UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	PRAKTIKUM IZ MATERIALOV
Course Title:	PRACTICAL COURSE IN MATERIALS CHARACTERISATION

Študijski program in stopnja Study Programme and Level	Študijska smer Study Field	Letnik Academic Year	Semester Semester
VSŠP Kemijska tehnologija, 1. stopnja	**/**	**3.**	**6.**
PSP Chemical Technology, 1st Cycle	**/**	**3rd**	**6th**

Vrsta predmeta / Course Type: izbirni strokovni / Elective Professional

Univerzitetna koda predmeta / University Course Code: KTSI34

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Work	Druge oblike študija	Samost. delo Individual Work	ECTS
/	**/**	**25 SV + 50 LV**	**/**	**/**	**75**	**5**

Nosilec predmeta / Lecturer: Doc. dr. Boštjan Genorio / Dr. Boštjan Genorio, Assistant Professor

Jeziki / Languages:

Predavanja / Lectures: **/**

Vaje / Tutorial: **slovenski / Slovenian**

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

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

Prerequisites:

The course has to be assigned to the student.

Vsebina:

I.del: primeri računskih problemov s področja materialov
Mehanske lastnosti, električne lastnosti, termične lastnosti, magnetne lastnosti
Gostota in poroznost
Kemijske vezi, koordinacija
Geometrija kristalov, smeri, ravnine, prostor, nekatere osnovne strukture, polimorfizem
Točkasti defekti, difuzija v trdnem, teoretična zlomna trdnost, Schmidov zakon, Griffithova teorija
Fazni diagrami (binarni, ternarni)
fazni diagrami v povezavi z mikrostrukturo,
Trdne raztopine, nestehiometrične spojine
Korozija, kinetika korozije

Content (Syllabus outline):

Part I: Computational problems solving in the field of materials
Mechanical, electrical, thermal, magnetic properties
Density and porosity.
Chemical bonding, coordination crystal geometry, crystallographic directions, planes and some basic structures, polymorphism -
Point defects, diffusion in the solid, theoretical strength, Schmid's Law, Griffith theory
Phase diagrams (binary, ternary)
phase diagrams in relation with the microstructure.
Solid solution, a non-stoichiometric compound
Corrosion, corrosion kinetics.
Part II: practical course in materials

II.del: praktične vaje iz karakterizacije materialov Mikrostruktura materialov z optično, elektronsko mikroskopijo, mikroskopija na atomsko silo (AFM). Kvantitativna analiza mikrostrukture. Rentgenska praškovna analiza: tehnika z Guinierjevo kamero ter identifikacija vzorca po Hanawaltovi metodi in metoda rentgenske praškovne difrakcije ter identifikacija z uporabo ustreznih identifikacijskih programov. Določanje velikosti kristalitov. Mehanske lastnosti: Mehanski preizkus, določitev deformacije in sile potrebne za zlom preizkušanega materiala, izračun σ_{nat}, $\sigma_{zlomna\ tehnična}$, $\sigma_{zlomna\ realna}$, kontrakcija in E-modul. Določanje trdote materialov. Električne lastnosti: Merjenje odvisnosti upornosti od temperature. Merjenje kapacitivnosti in dielektričnih izgub ploščatega kondenzatorja. Določanje varistorskih lastnosti koeficient nelinearnosti in prebojno napetost. Impedančna spektroskopija: karakterizacija električnih lastnosti materialov (dielektrične konstante in specifične upornosti). Termična analiza: TG in DSC analiza različnih materialov. Vrednotenje rezultatov, določanje vsebnosti posameznih komponent v vzorcu. Določanje parametrov sintranja s segrevalno mikroskopijo. Gostota, poroznost in specifična površina: Piknometrična določitev gostote in poroznosti materialov,, določanje specifične površine z adsorbcijo plinov (BET). Metode klasične kemijske in instrumentalne analize materialov (IR, UV, NMR, MS)	characterization Optical, electron and atomic force microscopy (AFM) analysis of microstructure, quantitative microstructures analysis. X-ray powder diffraction: technique using Guinier camera and identification of the sample by Hanawalt and by identification programs. Determination of crystallite size. Mechanical properties: Mechanical testing, determination force versus deformation, calculation of tensile strength, rupture strength, contraction and elastic moduli. Materials hardness determination. Electrical properties: electrical resistance versus temperature. Measuring capacitance and dielectric losses of the flat capacitor. Varistor characteristics, nonlinearity coefficient and breakdown voltage. Impedance spectroscopy: characterization of materials (dielectric constant and resistivity). Thermal analysis: DSC and TG analysis of different materials, determination of components contents. Defining parameters of sintering by a heating microscopy. Density, porosity and specific surface area. Picnometric determination of density and porosity of materials. D3etermination of the specific surface area by gas adsorption (BET). Classical methods of chemical and instrumental analysis of materials (IR, UV, NMR, MS).

