SYLLABUS

regarding the qualification cycle FROM 2023/2024–2026/2027

Academic year: 2023/24

1. Basic Course/Module Information

Course/Module title	**Nanotechnology and nanomaterials**
Course/Module code *	
Faculty (name of the unit offering the field of study)	College of Natural Sciences
Name of the unit running the course	College of Natural Sciences
Field of study	Optometry
Qualification level	First degree, bachelor
Profile	General academic
Study mode	Part-time
Year and semester of studies	1-st year, 2-nd semester
Course type	Directional course
Language of instruction	English
Coordinator	**dr hab. Małgorzata Sznajder, prof. UR**
Course instructor	dr hab. Małgorzata Sznajder, prof. UR

* – as agreed at the faculty

1.1. Learning format – number of hours and ECTS credits

Semester (no.)	Lectures	Classes	Colloquia	Lab classes	Seminars	Practical classes	Internships	others	**ECTS credits**
2	18								2

1.2. Course delivery methods

– <u>conducted in a traditional way</u>
– involving distance education methods and techniques

1.3. Course/Module assessment (exam, pass with a grade, pass without a grade)

PASS WITHOUT A GRADE

2. Prerequisites

The student has knowledge about fundamentals of physics, biophysics and chemistry in the scope described in the syllabuses of the basic module of the first-degree study. Student is able to search and analyse professional literature, discusses topics related to the selected specialization, expresses his own opinions, and works independently.

3. Objectives, Learning Outcomes, Course Content, and Instructional Methods

3.1. Course/Module objectives

O1	To acquaint students with the basic systems of reduced dimensionality.
O2	Learning about selected "top-down" and "bottom-up" techniques for the production of nano-scale systems.
O3	Familiarization with selected physical properties of nanotubes, nanoparticles and quantum dots.
O4	Learning about the ways of functionalization of nano-dimensional objects.
O5	Learning about the applications of nano-objects in imaging, diagnostics and detection of substances.
O6	Preparing the student for scientific research in the field of selected issues in nanotechnology

3.2. Course/Module Learning Outcomes (to be completed by the coordinator)

Learning Outcome	The description of the learning outcome defined for the course/module	Relation to the degree programme outcomes
LO_01	The student knows and understands the phenomenon of self-organisation based upon the growth of nanowires and nanoparticles. he understands the source of new properties of a nano-size system, knows and understands the top-down and bottom-up processes, knows the basic properties of selected nano-objects. The student also knows the methodology of scientific research in the field of selected issues of nanotechnology.	K_W02
LO_02	The student knows and understands ways of functionalisation of nanowires, nanotubes and nanoparticles leading to changes in their solubility, achieving the intended electrical conductivity, as well as physical and chemical properties.	K_W02
LO_03	The student knows and understands the economic conditions related to professional activity and the basic terms and principles of copyright.	K_W07
LO_04	The student can analyse and solve the problem concerning the relationship between the length of light wave emitted and the size of nano-object based on the model of a three-dimensional quantum well.	K_U01
LO_05	The student is able to prepare a written paper in Polish or English on nanotechnology issues, using up-to-date literature sources.	K_U08
LO_06	The student is ready to fulfil the social obligations related to the gained knowledge and skills in the field of nanomaterials, as well as to take actions of popularisation of the knowledge from studies.	K_K03

3.3. Course content (to be completed by the coordinator)

A. Lectures

Content outline
1. Nanotechnology as an interdisciplinary field of science, its place and role in modern science. R. Feynmann's concept of miniaturization. Classification of nanomaterials, properties, examples of systems with reduced dimensions: 2D, 1D, 0D. 2. Review of selected methods for fabrication of nanostructures, "top-down" techniques: photolithography, electron beam lithography, high-energy ball milling. Bottom-up techniques: physical deposition methods (MBE, PLD, sputtering) and chemical deposition methods (CVD, MOCVD). Epitaxial layers and their applications. Graphene as an example of a novel two-dimensional material. OMBD method. Monomolecular layers. Lipophilization and surface functionalization. Self-organization. The Langmuir-Blodgett technique for biological layers, examples of the LB layer in living organisms. Precipitation methods (sol-gel), electrochemical methods, reduction in solution, hydrothermal method. Exemplary applications of epitaxial layers (stents, orthopaedic implants, drains, contact lenses). 3. Carbon-based nanomaterials (graphene, fullerenes, nanotubes SW-CNT and MW-CNT, nanospheres and nanodots), defective CNTs, doped CNTs, functionalization. Functionalized carbon nanotubes as drug carriers. Graphene nanoribbons. Graphene nanoribbons with point defects. Chemical and biochemical sensors based on CNTs. Bioimaging applications. 4. Nanodiamonds (NDs) in nanomedicine. Basic synthesis methods (Dynamic synthesis using detonation techniques; High pressure and high temperature (HPHT); Ball milling of HPHT diamond microcrystals; Laser ablation; Chemical vapor deposition). Chemical, physical and mechanical properties of NDs. Role of NV centers. The recent progress of NDs in nanomedical applications, including tribology, lubrication, energy storage, catalysis, bioimaging, drug delivery, thermotherapy and biosensing. An outlook towards the future developments and applications of NDs. 5. Metal nanoparticles (Ag, Au, Cu, Pt). Synthesis of silver nanoparticles (chemical reduction, microemulsion method, reduction: photochemical, ultrasound and gamma radiation). Mechanism of bactericidal action of nanoparticles. The use of silver and gold nanoparticles in medical procedures (the use of hyperthermia, antibacterial activity and fungicidal properties of nanoparticles). Nanoparticles as carriers of RNA, DNA, drugs; nanoparticles in medical diagnostics, in infrared and Raman imaging, for enhancement of contrast medium in computed tomography – examples. Semiconductor nanoparticles TiO_2, SiO_2, ZrO (synthesis in the chlorine, sulfate and Becher processes). Photocatalytic and bactericidal properties of semiconductor nanoparticles, UV radiation blocking – applications. Magnetic iron nanoparticles (Fe_2O_3, γ-Fe_2O_3) – biomedical applications. Organic nanoparticles (polymers, liposomes, dendrimers) as drug carriers. 6. Quantum dots. Stranskii-Krastanov and Volmer-Weber growth modes. Colloidal quantum dots. The use of quantum dots in light-emitting elements. Functionalized quantum dots (CdSe, ZnS) in medicine and biology – diagnostics, marking, imaging and treatment. 7. Flexible electronics. High-frequency electronics. Optoelectronics, photonics, plasmonics. Opacity of grapheme and fine structure constant. Harnessing grapheme with light: a new dimension of possibilities. Digital logic gates. Digital non-volatile graphene memories. Graphene nanoresonators.

