Univerza v Novi Gorici
Fakulteta za naravoslovje

University of Nova Gorica
School of Sciences

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Elektronske mikroskopije
Course title:	Electron Microscopies

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Znanost o materialih (2. Stopnja)	**/**	**1**	**2**
Materials science (2nd level)	**/**	**1**	**2**

Vrsta predmeta / Course type	obvezni / mandatory
Univerzitetna koda predmeta / University course code:	

Predavanja **Lectures**	**Seminar** **Seminar**	**Sem. vaje** **Tutorial**	**Lab. vaje** **Laboratory work**	**Teren. vaje** **Field work**	**Samost. delo** **Individ. work**	**ECTS**
25	**/**	**15**	**10**	**/**	**120**	**6**

Nosilec predmeta / Lecturer:	Prof. dr. Mattia Fanetti

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina / English
	Vaje / Tutorial:	slovenščina / English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
/	/

Vsebina:	**Content (Syllabus outline):**
Predmet obravnava elektronsko mikroskopijo in druge mikroskopske tehnike, ki se trenutno uporabljajo pri preučevanju materialov. Predmet vključuje naslednje teme: Splošne značilnosti mikroskopskih tehnik: • Kaj je slika • Različni pristopi k mikroskopiji • Osnovni koncepti in fizikalne količine (leča, povečava, goriščna razdalja, ločljivost…) Elektronska mikroskopija • Splošne značilnosti (izvori elektronov, elektro-magnetne leče, meja resolucije) • Elektronski žarek – interakcija z vzorcem • Vrstična elektronska mikroskopija (SEM)	The course discusses electron microscopy and other microscopy techniques currently used in the study of materials. The course includes the topics of: General features of microscopy techniques • What is a map • Different approaches to microscopy • Basic concepts and physical quantities (lens, magnification, focal length, resolution …) Electron microscopy • General features (electron emitters, electro-magnetic lenses, resolution limit) • Electron beam – specimen interaction • Scanning electron microscopy (SEM)

- Transmisijska elektronska mikroskopija (TEM)
- Elektronska difrakcija v elektronski mikroskopiji
- Lokalna spektroskopija za mikroanalizo (EDX, EELS, SAM, CL)
- Litografija z elektronskim žarkom (EBL) in druge »beam-induced« tehnike
- Tehnike priprave vzorca

Vrstična sondna mikroskopija (SPM)

- Splošne značilnosti SPM (sonde, kontrola položaja, povratna vezja ...)
- Mikroskopija na atomsko silo (AFM)
- Tunelska mikroskopija (STM)
- Kratek povzetek pomožnih tehnik (npr. vrstična tunelska spektroskopija, mikroskopija na magnetno silo, Kelvinova sondo)

Kratka predstavitev drugih mikroskopskih tehnik, kot so:

- Vrstična fotoemisijska elektronska mikroskopija (SPEM)
- Fotoemisijska elektronska mikroskopija (PEEM)
- Nizko energijska elektronska mikroskopija (LEEM)

- Transmission electron microscopy (TEM)
- Electron diffraction in electron microscopy
- Local spectroscopy for microanalysis (EDX, EELS, SAM, CL)
- Electron-beam lithography (EBL) and other beam-induced techniques
- Specimen preparation techniques

Scanning Probe Microscopy (SPM)

- General features about SPM (the probes, the position control, the feed-back circuit)
- Atomic Force Microscopy (AFM)
- Scanning Tunneling Microscopy (STM)
- Brief exposition of ancillary techniques (e.g. scanning tunneling spectroscopy, magnetic force microscopy, Kelvin-probe)

Brief exposition of other microscopy techniques, such as:

- Scanning Photoemitted Electron Microscopy (SPEM)
- Photoemission electron microscopy (PEEM)
- Low Energy Electron Microscopy (LEEM)

Temeljna literatura in viri / Readings:

- Joseph I. Goldstein et al., Scanning Electron Microscopy and X-ray Microanalysis, Springer, 2003
- P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, Taylor & Francis, 2001
- D.B. Williams, C.B. Carter, Transmission Electron Microscopy. A textbook for materials science, Springer, 2009
- C. Julian Chen, Introduction to Scanning Tunneling Microscopy, Oxford University Press (New York) 1993 (or its second edition)
- Supporting material from the web will be also indicated

Cilji in kompetence:

Cilj predmeta je podati študentom poglobljeno znanje o najpomembnejših mikroskopskih tehnikah, ki so ključnega pomena za karakterizacijo materialov.
Cilj je tudi poskus dela z nekaterimi od teh tehnologij in priprava vzorca.

Objectives and competences:

The objective is to give the students a detailed knowledge of the most important microscopy techniques, which are fundamental in the characterization of materials. A hand-on experience on some of these techniques and on specimen preparation is also a goal.