Temeljna literatura in viri / Readings:

- Zhang s., Li L., Kumar A, Materials Characterization Cechniques, CRC Press, London, 2009
- D. Brandon, W.D. Kaplan, Microstructural Characterization of Materials, 2nd.ed., John Wiley& Sons, 2008
- Kaufman E. N., Characterization of Materials 1&2, A John Wiley and Sons Publication, New Jersey, 2003, 1392 strani. (10 %)
- Sibilia J. P., A Guide to Materials Characterisation and Chemical Analysis, Wiley-VCH, New York, 1996, 388 strani. (30 %)
- Pejovnik, S., Zupan, K., Kolar, D-, Čeh, M., Malič, B., Zbirka nalog iz predmeta Gradiva v kemijski tehniki. [Ljubljana: Fakulteta za kemijo in kemijsko tehnologijo], 1999/2000, 28 strani.

Cilji in kompetence:	**Objectives and Competences:**
Namen predmeta je, da v prvem delu študentje	The purpose of this course is that in the first

pridobijo znanja za računsko obravnavo problemov s področja materialov, v smislu razumevanja njihove zgradbe v povezavi z lastnostmi (mehanskimi, termičnimi električnimi..) na mikro in makro nivoju. V drugem delu pa z laboratorijskim praktičnim delom pridobijo znanja o metodah karakterizacije materialov. Rezultate praktičnih meritev obdelajo in obrazložijo v skladu s teoretičnimi napovedmi. Znanje naj omogoči razumevanje in dialog inženirja s strokovnjaki drugih profilov v praksi in sodobni interdisciplinarni pristop k reševanju nalog.	part, students acquire skills for computational problem solving in the field of materials. in terms of understanding their structure in relation with properties (mechanical, thermal, electrical ...) at the micro and macro level. The goal of the second part of the laboratory practical work is to gain knowledge about the methods of characterization of materials. The students learn to process and explain results of practical measurement in accordance with theoretical predictions. They learn to communicate with experts from other fields in practice and contemporary interdisciplinary approach to problem solving.

Predvideni študijski rezultati:	**Intended Learning Outcomes:**
Znanje in razumevanje Študentje spoznajo soodvisnost med zgradbo in lastnostmi materialov. V tečaju bomo podali znanja o metodah karakterizacije materialov ter jih praktično izvedli. Študent pridobi praktično zanje o računski obravnavi primerov s področja razumevanja strukture in sprememb na mikro in makro nivoju.	Knowledge and Comprehension Students learn relationships between structure and material properties. The course will cover knowledge of characterization methods and practical application. Students acquire knowledge of computational problem solving of cases regarding structure and changes at the macro and micro level.
Uporaba Pridobljena znanja je sposoben uporabljati za samostojno, logično in kritično razmišljanje o lastnostih, načrtovanju, izbiri in uporabi različnih materialov.	Application Knowledge is applied independently using logical and critical thinking about characteristics, planning, choice and use of different materials.
Refleksija Laboratorijske vaje in računanje primerov so vezane na vsebine premeta, ki obravnava materiale, njihovo načrtovanje, uporabo in njihov propad. Zaradi svoji interdisciplinarnosti so vezane tudi na osnovna znanja Fizike, Kemije (anorganske, organske, fizikalne)	Analysis Practical course and computation depends on course curriculum addressing the development of materials, use, decomposition. Due to interdisciplinary properties of the course, knowledge of Physics, Chemistry (inorganic, organic, physical) is required.
Prenosljive spretnosti Sposobnost uporabe principov vede o materialih pri njihovi karakterizaciji in vrednotenju njihovih lastnosti tako pri raziskovalnem kot razvojnem delu.	Skill-transference Ability Ability to use principles of material science. Ability to evaluate material characteristics in research and development

