GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Physical fundamentals of nanotechnology, PG_00048741		
Field of study	Materials Engineering, Materials Engineering, Materials Engineering		
Date of commencement of studies	February 2022	Academic year of realisation of subject	2021/2022
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	Polish
Semester of study	1	ECTS credits	4.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Department of Solid State Physics -> Faculty of Applied Physics and Mathematics		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Barbara Kościelska	
	Teachers	dr hab. inż. Barbara Kościelska	

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	0.0	0.0	0.0	15.0	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	10.0	45.0	100

Subject objectives

The aim of the course is to acquaint students with the physical fundamentals of nanotechnology

Learning outcomes

Course outcome	Subject outcome	Method of verification
K7_U03	Preparation and oral presentation of a seminar paper.	[SU2] Assessment of ability to analyse information
K7_K02	Preparation and oral presentation of a seminar paper.	[SK4] Assessment of communication skills, including language correctness
K7_U01	Ability to understand textbooks and ability to critical usage of internet.	[SU2] Assessment of ability to analyse information
K7_W07	Has basic knowledge in quantum mechanics, that is a key field within materials scienca.	[SW1] Assessment of factual knowledge
K7_W01	Konwledge of basic principles of quantum mechanics and understanding of its fundamental role in modern physics.	[SW1] Assessment of factual knowledge

Subject contents

1. General concepts related to nanotechnology, methods of production and test methods nanostructures.

2. Physico-chemistry of surface.

3. Elements of solid state physics: crystal structure, binding models in crystal, the electron density of states, band structure.

4. Quantum wells.

5. Physical phenomena in nanostructures: ballistic transport, the quantum Hall effect, tunneling, Coulomb blockade, Aharonow - Bohm effect, the absorption and emission of radiation, lasers.

6. Specific heat in the crystal, the thermal properties of nanostructures.

7.Pphotonic structures and their application.

8. Nanomagneism: magnetic properties of materials, spin-orbit coupling, GMR, TMR, spin valves, spin Hall effect, the Kondo effect.

9. Physical properties of nanotubes and graphene.

<table>
<tr><td>Prerequisites and co-requisites</td><td colspan="2">Completed a course of experimental physics.</td></tr>
<tr><td>Assessment methods and criteria</td><td colspan="2"><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Written exam</td><td>50.0%</td><td>67.0%</td></tr>
<tr><td>Seminar: presentation and writing a summary</td><td>50.0%</td><td>33.0%</td></tr>
</table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>1. Nanotechnologie. Red. Nauk. R.W.Kelsall i in. PWN 2008.

2. The Physics and Chemistry of Materials. J.I.Gersten, F.W.Smith, Wiley 2001.

3. Introduction to nanotechnology. Ch.P.Poole Jr, F.J.Owens. Wiley 2003</td></tr>
<tr><td>Supplementary literature</td><td>1 Fulereny i nanorurki. W.Przygocki i A. Łochowicz, NT 2001.

2. Nanoelectronics and Information Technology. Rainer Waser. Wiley-VCH 2003.</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="2">1. Types of chemical bonds in crystal.
2. Density of states? Discuss the density of states g (E) in the system 0D, 1D, 2D and 3D.
3. Band structure of the crystal: how energy bands are formed and how do they affect the properties of the crystal.
4. Effective mass.
5. An electron trapped in one, two and three-dimensions.
6. A particle in a potential well and the tunnel effect.
7. Discuss the principle of the laser quantum wells and quantum dots.
8. Define the surface tension and surface energy, and discuss their importance in nanostructured systems.
9. Discuss phenomenon capable of varying surface energy.
10. Discuss the electron heat capacity and thermal conductivity.
11. Discuss the specific heat network and thermal conductivity.
12. Thermoelectric cooling: 3D systems and nanosize systems.
13. Quantization of conductivity - Landauer theory.
14. Three-dimensional and two-dimensional electron gas in an external magnetic field.
15. Quantum Hall effect and the effect of Shubnikova - de Hass.
16. Discuss the phenomenon of Coulomb blockade and the formation of the so-called. "Coulomb diamonds".

17. Discuss the polarization of dielectrics.
18. Propagation of light in the crystal. Maxwell's equations
19. What are the photonic structures and how they can be prepared.
20. A photonic gap.
21. What is the spin-orbit coupling (both in the atom as in the 2D electron gas)?
22. Applications of magnetic nanowires.
23. Spin Hall effect.
24. Kondo effect.
25. The phenomenon of giant magnetoresistance and magnetic tunnel junction. Transistor spin and spin valve.
26. List and discuss the physical properties of graphene and nanotubes.</td></tr>
<tr><td>Work placement</td><td colspan="2">Not applicable</td></tr>
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