COURSE DESCRIPTION CARD - SYLLABUS

Course name
Materials for advanced technology [S1FT2>MdZT]

Course

Field of study
Technical Physics

Year/Semester
3/5

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
15

Projects/seminars
0

Number of credit points

5,00

Coordinators

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Lecturers

Prerequisites

Knowledge of experimental physics and basic specialist knowledge of nanotechnology and functional materials. The ability to solve simple physical problems based on the acquired knowledge, the ability to obtain information from the indicated sources. Understanding the need to expand your competences and make decisions for the academic community.

Course objective

1. Providing students knowledge on modern functional materials for molecular electronics, optoelectronics, scintillators, sensors, photomedicine; acquainting with the properties of zero-, two- and three-dimensional structures on the nanometer scale, thin-film organic structures, metamaterials, fullerenes, carbon nanotubes, graphene, single crystalline films and single crystal matrix materials, photonic crystals and materials for nonlinear optics. 2. Developing the ability to select modern materials for applications in electronics and optoelectronics. Ability to search for development technologies for producing innovative devices. 3. Developing teamwork skills in students.

Course-related learning outcomes

Knowledge:

1. She/he has detailed knowledge on selected functional materials and the requirements related to application of these materials in the broadly understood optoelectronics
2. She/He possesses structured and in-depth knowledge on physical phenomena in the field of classical experimental physics
3. She/he knows the state of knowledge and is familiar with the latest trends in technology and materials science

Skills:
1. She/he is able to prepare a well-documented study on issues related to new functional materials and their applications in optoelectronics
2. She/He can choose materials with appropriate physicochemical and design properties for laboratory and engineering applications for creating new electronic components
3. She/he can, on the basis of literature, independently make a preliminary analysis of the results of laboratory measurements and draw conclusions
4. She/he is able to independently and efficiently present an oral presentation in Polish with well-documented and interpreted measurement results
5. She/he can explain the essence of measurement and experimental method on the basis of the indicated literature; shows particular commitment and independence at work and diligence in the development of results, looks for solutions in non-standard situations

Social competences:
1. She/he can solve problems on his own, as well as cooperate as part of a team
2. She/he understands the need and knows the possibilities of continuous training, improving professional, personal and social competences

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Efect Form of evaluation Evaluation criteria
W12, W13 Written exam 3 - 51%-70.0%
4 - 70.1%-90.0%
5 - od 90.1%
U04, U14, U18 Final tests (classes) 3 - 51%-70.0%
Assessment of the student's skills at the blackboard 4 - 70.1%-90.0%
5 - od 90.1%
U_02, U_14, U_15 Laboratory exercise report (lab.) 3 - 51%-70.0%
inout test 4 - 70.1%-90.0%
5 - od 90.1%
K01, K08, K09 Assessment of the student's competences acquired 3 - 51%-70.0%
during the lecture and exercises 4 - 70.1%-90.0%
5 - od 90.1%

Programme content

The lecture covers the following topics:
Part I.
Organic materials for optoelectronics.
Methods for the production and characterization of ultra-thin, organic active layers of optoelectronic devices.
Nanomaterials with application potential in medicine.
Part II.
Maxwell"s equations and constitutive matrices for natural and artificial centers.
Isotropic, anisotropic and bianisotropic materials.
The wave equation and its solutions.
Metamaterials (Pendry model).
Part III.
Raman effect.
Crystallization process using the Czochralski method.
Crystallographic structure of perovskite and garnet crystals.
Elements of group theory.

Spectroscopic characterization of perovskite and garnet structures.
Single crystalline films of perovskites and garnets as a scintillation materials.
Organnic-inorganic perovskite structures for photovoltaics.
Part IV.
Metalophthalocyanines and carbon materials.
Types of polymorphic forms of thin layers of
metal phthalocyanines and their properties.
Absorption and Raman spectra of metallophthalocyanines.
Types of carbon nanotubes, chiral vector.
Methods of obtaining micro and nanodiamond thin-film
structures.
Part V.
Photonic crystals.
Photonic band gap, mirror / Bragg grating, photonic opitcal fibers. Luminescent crystals.
The phenomenon of "up-conwersion" and the phenomenon of down-conversion.
Semiconductors: energy gap of semiconductors, optical properties of semiconductors.
Semiconductor quantum dots.

