

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Spektroskopija in mikroskopija
Course title:	Spectroscopy and Microscopy

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 2. stopnja	/	1	2
Nanosciences and Nanotechnologies, 2 nd cycle	/	1	2

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: NANO2-269

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Druge oblike Other	Samost. delo Individ. work	ECTS
30	30		30	210	10

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transferred to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Miran Čeh
Prof. dr. Vid Bobnar
Prof. dr. Sašo Šturm
Prof. dr. Goran Dražič

Jeziki / Languages: Predavanja / Lectures: slovenski, angleški
Slovenian, English

Vaje / Tutorial:

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Zaključen študij prve stopnje s področja naravoslovja ali tehnike ali zaključen študij prve stopnje na drugih področjih z znanjem osnov s področja predmeta.

Prerequisites:

Completed first cycle studies in natural sciences or engineering or completed first cycle studies in other fields with knowledge of fundamentals in the field of this course.

Vsebina:

Uvod: Elektronska struktura, Magnetne lastnosti, Simetrije v trdni snovi, Interakcija svetloba-snov, Interakcija elektroni-snov, Osnove elektronske optike, Nastanek slike v SEM in TEM.

Spektroskopske tehnike: Infrardeča spektroskopija, Meritve reflektivnosti, Infrardeča spektroskopija fononov, Fourier Transform spektroskopija, Elipsometrija, Ramanovo in Reyleighovo sipanje, Ultrahitre časovno-ločljive tehnike, Jedrska magnetna resonanca, Elektronska spinska resonanca, Mionska spinska rotacija, Neutronsko sipanje (elastično in neelastično).

Content (Syllabus outline):

Introduction: Electronic structure, Magnetic properties, Symmetry in solids, Light-matter interaction, Electron-matter interaction, Electron optics, Image formation in SEM and in TEM.

Spectroscopic techniques: Spectroscopy in the Infrared, Reflectivity measurements, Infrared Spectroscopy of Phonons, Fourier Transform Spectroscopy, Ellipsometry, Raman and Reyleigh Scattering, Ultrafast real-time techniques, Nuclear Magnetic Resonance, Electron Spin Resonance, Muon-Spin-Rotation, Neutron Scattering (elastic and inelastic).

Mikroskopske tehnike: Vrstična elektronska mikroskopija (SEM), Presevna elektronska mikroskopija (TEM, CTEM, HRTEM), Elektronska difrakcija (SAD, mikrodifrakcija), Vrstična presečna elektronska mikroskopija (STEM, HAADF-STEM), Energijsko-disperzijska spektroskopija rentgenskih žarkov (EDXS), Tipalna mikroskopija (SPM), Vrstična tunelska mikroskopija (STM) in mikroskopija na atomsko silo (AFM).

Microscopic techniques: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM, CTEM, HRTEM), Electron diffraction (SAD, micro-diffraction), Scanning transmission electron microscopy (STEM, HAADF-STEM), energy-dispersive X-ray spectroscopy (EDX), Scanning probe microscopy (SPM), Scanning tunnelling microscopy (STM), atomic force microscopy (AFM).

Temeljni literatura in viri / Readings:

1. Spektroskopija:

Charles Kittel, "Introduction to Solid State Physics".

H. Kuzmanny, "Solid-State Spectroscopy: An Introduction".

G. Grüner and M. Dressel, "Electrodynamics of Solids: Optical Properties of Electrons in Matter".

Donald A. McQuarrie and John D. Simon, "Physical Chemistry – A molecular approach".

Amon Yariv, "Optical Electronics in Modern Communications".

David Jiles, "Magnetism and Magnetic Materials", W. Demtröder, Laser spectroscopy, 2nd. Ed.

2. Mikroskopija:

J. I. Goldstein et al., Scanning Electron Microscopy and X-ray Microanalysis, Plenum Press, 1992.

D. B. Williams, C. B. Carter, Transmission Electron Microscopy, Plenum Press, 1996.

Cilji in kompetence:

Cilj predmeta je spoznavanje aktualnih problemov in najnovejših dosežkov na področju spektroskopije in mikroskopije.

Objectives and competences:

The goal of this course is to give an overview of the major directions of research and the latest achievements in the field of nanomaterial synthesis via interaction with high-level researchers from this field.

Predvideni študijski rezultati:

Študentje bodo dobili pregled o spektroskopskih in mikroskopskih tehnikah za študij elektronskih in magnetnih lastnosti trdnih snovi ter za študij strukture in kemijske sestave materialov na mikro-, nano- in atomarnem nivoju. Seznanili se bodo s širokim spektrom eksperimentalnih tehnik, ki so dostopne na Institutu "Jožef Stefan".

Intended learning outcomes:

Students will gain an overview of spectroscopic and microscopic techniques for studying electronic and magnetic properties of solid state systems and to characterize structure and chemical composition of solid materials on micro-, nano- and atomic scale. They will get acquainted with a broad range of experimental techniques that are available at the Jožef Stefan Institute.

Metode poučevanja in učenja:

Interaktivna predavanja
Naloge
Konzultacije
Individualno voden študij

Learning and teaching methods:

Interactive lectures
Coursework
Consultations
Individual guided studies

Načini ocenjevanja:

Naloge
Ustni izpit

Delež (v %) /

Weight (in %)

Assessment:

Coursework
Oral examination

Reference nosilca / Lecturer's references:

- L. Suhadolnik, M. Krivec, K. Žagar, G. Dražić, M. Čeh. A TiO₂-nanotubes-based coil-type microreactor for highly efficient photoelectrocatalytic degradation of organic compounds. *Journal of industrial and engineering chemistry*, ISSN 1226-086X, 2017, vol. 47, str. 384-390.
- L. Suhadolnik, A. Pohar, B. Likozar, M. Čeh, Mechanism and kinetics of phenol photocatalytic, electrocatalytic and photoelectrocatalytic degradation in a TiO₂-nanotube fixed-bed microreactor. *The chemical engineering journal*, ISSN 1385-8947. [Print ed.], 2016, vol. 303, str. 292-301.
- L. Fulanović, J. Koruza, N. Novak, F. Weyland, M. Barbara, V. Bobnar, Fatigue-less electrocaloric effect in relaxor Pb(Mg_{1/3}Nb_{2/3}O₃)_{1-x}Pb(Mg_{1/3}Nb_{2/3}O₃)_x, *Journal of the European ceramic society*, 2017, vol. 37, no. 15, 5105-5108.
- L. Kelhar, J. Bezjak, M. Maček, J. Zavašnik, S. Šturm, P. Koželj, S. Kobe, J.M. Dubois, The role of Fe and Cu additions on the structural, thermal and magnetic properties of amorphous Al-Ce-Fe-Cu alloys, *Journal of non-crystalline solids*, 2017, 9.
- S. Tominc, A. Rečnik, Z. Samardžija, G. Dražić, M. Podlogar, S. Bernik, N. Daneu, Twinning and charge compensation in Nb₂O₅-doped SnO₂-CoO ceramics exhibiting promising varistor characteristics, *Ceramics international*, 2018, vol. 44, no. 2, 1603-1613.