Predvideni študijski rezultati:

Študenti se naučijo splošnega pomena opravljanja mikroskopije in se seznanijo s podrobnostmi glavnih tehnik (elektronsko mikroskopijo in vrstična sondna mikroskopijo), tako z teoretičnega kot tudi z eksperimentalnega vidika.
Prav tako se študenti seznanijo s pomožnimi tehnikami karakterizacije kot so elementna mikroanaliza (EDX), lokalna spektroskopija (SAM, ELES, SPEM) in elektronska difrakcija.
Študenti bodo izvedli poskus/vaje na SEM/EDX, TEM in se srečali s tehnikami za pripravo vzorcev.

Intended learning outcomes:

Students learn the general meaning of performing microscopy, and are brought into details of the main techniques (electron microscopy and scanning probe microscopy), both from theoretical and experimental points of view.
They are also introduced to ancillary characterization techniques, such as elemental microanalysis (EDX), local spectroscopy (SAM, EELS, CL, SPEM) and electron diffraction.
A hand-on experience/tutorial on SEM/EDX, TEM and specimen preparation techniques will also be provided.

Metode poučevanja in učenja:

- Predavanja
- Vaje na elektronskih mikroskopih in priprava vzorcev

Learning and teaching methods:

- Lectures
- Tutorial and hand-on activity on electron microscopes and sample preparation

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
• Ustni izpit	50	• Oral exam
• Predstavitev seminarja	50	• Seminar presentation

Reference nosilca / Lecturer's references:

Prof. Dr. Mattia Fanetti:

Izredni profesor za področje fizike na Univerzi v Novi Gorici

Associate Professor of Physics at University of Nova Gorica

11. MAVER, Ksenija, ARČON, Iztok, FANETTI, Mattia, EMIN, Saim, VALANT, Matjaž, LAVRENČIČ ŠTANGAR, Urška. Improved photocatalytic activity of anatase-rutile nanocomposites induced by low-temperature sol-gel Sn-modification of TiO_2. *Catalysis today*. [Print ed.]. 2020, str. 1-6, ilustr. ISSN 0920-5861. https://doi.org/10.1016/j.cattod.2020.01.045, DOI: 10.1016/j.cattod.2020.01.045. [COBISS.SI-ID 5565179]

12. FERFOLJA, Katja, FANETTI, Mattia, GARDONIO, Sandra, PANIGHEL, Mirco, PIŠ, Igor, NAPPINI, Silvia, VALANT, Matjaž. A cryogenic solid-state reaction at the interface between Ti and the Bi_2Se_3 topological insulator. *Journal of materials chemistry. C, Materials for optical and electronic devices*. [Print ed.]. 2020, vol. 8, no. 33, str. 11492-11498, ilustr. ISSN 2050-7526. DOI: 10.1039/d0tc00863j. [COBISS.SI-ID 23224835]

13. KHABBAZ ABKENAR, Sirous, KOCJAN, Andraž, SAMARDŽIJA, Zoran, FANETTI, Mattia, COŞGUN ERGENE, Arzu, ŠTURM, Sašo, SEZEN, Meltem, OW-YANG, Cleva. Effect of sintering and boron content on rare earth dopant distribution in long afterglow strontium aluminate. *Journal of the European ceramic society*. [Print ed.]. 2020, vol. 40, no. 12, str. 4129-4139. ISSN 0955-2219. DOI: 10.1016/j.jeurceramsoc.2020.04.048. [COBISS.SI-ID 24960771]

14. FANETTI, Mattia, MIKULSKA, Iuliia, FERFOLJA, Katja, MORAS, Paolo, SHEVERDYAEVA, P. M., PANIGHEL, M., LODI-RIZZINI, A., PÍŠ, I., NAPPINI, S., VALANT, Matjaž, GARDONIO, Sandra. Growth, morphology and stability of Au in contact with the Bi_2Se_3(0001) surface. *Applied Surface Science*. [Print ed.]. Mar. 2019, vol. 471, str. 753-758, ilustr. ISSN 0169-4332. DOI: 10.1016/j.apsusc.2018.11.140. [COBISS.SI-ID 5276923]

15. PLIEKHOVA, Olena, PLIEKHOV, Oleksii, FANETTI, Mattia, ARČON, Iztok, NOVAK TUŠAR, Nataša, LAVRENČIČ ŠTANGAR, Urška. Cu and Zr surface sites in photocatalytic activity of TiO_2 nanoparticles: the effect of Zr distribution. *Catalysis today*. [Print ed.]. 15 May 2019, vol. 328, str. 105-110, ilustr. ISSN 0920-5861. https://www.sciencedirect.com/science/article/pii/S0920586118308198, DOI: 10.1016/j.cattod.2019.01.022. [COBISS.SI-ID 1538149571]