Course topics

Part I (3 lectures).
Organic materials for use in optoelectronics.
The physical processes underlying the operation of organic optoelectronic devices, such as field effect transistors, displays, photovoltaic cells, etc., and the principles of their operation.
Methods for the production and characterization of ultra-thin, organic
active layers of optoelectronic devices.
Nanomaterials with application potential in medicine.
Models of cell membranes.
Methods of studying the interaction of nanomaterials with model cell membranes.
Part II (3 lectures).
Maxwell"s equations and constitutive matrices for natural and artificial centers (Maxwell"s equations in differential form, the law of conservation of electric charge, constitutive relationships, constitutive parameters, constitutive matrix, classification of media based on the type of constitutive matrix). Isotropic, anisotropic and bianisotropic materials (electromagnetic characteristics of media based on the type of constitutive matrix). The wave equation and its solutions (wave equation, dispersion relationship, plane wave, period, frequency, wavelength, wavenumber, phase velocity, Poynting vector, conservation of energy for electromagnetic field). Metamaterials (negative refractiveindex, refraction of electromagnetic waves at the border of natural and metamaterial media, a system of rings with a gap and rectilinear wires forming a metamaterial structure (Pendry model).
Part III (3 lectures).
Characterization of crystalline materials with a perovskite structure by Raman spectroscopy.
Crystallization process using the Czochralski method.
Crystallographic structure of perovskite and garnet crystals.
Elements of group theory. Site symmetry analysis for selected space groups.
Characterization of crystalline materials of perovskite and garnet structure using Raman spectroscopy method.
Ordering of cation sublattice for mixed perovskite structures (two- and three-component crystals). Relation with order parameter.
Single crystalline films of perovskites and garnets as scintillation materials
Organic-inorganic perovskite structures for photovoltaics.
Part IV (3 lectures).
Metalophthalocyanines and carbon materials.
Types of polymorphic forms of thin layers of metal phthalocyanines deposited on solid substrates and their change with temperature.
Change in energy gap and trap level with the thickness of the metal phthalocyanine layer.
Absorption spectra of metallophthalocyanines and their characteristic absorption bands.
Polymorphic forms of metallophthalocyanines characterized by Raman light scattering spectra.
Types of carbon nanotubes, folding of graphene layers, chiral vector.
Methods of obtaining micro and nanodiamond thin-film structures.
Influence of gas concentration on the behavior of diamond structure (sp3 / sp2 hybridization) and

characterization of structures by Raman light scattering.
Part V (3 lectures).
Photonic crystals: natural photonic crystals, one-, two- and three-dimensional photonic crystals, photonic band gap, mirror / Bragg grating, photonic opitcal fibers.
Luminescent crystals: natural luminescence, the luminescence of crystals doped with rare earth ions, structure, the phenomenon of
"up-conwersion" and the phenomenon of down-conversion.
Semiconductors: energy gap of
semiconductors, optical properties of semiconductors, semiconductor quantum dots.

Teaching methods

Lecture: multimedia presentation, illustrated with graphic examples, animations and films.
Exercises: blackboard classes; multimedia presentation of selected issues; solving of example tasks for each topic; individual solving of tasks given by the tutor.
Laboratory: individual measurements in a research laboratory, evaluation of the results by the student under the supervision of the tutor, preparation of a report.

Bibliography

Basic:
1. G.T. Barnes, I.R. Gentle, Interfacial Science: an introduction, Oxford Univ. Press, second edit. 2011
2. S. A. Ramakrishna, T. M. Grzegorczyk, Physics and Applications of Negative Refractive Index Materials, CRC Press Taylor & Francis, Boca Raton, 2009.
3. A.Oleś, Metody eksperymentalne fizyki ciała stałego, Warszawa, WNT, 1998.
4. J. A. Kong, Electromagnetic Wave Theory, Willey, New York, 1986.
5. M. Drozdowski Spektroskopia Ciała Stałego, Wydawnictwo Politechniki Poznańskiej, 2001
6. Z. Kęcki, Podstawy spektroskopii molekularnej, PWN, Warszawa, 1992
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10. H.J. Guntherodt, R. Wiesendanger (Eds.), Scanning Tunneling Microscopy, Springer-Verlag, Berlin, 1992.

Additional:
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2. E. T. Dutkiewicz, Fizykochemia powierzchni, WNT, Warszawa, 1998.
3. E. Wolarz, Metamateriały we współczesnej fizyce, materiały do wykładu.
4. D.J. Griffiths, Podstawy elektrodynamiki, PWN, Warszawa, 2011.
5. G. Turrel, J. Corset, Raman microscopy - development and applications, Elsevier Ltd., San Diego, California, 1996.
6. M. Bertrandt - „II pracownia fizyczna”; Wydawnictwo Politechniki Poznańskiej , Poznań 2008;
7. Barltrop J. A., Coyle J. D., Fotochemia - podstawy, PWN, Warszawa, 1987.
8. R.W. Kelsall, I.W. Hamley, M. Geoghegan, Nanotechnologie, PWN, Warszawa, 2008.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	62	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	63	2,50