GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Photophysics and introduction to molecular spectroscopy , PG_00061307		
Field of study	Nanotechnology		
Date of commencement of studies	October 2023	Academic year of realisation of subject	2025/2026
Education level	first-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	3	Language of instruction	Polish
Semester of study	6	ECTS credits	2.0
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	15.0	0.0	0.0	0.0	0.0	15

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	15	2.0	33.0	50

Subject objectives

The aim of the course is to present the main issues related to the interaction between electromagnetic radiation and matter, to discuss photophysical processes and the basics of molecular spectroscopy.

Learning outcomes

Course outcome	Subject outcome	Method of verification
K6_W07	The student acquires knowledge in the field of optical properties of materials and nanomaterials, learns spectroscopic methods of studying the structural and physico-chemical properties of materials and nanomaterials.	[SW1] Assessment of factual knowledge
K6_U06	The student acquires knowledge that will enable him/her to present in a simple and understandable way technological and scientific issues and problems related to the properties and applications of nanostructures in photophysical processes.	[SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject
K6_W06	The student acquires knowledge of the optical and photophysical properties of materials and nanomaterials and the correlation of these properties with their structure and other non-optical properties.	[SW1] Assessment of factual knowledge

<table>
<tr><td>Subject contents</td><td>Course content – lecture
Lecture:

1) Introduction. The nature of EM radiation (classical electrodynamics and Maxwell's equations, waveparticle duality); nature and structure of matter (Waveparticle duality, quantum mechanics, atomic and molecular orbitals, energy states in a molecule); interaction of EM radiation with matter (electric dipole approximation, Einstein coefficients, selection rules for optical transitions).

2) Jabłoński diagram of photophysical processes: radiative transitions (fluorescence and phosphorescence, Kasha's rule, mirror symmetry rule for absorption and emission spectra, Stokes shift, quantum efficiency and lifetime of fluorescence and phosphorescence decay), non-radiative transitions (vibrational relaxation, internal conversion, intersystem crossing). Types of luminescence.

3) Spectroscopy methods: classification of spectroscopy methods; Beer-Lambert law, transmittance, absorbance, absorption coefficient, attenuation length; measurement methods (continuous wave and Fourier Transform methods); absorption and emission spectrometer; spectrum, basic parameters of spectral lines and their physical meaning. Infrared absorption spectroscopy vs. Raman spectroscopy. UV-Vis spectroscopy.</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>Basic knowledge of electromagnetism, modern physics, atomic and molecular physics and solid state physics.</td></tr>
<tr><td>Assessment methods and criteria</td><td><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Written test</td><td>51.0%</td><td>90.0%</td></tr>
<tr><td>Participation in classes</td><td>0.0%</td><td>10.0%</td></tr>
</table></td></tr>
<tr><td>Recommended reading</td><td><table>
<tr><td>Basic literature</td><td>[1] D.L.Andrews, Molecular Photophysics and Spectroscopy, Morgan & Claypool Publ.

[2] J.Sadlej, Spektroskopia molekularna, WNT, Warszawa (in polish)</td></tr>
<tr><td>Supplementary literature</td><td>[3] H.Haken, H.Ch.Wolf, Molecular Physics and Elements of Quantum Chemistry, Springer

[4] D.L.Pavia i in., Introduction to Spectroscopy, Brooks/Cole</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
</table></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td>1. Using Maxwell's equations, prove that light is an electro-magnetic wave.
2. List and describe a few types of molecular orbitals.
3. List and briefly discuss mechanisms of light absorption in the molecule.
4. Describe term symbol which characterize atomic states under Russell-Saunders coupling condition. Discuss the excited Singlet and Triplet state.
5. Explain the phenomena of absorption, spontaneous and stimulated emission. What is the probability of individual processes occurring and what parameter allows to assess this probability.
6. Photophysical vs. photochemical processes state the difference between them.
7. Present the Jabłoński diagram and use it to discuss the basic photophysical processes.
8. Explain Kasha's rule
9. Fluorescence: basic rules, laws, quantum yield and the fluorescence decay time.
10. Spectroscopy: definition, types of spectroscopy methods.
11. Specify and describe physical meaning of the parameters that characterize spectral line shape.
12. Define: transmittance, absorbance and absorption coefficient. Descibe the relations between them.
13. Raman spectroscopy: discuss the origin and the idea of the phenomenon and describe shape of the Raman spectra.
14. What is the auxochrome and how it can change the UV-Vis spectrum.</td></tr>
<tr><td>Practical activites within the subject</td><td>Not applicable</td></tr>
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