3.4. Methods of Instruction

A lecture supported by a multimedia presentation.

4. Assessment techniques and criteria

4.1. Methods of evaluating learning outcomes

Learning outcome	Methods of assessment of learning outcomes (e.g. test, oral exam, written exam, project, report, observation during classes)	Learning format (lectures, classes,...)
LO–01	observation during classes, discussion, a written report	I
LO–02	observation during classes, discussion, a written report	I
LO–03	observation during classes, discussion, a written report	I
LO–04	observation during classes, discussion, a written report	I
LO–05	observation during classes, discussion, a written report	I
LO–06	observation during classes, discussion.	I

4.2. Course assessment criteria

Pass without grade. The condition for obtaining a credit is attendance at lectures and presentation of a written report on a topic related to the discussed issues.

5. Total student workload needed to achieve the intended learning outcomes – number of hours and ECTS credits

Activity	Number of hours
Scheduled course contact hours	18
Other contact hours involving the teacher (consultation hours)	2
Non-contact hours – student's own work (preparation for classes, project)	30
Total number of hours	50
Total number of ECTS credits	**2**

* One ECTS point corresponds to 25–30 hours of total student workload

6. Internships related to the course/module

Number of hours	–
Internship regulations and procedures	–

7. Instructional materials

Compulsory literature:

1. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley, Mark Geoghegan, John Wiley & Sons Ltd., 2005
2. Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, Stephane Evoy, James R. Heflin Jr. Kluver Academic Publishers, Boston, 2004
3. Nanotechnology: Principles and Practices, Kulkarni, Sulabha K., Springer Verlag 2015, ISBN 978-3-319-09171-6.
4. Buzea, C.; Pacheco, I. I.; Robbie, K. (2007). "Nanomaterials and nanoparticles: Sources and toxicity". Biointerphases. 2 (4): MR17–MR71. arXiv:0801.3280. doi:10.1116/1.2815690

Complementary literature:

1. Advanced Micro & Nanosystems, Volume 8: Carbon Nanotube Devices, ed. C. Hierold, Wiley, 2008
2. NANOTECHNOLOGY IN BIOLOGY AND MEDICINE, Methods, Devices, and Applications, ed. Tuan Vo-Dinh, Taylor & Francis Group 2007
3. Quantum Dots, Applications in Biology, ed. M.P. Bruchez, Ch. Z. Hotz, Humana Press Inc. 2007
4. W. Hallstrom et al., Nano Lett., 2010, 10 (3), pp 782–787
5. F. Patolsky and Ch. M. Lieber, Materials Today, Volume 8, Issue 5, May 2005, Pages 20–28
6. S. Iijima, Nature 354, 56 (1991)
7. Angewandte Chemie, Volume44, Issue39, October 7, 2005, Pages 6358–6362
8. Chemical Physics Letters 478 (2009) 200–205
9. Angew. Chem. Int. Ed. 2004, 43, 2113 –2117
10. Nanotoday, 34 JUNE 2007 | VOLUME 2 | NUMBER 3, 34–43
11. Chem. Soc. Rev., 2012, 41, 4306–4334
12. M.L. Curri et al. / Materials Science and Engineering C 23 (2003) 285–289
13. Journal of Nanomaterials, vol. 2012, article ID: 964381, 36 pages
14. Biological Trace Element Research (2020) 193: 118–129
15. Jin-Xu Qin et al., Materials & Design 210 (2021) 110091
16. Swati Chauhan et al., Journal of Pharmaceutical Analysis 10 (2020) 1-12
17. Weina Liu et al., Nano Lett. 2022, 22, 2881−2888
18. V. Benson et al. Cancer Drug Resist 2020;3:854-66
19. C. Fryer et al, Nanomaterials 2022, 12, 4196.

Approved by the Head of the Department or an authorised person