GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Transport properties of materials and superconductivity, PG_00038597		
Field of study	Nanotechnology		
Date of commencement of studies	October 2022	Academic year of realisation of subject	2025/2026
Education level	first-cycle studies	Subject group	
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	4	Language of instruction	Polish
Semester of study	7	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Division Of Electrochemistry And Surface Physical Chemistry -> Institute Of Nanotechnology And Materials Engineering -> Faculty Of Applied Physics And Mathematics -> Wydziały Politechniki Gdańskiej		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Natalia Wójcik	
	Teachers	dr hab. inż. Natalia Wójcik	

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	0.0	30
	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	30	0.0	0.0	30

Subject objectives

Understanding the mechanisms of charge, heat and mixed transport in materials.

Gaining the information on superconductivity, parameters of the superconducting state and related types of ordering.

Learning outcomes

Course outcome	Subject outcome	Method of verification
K6_W07	Student is able to describe and explain the effects of transport and superconductivity.	[SW1] Assessment of factual knowledge
K6_U06	Student posesses the knowledge of tranport properties in low dimensional materials and is able to use it to describe the effects mentionned above.	[SU1] Assessment of task fulfilment

Subject contents

1. Introduction to the course (1h)
2. Reminder of basic concepts related to transport: charge and heat transport, carriers, Fermi level, Fermi surface, state density, metals, semiconductors, compensated semiconductors, effective mass, its dependence on band dispersion, mobility, dispersion, relaxation time, Matthiessen's rule - (2h)
3. Boltzmann kinetic equation, conductivity as a tensor, conductivity and electrical resistance in metal and semiconductor, activation conductivity, Arrhenius plots, resistance measurement methods - (3h)
4. Ion transport, diffusion, Fick's laws, Nernst-Einstein equations, relation between diffusion and mobility - (3h)
5. Magneto-resistance, classical approach to magnetoresistance, electron orbit in a magnetic field, Onsagere's rule, Kohler's rule, giant magnetoresistance, magnetoresistance measurement - (3h)
6. Shubnikov de Haas and de Haas van Alpen quantum oscillations, Hall effect, anomalous (spin) Hall effect, quantum Hall effect, measurement and application of the Hall effect - (3h)
7. Thermal conductivity, thermoelectric effects: Seebeck, Peltier, Thomson and thermo-magnetic effects: Righi-Leduca, Nernst-Ettigshausen, Maggie-Righi-Leduca - (2h)
8. Electron-electron and electron-phonon interaction (polarone), Hubbard model, Mott insulator, Kondo effect, topological insulator - (2h)
9. Superconductivity (9 h)
10. Introduction - discovery history, milestones;
11. Properties of superconducting state, derivation and interpretation of London equations, basic assumptions of BCS theory;
12. Measurements of superconductors: electrical resistance, magnetic susceptibility, specific heat;
13. Determination of the basic parameters of the superconducting state, application of superconductors.
14. test (2h)

<table>
<tr><td>Prerequisites and co-requisites</td><td colspan="3">Completed the course of crystallography</td></tr>
<tr><td>Assessment methods and criteria</td><td colspan="3"><table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td>Final test (written), 1h</td><td>50.0%</td><td>100.0%</td></tr></table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td colspan="2">1. M. Tinkham, Introduction to Superconductivity, Dover, 1996.
2. M. Cyrot and D. Pavuna, ; (Introduction to Superconductivity, World Scientific, 1995).
3. Charles Kittel, Introduction to solid state physics</td></tr>
<tr><td>Supplementary literature</td><td colspan="2">A. B. Pippard, Magnetoresistance in Metals, Cambridge University Press, 1989</td></tr>
<tr><td>eResources addresses</td><td colspan="2">Adresy na platformie eNauczanie:</td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="3">1) Explain the phenomenon of giant magnetoresistance and write in what materials it can occur.

2) How does the four probe resistance measurement work?</td></tr>
<tr><td>Work placement</td><td colspan="3">Not applicable</td></tr>
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