COURSE DESCRIPTION CARD - SYLLABUS

Course name

Foundations of nanotechnology

Course

Field of study
Technical Physics

Area of study (specialization)

Level of study
First-cycle studies

Form of study
full-time

Year/Semester
3/6

Profile of study
general academic

Course offered in
Polish

Requirements
compulsory

Number of hours

Lecture
60

Laboratory classes
45

Other (e.g. online)

Tutorials

Projects/seminars
30

Number of credit points

12

Lecturers

Responsible for the course/lecturer:

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Faculty of Materials Engineering and Technical Physics

Piotrowo street 3, 60-965 Poznan, Poland

Responsible for the course/lecturer:

Prerequisites

General knowledge of physics, mathematics and the basics of programming at the level achieved after five semestrs of study in the field of technical physics. The ability to solve simple physical problems based on the acquired knowledge, the ability to obtain information from indicated sources. Understanding the necessity of self-training.

Course objective

1. To acquaint students with the characterization methods of functional materials, technology of their productuion and applications.

2. To provide students with basic knowledge on the use of laser techniques in various scientific industrial, metrological, military and medical disciplines. Developing the ability to design laser systems with given parameters.

3. To acquaint students with computational techniques used to simulate physical phenomena with the use of Java or Python programming languages.

Course-related learning outcomes

Knowledge

1. The student has knowledge of the structure and properties of functional materials and the latest development trends in the field of optoelectronics, molecular electronics and nanotechnology [K1_W12, K1_W13].

2. The student knows the basic methods of shaping the characteristics of laser radiation [K1_W10].

3. The student knows the current state of technological advancement and is aware of the latest development trends in the field of laser technology applications in various fields of science and economy [K1_W13].

4. The student knows the mathematical apparatus necessary to describe the basic laws of physics and solve tasks related to the issues of technical physics, has an ordered and theoretically founded general knowledge of the structure and functions of nano- and microworld objects, knows the current state of advancement and is familiar with the latest development trends in the field of computer simulation of physical processes [K1_W01, K1_W11, K1_W13].

Skills

The student is able to:

1. apply the appropriate mathematical apparatus and perform computer simulations of basic physical phenomena and technical processes with the use of standard software [K1_U01, K1_09, K1_U14, K1_U19].

2. plan, carry out standard measurements, analyze and document the results of research on classical and quantum physical phenomena, in the macro, micro and nano scale; is able to identify and assess the importance of basic factors disturbing the measurement [K1_U17].

3. select materials with appropriate physicochemical and design properties for laboratory and engineering applications [K1_U18].

4. configure basic measuring systems in the field of optics and optoelectronics [K1_U20].

5. define the problem related to the application of laser techniques and propose a solution [K1_U14].

Social competences

The student acquires competences allowing for:

1. independent and creative work on the given task [K1_K01, K1_K08];

2. understanding the needs and possibilities of continuous training [K1_K03].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcome (symbol)	Method of assessment	Assessment criteria	
Lecture:			
W01, W10-W13, K01, K03, K08	open question/test	3:	50.1%–70.0%
		4:	70.1%–90.0%
		5:	from 90.1%
Project:			
U01, U09, U14, U17-U20	project tasks	3:	50.1%–70.0%
		4:	70.1%–90.0%
		5:	from 90.1%
assessment of transitional work	– carried out by the promoter		
Laboratory:			
assessment of activity in a specialized laboratory	– carried out by the promoter		

Programme content

Field of "modeling"

1. Elements of statistical physics.

2. Fundamentals of dynamics of nonlinear systems.

3. Molecular dynamics simulation methods:

a) motion equation integration algorithms,

b) periodic boundary conditions,

c) equilibrium and non-equilibrium molecular dynamics,

d) selected stochastic methods (Monte Carlo algorithm, Brown dynamics, Langevin dynamics),

4. Fundamentals of programming and creating computer simulations in Java and / or Python.

5. Fundamentals of data analysis and visualization using Java and / or Python.

Field of "laser techniques"

1. Methods of shaping the spatial, temporal and spectral characteristics of light generated by the laser

2. Methods of stabilizing lasers, Measurement of the generation wavelength, generation of attosecond pulses.

3. Mechanisms of interaction of laser radiation with living tissue, review of lasers used in medicine and their basic properties, lasers in ophthalmology, laser lancet surgical, laparoscopy, lasers in oncology, photodynamic laser therapy, selective destruction tumor tissue

4. Laser analysis of environmental pollution, lidars

5. Laser spectroscopy of atoms, ions and molecules in scientific research, spectroscopy systems linear and nonlinear. Laser cooling, ion and atomic traps, quantum metrology

6. Laser cutting of materials and welding, types of lasers used, required parameters beams, power density calculation, laser engraving and drilling, microtechnology.

7. Information recording and reading by laser, CD recorders and players, printers laser, holography, methods of recording and reading a holographic image, types of holograms.

8. Laser distance meters. Distortion measurements, laser interferometry, anemometry, gyroscope fiber optic

9. Military applications of lasers, laser sights, chemical lasers, images created with laser beams, multimedia shows

Field of "nanotechnology and functional materials"

1. Methods of production and characterization of monolayers at the interface, swirled and cast layers with the use of functional materials.

