

## UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	SODOBNE METODE KARAKTERIZACIJE MATERIALOV
<b>Course Title:</b>	MODERN METHODS OF MATERIALS CHARACTERIZATION

Študijski program in stopnja Study Programme and Level	Študijska smer Study Field	Letnik Academic Year	Semester Semester
UŠP Kemijsko inženirstvo, 1. stopnja	/	3.	5.
USP Chemical Engineering, 1 <sup>st</sup> Cycle	/	3 <sup>rd</sup>	5 <sup>th</sup>

**Vrsta predmeta / Course Type:**

izbirni strokovni / Elective Professional

**Univerzitetna koda predmeta / University Course Code:**

INSI32

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Work	Druge oblike študija	Samost. delo Individual Work	ECTS
45	15	15 LV	/	/	75	5

**Nosilec predmeta /  
Lecturer:**

izr. prof. dr. Boštjan Genorio / Dr. Boštjan Genorio, Associate Professor

**Jeziki / Languages:**

**Predavanja / Lectures:**

slovenski / Slovenian

**Vaje / Tutorial:**

slovenski / Slovenian

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

**Prerequisites:**

Študent oz. kandidat mora imeti predmet opredeljen kot študijsko obveznost.

The course has to be assigned to the student.

**Vsebina:**

**Content (Syllabus outline):**

**1. Disperzni sistemi:** Definicija disperznega sistema, merjenje velikosti in porazdelitve velikosti v disperznem sistemu, določevanje faktorja oblike delcev, specifična površina disperznega sistema, določevanje poroznosti.

**1. Disperse systems:** Definition of disperse systems, particle size and size distribution measurements, shape factor determination, specific surface of a disperse system, porosity measurements.

**2. Mikrostruktura materialov:** Optična in elektronska mikroskopija (SEM, TEM), mikroskopija na atomsko silo (AFM), vrstična tunelska mikroskopija (STM) in kvantitativna analiza mikrostrukture materialov.

**2. Materials microstructure:** optical and electron microscopy (SEM, TEM), atomic force microscopy (AFM), scanning tunneling microscopy (STM), microstructure quantitative analysis of materials.

**3. Merjenje termičnih lastnosti materialov:** Osnove termogravimetrije (TG), diferenčne dinamične kalorimetrije (DSC), diferenčne termične analize (DTA). Osnove in načini merjenja kinetike v trdnih sistemih, merjenje

**3. Thermal properties of materials:** Principles of Thermogravimetric Analysis (TG), differential scanning calorimetry (DSC), differential thermal analysis (DTA). Basic principles of kinetics in solids and temperature measurements.

temperature.

**4. Kristalna struktura:** Osnove kristalografije, osnove metod rentgenske difrakcije (XRD), povezava lastnosti materialov in njihove kristalne strukture, osnove EXAFS metode.

**5. Mehanske lastnosti materialov:** Elastična in plastična deformacija, natezni testi, duktilen in trden lom materialov, določevanje trdote materialov, testi utrujanja materialov, testi lezenja.

**6. IR in Ramanska spektroskopija:** Teorija IR in Ramanske spektroskopije, merjenje IR in Ramanskih spektrov.

**7. Električne lastnosti materialov:** Principi ciklične voltometrije, principi impedančne spektroskopije.

**8. Površina materialov:** Principi rentgenske fotoelektronske spektroskopije (XPS) in ostalih spektroskopskih tehnik v ultra-visokem vakuumu ter elipsometrija.

**4. Crystalline structure:** Basics of crystallography, theory of the X-rays diffraction methods (XRD), Comparison of structures and properties of the solids, basics of EXAFS analysis.

**5. Mechanic properties of solids:** Elastic and plastic deformation, tensile testing, ductile and brittle fracture, hardness testing, fatigue and creep testing.

**6. IR and Raman spectroscopy:** Theory of IR and Raman spectroscopies, Principles of IR and Raman measurements.

**7. Electrical properties of materials:** Principles of cyclic voltammetry and principles of impedance spectroscopy.

**8. Surface of materials:** Principles of X-ray photoelectron spectroscopy and other ultra high vacuum spectroscopic techniques and ellipsometry.

