UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Mikroskopske in mikroanalizne metode
Course title:	Microscopical and Microanalytical Methods

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 3. stopnja Nanosciences and Nanotechnologies, 3rd cycle	/	1	1

Vrsta predmeta / Course type	Izbirni / Elective
Univerzitetna koda predmeta / University course code:	NANO3-813

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 transfered to individual work.*

Nosilec predmeta / Lecturer:	Prof. dr. Miran Čeh Prof. dr. Sašo Šturm Prof. dr. Goran Dražić

Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina, angleščina, Slovenian, English
	Vaje / Tutorial:	slovenščina, angleščina, Slovenian, English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Poznavanje in razumevanje osnov fizike in kemije trdnega stanja in elektronske optike.	Knowledge and understanding of the basic concepts of physics and chemistry of condensed matter and electron optics.

Vsebina:	**Content (Syllabus outline):**
Predmet obsega teoretične osnove in praktično delo z naslednjimi tehnikami: • elektronska mikroskopija: vrstična elektronska mikroskopija (SEM), presevna elektronska mikroskopija (TEM, CTEM, HRTEM), elektronska difrakcija (SAD, mikrodifrakcija), vrstična presevna elektronska mikroskopija (STEM,HAADF-STEM, ABF) • Posebne tehnike elektronske mikroskopije: in-situ mikroskopija, elektronska holografija, 3D tomografija, elektronska precesija • Mikroanaliza in spektroskopija: energijsko-	The course includes theoretical and practical work with the following techniques: • Electron microscopy: scanning electron microscopy (SEM), transmission electron microscopy (TEM, CTEM, HRTEM), electron diffraction (SAD, micro-diffraction), scanning transmission electron microscopy (STEM,HAADF-STEM, ABF) • Special electron microscopy techniques: in-situ microscopy, electron holography, 3D tomography, electron precession • Microanalysis and spectroscopy: energy-

disperzijska spektroskopija rentgenskih žarkov (EDXS),valovno-disperzijska spektroskopija rentgenskih žarkov (WDXS), spektroskopija izgub energije elektronov (EELS) • Tipalna mikroskopija (SPM): vrstična tunelska mikroskopija (STM), mikroskopija na atomsko silo (AFM)	dispersive X-ray spectroscopy (EDXS), wave-dispersive X-ray spectroscopy (WDXS), electron energy loss spectroscopy (EELS • Scanning probe microscopy (SPM): scanning tunnelling microscopy (STM), atomic force microscopy (AFM)

Temeljni literatura in viri / Readings:

1. J. I. Goldstein et al., Scanning Electron Microscopy and X-ray Microanalysis, Springer, 4th edition, 2017
2. D. B. Williams, C. B. Carter, Transmission Electron Microscopy, Plenum Press, 2009
3. Ludwig Reimer, Transmission Electrons Microscopy, Springer, 2008
4. R. Wiesendanger, Scanning probe microscopy and spectroscopy, Methods and applications, Cambridge University Press, Cambridge, 1994
5. Aberration-Corrected Analytical Transmission Electron Microscopy, edited by Rik Brydson, Wiley and sons, 2011

Cilji in kompetence:	**Objectives and competences:**
Seznaniti študente s pomembnimi modernimi mikroskopskimi in mikroanaliznimi tehnikami, ki omogočajo identifikacijo in karakterizacijo strukture in kemijske sestave materialov na mikro-, nano- in atomarnem nivoju. Splošne kompetence: • Zmožnost uporabe (pod nadzorom) zahtevnih eksperimentalnih tehnik, vrednotenja postopkov in procesov ter razvoja kritične in samokritične presoje pridobljenih rezultatov; • Sposobnost nadaljnjega izpopolnjevanja in uporabe pridobljenega znanja v praksi; • Razvoj komunikacijskih sposobnosti in spretnosti, tako v domačem kot v mednarodnem okolju; • Sodelovanje in skupinsko delo. Predmetnospecifične kompetence: Predmet daje potrebno teoretično znanje in pripravlja študente za samostojno raziskovalno delo na eksperimentalno zahtevnem področju.	To get the students acquainted with the most important and recent microscopic and microanalytical methods for identification and characterization of the structure and chemical composition of materials on micro-, nano- and atomic scale. General Competences: • Ability to perform (under supervision) the sophisticated experimental techniques, to evaluate the procedures and processes and to acquire critical and self-critical judgment of the acquired results; • Ability to acquire additional knowledge and to apply it in solving practical problems; • Improvement of communication abilities within domestic and international communities; • Collaboration and team work. Course Specific Competences: The course provides necessary theoretical knowledge and prepares the students for independent research work in the experimentally demanding field.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: • Razumevanje fizikalnih pojavov, na katerih so	Knowledge and Understanding: • Understanding of physical processes on which

osnovane mikroskopske in mikroanalizne metode; • Sposobnost kritičnega vrednotenja in predstavitve rezultatov v sodelovanju z mentorjem.	the microscopic and microanalytical methods are based; • Ability of a critical evaluation and presentation of the results under supervision of the mentor.

Metode poučevanja in učenja:	**Learning and teaching methods:**
• Predavanja • Seminarji, naloge • Konzultacije • Praktične vaje na opremi za elektronsko mikroskopijo in analizo površin	• Lectures • Seminars, coursework • Consultations • Practical work on the equipment for electron microscopy and surface analysis

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
• Ustni izpit	80 %	• Oral examination
• Seminarji	10 %	• Seminars
• Naloge	10 %	• Assignments

Reference nosilca / Lecturer's references:

- V. Šrot, M. Gec, P. van Aken, J.H. Jeon, M. Čeh, Influence of TEM specimen preparation on chemical composition of $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ single crystals. *Micron*, ISSN 0968-4328. [Print ed.], 2014, vol. 62, str. 37-42
- L. Suhadolnik, M. Krivec, K. Žagar, G. Dražić, M. Čeh. A TiO_2-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 TiO_2-nanotube fixed-bed microreactor. *The chemical engineering journal*, ISSN 1385-8947. [Print ed.], 2016, vol. 303, str. 292-301
- 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