2. The use of ultrasonic waves for material analysis and in medical applications.

3. Zastosowanie metod termowizyjnych w badaniach materiałów.

4. Modern spectroscopic methods and techniques used for the characterization and research of physical processes occurring in crystalline, layered, carbon and organic materials.

5. Construction and operation of optical fibers and photonic crystals. Properties of nonlinear materials and up-conversion processes.

6. Scanning probe microscopy: fundamentals of operation and working modes of AFM and STM microscopes and their design variants.

Teaching methods

Conversational lecture: multimedia presentation, simulation demonstrations, examples given on the blackboard, solving research problems.

Laboratory exercises: performing specialized experiments, discussion, individual work.

Project: individual student's project work, discussion.

Bibliography

Basic

1. Materials from lectures (in Polish)

2. Podstawy fizyki statystycznej, Kerson Huang,Wydawnictwo Naukowe PWN, Warszawa 2006.

3. Understanding Molecular Simulation. From Algorithms to Applications, D. Frenkel, B. Smit, Academic Press.

4. E. Dutkiewicz, Fizykochemia powierzchni, WNT, Warszawa, 1998.

5. A. Ulman, An introduction to ultrathin organic films, Academic Press, Boston 1991.

6. A. Śliwiński „Ultradźwięki i ich zastosowania”, WNT, Warszawa 2001.

7. B. Więcek, G. De Mey „Termowizja w podczerwieni, podstawy i zastosowania”, Wydawnictwo PAK, Warszawa 2011.

8. B. H. Stuart, Infrared Spectroscopy: Fundamentals and Applications, John Wiley & Sons, Ltd, 2004.

9. G. Turrell, J. Corset, Raman microscopy – Developments and Applications, Elsevier, 1996.

10. E. Meyer, H.J. Hug,R. Bennewitz, Scanning Probe Microscopy – The Lab on a Tip, Springer-Verlag, Berlin, 2003.

11. Roland Wiesendanger, Scanning Probe Microscopy and Spectroscopy: Methods and Applications, Cambridge University Press (2010).

12. Michael P. Allen and Dominic J. Tildesley, Computer Simulation of Liquids, second edition, Oxford University Press, 2017.

13. R. Jóźwicki„Technika laserowa i jej zastosowanie", Oficyna Wydawnicza P.W., Warszawa 2009.

14. A. Dubik „Zastosowanie laserów", WNT, Warszawa 1992.

15. P. Fiedor, „Zarys klinicznych zastosowań laserów" Dom wydawniczy Ankar, Warszawa 1995.

16. T. Kęcik„Lasery w okulistyce", PZWL, Warszawa 1984.

17. W. Demtroder„Spektroskopia laserowa", PWN, Warszawa 1992.

Additional

1. Molecular Modeling Techniques in Material Sciences, J.-R. Hill, L. Subramanian, A. Maiti, Taylor&Francis 2005.

2. Molecular Modeling and Simulation. An Interdisciplinary Guide, T. Schlick, 2nd edition, Springer 2010.

3. http://www.molnet.eu (po polsku).

4. K. Olszewska, I. Jastrzębska, A. Łapiński, M. Górecki, R. Santillan, N. Farfan, T. Runka, Steroidal Molecular Rotors with 1,4-Diethynylphenylene Rotators: Experimental and Theoretical Investigations Toward Seeking Efficient Properties, The Journal of Physical Chemistry B 124 (2020) 9625-9635.

5. D. Kasprowicz, M. G. Brik, A. Majchrowski, E. Michalski, P. Głuchowski, Spectroscopic properties of KGd(WO4)2 single crystals doped with Er3+, Ho3+, Tm3+ and Yb3+ ions: Luminescence and micro-Raman investigations, J. Alloys Comp., 577 (2013) 687 – 692.

6. K. Jaroszewski, P. Gluchowski, M. G. Brik, T. Pedzinski, A. Majchrowski, M. Chrunik, E. Michalski, D. Kasprowicz, Bifunctional Bi2ZnOB2O6:Nd3+ single crystal for near infrared lasers: luminescencje and μ-Raman investigations, Cryst. Growth Des., 17 (2017) 3656−3664.

7. Skrypt pt. „Mikroskopia elektronowa" pod red. A. Barbackiego, rozdz. 9, R. Czajka. „Mikroskopia sond skanujących", Wydawnictwo Politechniki Poznańskiej, Wydanie III, 2007.

8. R. Jóźwicki„Podstawy inżynierii fotonicznej" WNT, Warszawa 2008.

9. B. Ziętek, „Lasery", Wydawnictwo Uniwersytetu Mikołaja Kopernika, Toruń 2008.

10. W. W. Duley„Laser Processing and Analysis of Materials", Plenum Press New York and London 1983.

11. Daniel Shiffman, „The nature of Code", 2012.

Breakdown of average student's workload

	Hours	ECTS
Total workload	250	12,0
Classes requiring direct contact with the teacher	141	7,0
Student's own work (literature studies, preparation for laboratory classes, preparation for exam, report preparation) [1]	109	5,0

[1] delete or add other activities as appropriate