#### Temeljna literatura in viri / Readings:

1. D.A. Skoog, F.J. Holler, T.A. Nieman, Principles of instrumental analysis, Saunders College Publishing, Philadelphia, 1992, 849 strani (40%)
2. J.W. Dodd, K.H. Tonge, Thermal methods, John Wiley & Sons, Chichester, 1987, 337 strani (20%)
3. L. Ling Ooi, Principles of X-ray crystallography, Oxford University Press, Oxford, 2010, 208 strani (20%)
4. D.C. Koningsberger, R. Prins, X-ray Absorption, Principles, techniques of EXAFS, SEXAFS and XANES, John Wiley & Sons, New York, 1988, 688 strani (10%)
5. J.R. Ferraro, K. Nakamoto, C.W. Brown, Introductory Raman Spectroscopy, Academic Press, 2003, 434 strani (10%)  
J. Ross MacDonald, Ed., Impedance spectroscopy emphasising solid materials and systems, J. Wiley & Sons, Inc., New York, 1987, 368 strani (10%)

#### Cilji in kompetence:

Nagel razvoj tehnike temelji na novih in izboljšanih materialih in zahteva poznavanje metod njihove karakterizacije. Študent se seznani s principi in načini merjenja določenih lastnosti anorganskih materialov ter s pomenom opisane karakteristike za uporabnost materialov.

#### Objectives and Competences:

Development of technologies based on new improved materials requires also understanding of basic principles of materials characterization. Students acquire basic knowledge and ability regarding materials characterization.

#### Predvideni študijski rezultati:

#### Intended Learning Outcomes:

<u>Znanje in razumevanje</u> Študent spozna osnovne fizikalne principe na katerih temeljijo metode analize materialov. Z razumevanjem principov in rezultati analiz je študent sposoben kritično ovrednostiti različne materiale.	<u>Knowledge and Comprehension</u> Basic knowledge about physical principles of materials characterization on which students can describe various materials.
<u>Uporaba</u> Skozi principe karakterizacije materialov študentje spoznajo nekatere tehnološko najpomembnejše materiale (konstrukcijske materiale, materiale za elektroniko, inženirsko keramiko) ter načine njihove evalvacije.	<u>Application</u> Through materials characterization students describe various technologically important materials (i.e. construction materials, engineer ceramics, materials for electro applications).
<u>Refleksija</u> Študent pridobi nujno potrebna znanja in občutek za spremljanje procesa skozi karakterizacijo materialov.	<u>Analysis</u> Students acquire basic knowledge to follow materials' preparation through their characterization.
<u>Prenosljive spretnosti</u> Razvita sposobnost kritičnega razmišljanja in sklepanja. Sposobnost povezovanja osnovnih znanj ter študija domače in tuje literature.	<u>Skill-transference Ability</u> Integration of basic knowledge regarding material science, literature research; literature data collecting, data analysis and interpretation.

**Metode poučevanja in učenja:**

- Predavanja,
- laboratorijske vaje

**Learning and Teaching Methods:**

Lectures, seminars, tutorial work

**Načini ocenjevanja:**

Delež (v %) /  
Weight (in %)

**Assessment:**

Pisni in ustni izpit.

Written and oral exam.

**Reference nosilca / Lecturer's references:**

1. Genorio B, Lu W, Dimiev A M, Zhu Y, Raji A-R O, Novosel B, Alemany L B and Tour J M 2012 In Situ Intercalation Replacement and Selective Functionalization of Graphene Nanoribbon Stacks ACS Nano 6 4231–40
2. Genorio B and Znidarsic A 2014 Functionalization of graphene nanoribbons J. Phys. D. Appl. Phys. 47 094012
3. Genorio B, Staszak-Jirkovský J, Assary R S, Connell J G, Strmcnik D, Diesendruck C E, Lopes P P, Stamenkovic V R, Moore J S, Curtiss L A and Markovic N M 2016 Superoxide (Electro)Chemistry on Well-Defined Surfaces in Organic Environments J. Phys. Chem. C acs.jpcc.5b12230
4. S.-Jirkovsky J, Subbaraman R, Strmcnik D, Harrison K L, Diesendruck C E, Assary R S, Frank O, Kobr L, Wiberg G K H, Genorio B, Connell J G, Lopes P P, Stamenkovic V, Curtiss L A, Moore J S, Zavadil K R and Markovic N M 2015 Water as a promoter and catalyst for dioxygen electrochemistry in aqueous and organic media ACS Catal. 5 6600–7
5. Staszak-Jirkovský J, Malliakas C D D, Lopes P P P, Danilovic N, Kota S S S, Chang K-C, Genorio B, Strmcnik D, Stamenkovic V R R, Kanatzidis M G and Markovic N M 2015 Design of active and stable Co-Mo-Sx chalcogels as pH-universal catalysts for the hydrogen evolution reaction Nat Mater advance on 1–8