Study Programme: Physics

Course Unit Title: Nanomaterials and Nanotechnology

Course Unit Code: FD24NN

Name of Lecturer(s): Dr. Tamara Ivetić

Type and Level of Studies: Doctoral Academic Studies Physics

Course Status (compulsory/elective): Elective

Semester (winter/summer): Summer

Language of instruction: English

Mode of course unit delivery (face-to-face/distance learning): Face-to-face

Number of ECTS Allocated: 15

Prerequisites: None

Course Aims:

This course aims to teach students the properties, classifications, synthesis and applications of nanomaterials.

Learning Outcomes:

Students should develop:

- General abilities: Students will learn about the properties, synthesis technology, and application of nanomaterials.
- Course-specific abilities: Students will be able to design and conduct experiments of synthesis and characterization of nanomaterials.

Syllabus:

Theory

Introduction of basic properties and classification of nanomaterials. Nanotechnology timeline. Physical chemistry of solid surfaces. The surface of nanomaterials, surface to volume ratio – size and shape effect. Surface energy. Mechanisms to reduce the surface energy of nanomaterials. Chemical potential as a function of surface curvature. Ostwald ripening. Electrostatic and steric stabilization of nanoparticles.

Physical properties of nanomaterials: melting points and lattice constants, mechanical properties, optical properties (surface plasmon resonance, quantum size effects), electrical conductivity, ferroelectric and dielectric characteristics, superparamagnetism.

Synthesis methods for fabrication of nanomaterials. Homogeneous nucleation and subsequent particle growth. Synthesis of metallic nanoparticles (colloidal gold, silver, copper, iron) and influences of reduction reagents, polymer stabilizer, and other factors. Synthesis of semiconductor nanoparticles (pyrolysis, selective precipitation, thermal decomposition, solution synthesis). Synthesis of oxide nanoparticles (sol-gel, precipitation, hydrolysis, forced hydrolysis, controlled release of ions, vapor phase reactions, solid-state phase segregation). Synthesis of ZnO, Al_2O_3, TiO_2, Fe-oxide nanoparticles. Synthesis of nanoparticles according to the principles of green chemistry.

Heterogeneous nucleation. Kinetically confined synthesis of nanoparticles (synthesis inside micelles or using microemulsions, reverse micelle method, aerosol synthesis, growth termination, spray pyrolysis, template-based synthesis). Synthesis of ZnS nanoparticles. Synthesis of epitaxial core-shell nanoparticles.

Modern methods of nanomaterials characterization. Special nanomaterials, carbon fullerenes and nanotubes, zeolites, core-shell structures, organic-inorganic hybrids, metal-organic frameworks, nanomaterials for photocatalysis, and nanocomposites.

Application of nanomaterials in medicine, electronics, biology, environmental protection, photoelectrochemical cells, and forensics.

Practice

Experimental research work, preparation, and presentation of a seminar paper.

Required Reading:

1. G. Cao, Nanostructures and nanomaterials, Synthesis, properties, and applications, Imperial College Press, London, 2004.
2. Gerrard Eddy Jai Poinern, A laboratory course in nanoscience and nanotechnology, CRC Press, Taylor & Francis Group, New York, 2015.
3. D. Vollath, Nanomaterials, An introduction to synthesis, properties, and applications, Second edition, Wiley-VCH, Weinheim, Germany, 2013.
4. Springer Handbook of nanomaterials, Robert Vajtai (Ed.), Springer, London New York, 2013.
5. The science of nanomaterials, Basics and applications, S.C. Ameta and R. Ameta (Eds.), Apple Academic and CRC Press Inc. Florida, USA, 2023.
6. V. Pokropivny, R. Lohmus, I. Hussainova, A. Pokropivny, S. Vlassov, Introduction to nanomaterials and nanotechnology, Tartu University Press, Tartu, 2007.
7. S. Lukić-Petrović, S. Carić, G. Štrbac, F. Skuban, I. Gut, T. Ivetić, D. Petrović, Eksperimentalne tehnike za dobijanje i karakterizaciju materijala, Univerzitet u Novom Sadu, Prirodno-matematički fakultet, Departman za fiziku, Novi Sad, 2018.
8. Handbook of innovative nanomaterials, From syntheses to application, X. Fang and L. Wu (Eds.), CRC Press Taylor & Francis Group, Florida, USA, 2013.

Weekly Contact Hours:	**Lectures:** 5	**Practical work:** 5

Teaching Methods: Lectures and laboratory exercises.

Knowledge Assessment (maximum of 100 points):

Pre-exam obligations	points	**Final exam**	points
Active class participation	5	written exam	
Practical work	10	oral exam	70
Preliminary exam(s)			
Seminar(s)	15		