SODOBNE METODE KARAKTERIZACIJE MATERIALOV

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Sodobne metode karakterizacije materialov
Course title:	Modern Methods of Materials Characterisation
Članica nosilka/UL Member:	UL FKKT

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Kemijsko inženirstvo, prva stopnja, univerzitetni (od študijskega leta 2023/2024 dalje)	Ni členitve (študijski program)	2. letnik, 3. letnik		izbirni

Univerzitetna koda predmeta/University course code:	0072122
Koda učne enote na članici/UL Member course code:	INSI32

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
45	15	15 LV			75	5

Nosilec predmeta/Lecturer:	izr. prof. dr. Boštjan Genorio
Vrsta predmeta/Course type:	izbirni strokovni/Elective Professional
Jeziki/Languages:	Predavanja/Lectures: Angleščina, Slovenščina Vaje/Tutorial: Angleščina, Slovenščina

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. **2. Mikrostruktura materialov**: Optična in elektronska mikroskopija (SEM, TEM), mikroskopija na atomsko silo (AFM), vrstična tunelska mikroskopija (STM) in kvantitativna analiza mikrostrukture materialov. 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 temperature.	**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. Materials microstructure**: optical and electron microscopy (SEM, TEM), atomic force microscopy (AFM), scanning tunneling microscopy (STM), microstructure quantitative analysis of materials. 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. 4.**Crystalline structure**: Basics of crystallography, theory of the X-rays diffraction methods (XRD),

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 voltametrije, principi impedančne spektroskopije. 8. **Površina materialov**: Principi rentgenske fotoelektronske spektroskopije (XPS) in ostalih spektroskopskih tehnik v ultra-visokem vakuumu ter elipsometrija.	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 Willey & Sons, Chichester, 1987, 337 strani (20%)
3. L. Ling Ooi, Principles of X-ray crystallograhpy, 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%)
6. J. Ross MaCdonald, Ed., Impedance spectroscopy emphasising solid materials and systems, J. Wiley & Sons, Inc., New York, 1987, 368 strani (10%)

Cilji in kompetence:	**Objectives and competences:**
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.	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:**
Znanje in razumevanje Študent spozna osnovne fizikalne principe na katerih temeljijo metode analize materialov. Z razumevanjem principov in rezultati analiz je študent sposoben kritično ovrednotiti različne materiale. Uporaba Skozi principe karakterizacije materialov študentje spoznajo nekatere tehnološko najpomembnejše materiale (konstrukcujske nateriale, materiale za elektroniko, inženirsko keramiko) ter načine njihove evalvacije. Refleksija Študent pridobi nujno potrebna znanja in občutek za spremljanje procesa skozi karakterizacijo materialov. Prenosljive spretnosti	Knowledge and Comprehension Basic knowledge about physical principles of materials characterization on which students can describe various materials. Application Through materials characterization students describe various technologically important materials (i.e. construction materials, engineer cheramics, materials for electro applications). Analysis Students acquire basic knowledge to follow materials' preparation through their characterization. Skill-transference Ability Integration of basic knowledge regardin material science, literature research; literature data collecting, data analysis and interpretation.

Razvita sposobnost kritičnega razmišljanja in sklepanja. Sposobnost povezovanja osnovnih znanj ter študija domače in tuje literature.	

Metode poučevanja in učenja:	**Learning and teaching methods:**
- Predavanja, - laboratorijske vaje	Lectures, seminars, tutorial work

Načini ocenjevanja:	**Delež/Weight**	**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