parameters that characterize the spectral line shape. a. List and describe the main causes of spectral lines broadening. b. 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 apedrum and the idea of the phenomenon (e.g. on the basis of Placek polarizability theory) and shape of Raman apectrum. 15. Specify what the complementarity of Raman and IR spectroscopies means. 16. What is the auxochrome and hypochromic effect, bathochromic and hyposchromic shift. 20. Photoelectron spectroscopy (SE). ESCA): describe the main idea of the technique? 21. Why photoelectron spectroscopy is a surface sensitive technique? 22. X-ray absorption spectroscopy is a surface sensitive technique? 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		eResources addresses	Spectroscopy Methods in Nanotechnology 2023 - Moodle ID: 27232 https://enauczanie.pg.edu.pl/moodle/course/view.php?id=27232 Spectroscopy Methods in Nanotechnology 2023 - Moodle ID: 27232		
	Example issues/ example questions/ tasks being completed	 What is a spectroscopy? Describe the types of spectroscopy due to the kind of radiation used. What is a spectrum? Specify and describe the main parameters that characterize the spectral line shape. List and describe the main causes of spectral lines broadening. Define: transmittance, absorbance and absorption coefficient. Formulate and explain Beer-Lambert law and define attenuation length. Describe term symbol which characterize atomic states under Russell-Saunders coupling (Spin-Orbit coupling) condition. Discuss the Hund's rules. Write the selection rules for rotational transitions and define the rotational energy levels in a rigid rotor approximation. How on the basis of rotation spectrum the molecule bond length can be determined (in a rigid rotor approximation)? Write the selection rules for vibrational transitions and define the vibrational energy levels in an harmonic oscillator approximation. How on the basis of intration spectrum, bond energy of molecule can be determined? Describe the shape of the vibration spectrum. Ream spectroscopy: describe the origin and the idea of the phenomenon (e.g. on the basis of Placek polarizability theory) and shape of Raman spectroscopies means. What is the auxochrome and how it can change the UV-Vis spectrum? Explain the main cause of the line broadening observed in UV-Vis spectrum. What is the auxochrome and how it can change the tuV-Vis spectrum? Photoelectron spectroscopy (AS): ESCA): describe the main dea of the technique and present the phenomena which accompanying the effect of the core electron photoexcitation (secondary effects, multi-electron effects). How on the basis opectroscopy (AS): describe the main dea of the technique and present the phenomena which accomponying the effect of the core electron photoexcitation (secondary e			
	Work placement	Structure at the atomic level?			