Metode poučevanja in učenja:	**Learning and Teaching Methods:**
Računski seminarji, laboratorijske vaje, individualna seminarska naloga.	-Computational seminars , - practical course , -individual seminar work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
- pisni del iz računskih nalog in praktična izvedba vaj pri katerih študent teoretično obdela temo, ki se nanaša na izbrano metodo ali skupino metod karakterizacije v obliki projektnega dela, ki se zaključi s poročilom - ocenjevalna lestvica v skladu s Statutom UL in fakultetnimi pravili: 60 % dosežek za pozitivno oceno (ocena 6-10), manj kot 50 % negativna ocena (od 1-5).		Final grade is calculated as follows: Written exam: computation problems (50%) (Written part can be accomplished by achieving a positive grade of one written colloquium at the end of semester), individual seminar work (50%).
K končni oceni prispeva pisni del iz računskih nalog (50 %) in	**50 %**	
poročilo o projektnem delu (50%)	**50 %**	

Reference nosilca / Lecturer's references:

Genorio, B.; Lu, W.; Dimiev, A. M.; Zhu, Y.; Raji, A.-R. O.; Novosel, B.; Alemany, L. B.; Tour, J. M. In Situ Intercalation Replacement and Selective Functionalization of Graphene Nanoribbon Stacks. ACS Nano 2012, 6 (5), 4231–4240. https://doi.org/10.1021/nn300757t.

Xiang, C.; Cox, P. J.; Kukovecz, A.; Genorio, B.; Hashim, D. P.; Yan, Z.; Peng, Z.; Hwang, C.-C.; Ruan, G.; Samuel, E. L. G.; et al. Functionalized Low Defect Graphene Nanoribbons and Polyurethane Composite Film for Improved Gas Barrier and Mechanical Performances. ACS Nano 2013, 7 (11), 10380–10386. https://doi.org/10.1021/nn404843n.

Dimiev, A.; Zakhidov, D.; Genorio, B.; Oladimeji, K.; Crowgey, B.; Kempel, L.; Rothwell, E. J.; Tour, J. M. Permittivity of Dielectric Composite Materials Comprising Graphene Nanoribbons. The Effect of Nanostructure. ACS App. Mater. Interfaces 2013, 5 (15), 7567–7773. https://doi.org/10.1021/am401859j.

Genorio, B. Synthesis and Electrochemical Characterization of Graphene Nanoribbon Stacks Functionalized with Buckyballs. Acta Chim. Slov. 2015, 62, 895–901. https://doi.org/10.17344/acsi.2015.1626.

Genorio, B. The Synthesis of Diquinone and Dihydroquinone Derivatives of Calix [4] Arene and Electrochemical Characterization on Au (111) Surface. Acta Chim. Slov. 2016, 63, 496–508. https://doi.org/10.17344/acsi.2016.2289.

Vizintin, A.; Genorio, B.; Dominko, R. CHAPTER 8: Application of Graphene Derivatives in Lithium-Sulfur Batteries; 2018; Vol. 2018–Janua. https://doi.org/10.1039/9781788012829-00222.