UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Sodobni nanostrukturirani kovinski materiali
Course title:	Advanced Nanostructured Metallic Materials

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

Vrsta predmeta / Course type Izbirni/ Elective

Univerzitetna koda predmeta / University course code: NANO3-818

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	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. Monika Jenko

Jeziki / Languages:	**Predavanja / Lectures:**	Slovenščina, angleščina / Slovene, English
	Vaje / Tutorial:	Slovenščina, angleščina / Slovene, English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Zaključen študij druge stopnje naravoslovne ali tehniške smeri ali zaključen študij drugih smeri z dokazanim poznavanjem osnov področja predmeta (pisna dokazila, pogovor).	Completed second cycle studies in natural sciences or engineering or completed second cycle studies in other fields with proven knowledge of fundamentals in the field of this course (certificates, interview).

Vsebina:	**Content (Syllabus outline):**
• Znanost o sodobnih nanostrukturiranih kovinskih materialih, biomaterialih, inženiring površin - izbrana poglavja • Osnove elektronske teorije kovin • Kristalna struktura kovin • Napake v kristalih • Difuzijski procesi v kovinah in zlitinah • Mehanske lastnosti kovinskih materialov • Dislokacije in utrjevalni mehanizmi • Fazni diagrami (osnove) • Fazne spremembe v kovinah, kinetika reakcij v trdnem (nukleacija in rast) • Mikrostruktura kovinskih materialov • Razvoj kovinske mikrostrukture	• Materials science and engineering of advanced nanstructured metallic materials, biomaterials - selected chapters • Basics of Electron theory of metals • Crystal structure of Metals: Fundamental • Concepts of Crystallography • Imperfection in Crystals • Diffusion processes in solids - metals and alloys • Mechanical properties of metallic materials • Dislocations and Strengthening Mechanisms • Phase diagrams: Constitution of equilibrium metallic phase diagrams • Phase Transformations in Metals the kinetics of solid-state reactions (nucleation, growth)

• Nanostrukturirani kovinski materiali • Biokompatibilni kovinski materiali • Modifikacija površine kovin in zlitin • Kovinski biomateriali za uporabo v medicini; biokompatibilnost, mehanska kompatibilnost, odpornost proti koroziji, tribokoroziji • Zlitine z oblikovnim spominom, zlitine z martenzitno fazno premeno; super elastične zlitine • Degradacija kovinskih materialov • Degradacija kovinskih materialov za implantate • Elektrokemijska korozija, biokorozija, visokotemperaturna oksidacija	• Microstructure of metallic materials • Development of microstructure of metallic materials basic aspects • Nanostructured metallic materials • Biometalic materials • Surface modification of metals and alloys • Metallic biomaterials for application in medicine; biocompatibility, mechanical compatibility, corrosion resistance, tribo corrosion • Shape memory alloys –alloys with martensite phase transition; super elastic alloys • Deagradation of metallic materials • Degradation of metallic materials for implants • Electrochemical corrosion, biocorrosion, tribocorrosionhigh temperature oxidation

Temeljni literatura in viri / Readings:

1. Modern Physical Metallurgy *R.E. Smallman and A.H.W. Ngan* (Eighth Edition) 2014 Elsevier.
2. Physical Metallurgy (Fifth Edition) *Edited by:David E. Laughlin and Kazuhiro Hono*, 2015 Elsevier.
3. ASTM , Volume 23, Medical and Surgical Materials and Devices, 2012.
4. Degradation of Implant Materials Editors: **Eliaz**, Noam (Ed.) , Springer 2012.
5. Materials Science and Engineering: Introduction; 6th edition, W.D: Callister, John Willey, 2003).
6. Phase transformation in Metals and alloys 2nd edition, D.a.Porter, K.E. Eastrling (CRC Press, Taylor Francis group, 2004).
7. Scanning Electron Microscopy and X-ray Microanalysis, J.Goldstein, D. Newbury, D.Joy, Lyman, P.Echlin, E.Lifshin, L Sawyer and J. Michael, 3rd edition (Cluwer Academic Plenum Publishers, 2003).
8. Surface analysis by AES and XPS, Edts. D.Briggs and J.T.Grant (surface Spectra and Publications 2003).
9. Materials Science and Engineering; 6th edition, W.D: Callister, (John Willey, 2003) 12 F. N. Rhines: Phase Diagrams in Metallurgy.
10. Robert DeHoff: Thermodynamics in Materials Science, Taylor & Francis, Boca Raton, 2006.

Ciljani izbor in razprava o aktualnih znanstvenih objavah, predvsem v revijah Science, Nature Scientific reports, Nature Materials, Acta Metallurgica, Acta Biomaterialia Surface Science, Applied Surface Science, Corrosion science itd. / Targeted selection and discussion of scientific publications, particularly from Science, Nature, Scientific reports, Nature Materials, Acta Metallurgica, Acta Biomaterialia Surface Science, Applied Surface Science, Corrosion science.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je usposobiti študenta za razumevanje teoretičnega in praktičnega znanja o sodobnih kovinskih materialih, biomaterialih in inženirskih materialih, lastnostih kovinskih materialov, povezanih s strukturo. Cilj se navezuje na kompetence: • obvladovanje metod in tehnik znanstvenega raziskovanja, • sposobnost za samostojno in skupinsko	The objective of the course is to train a student to understand fundamental and applied knowledge of advanced metallic materials, biomaterials and engineering materials , properties of metallic materials and their structures. This objective is related to competences: • mastering of methods and techniques of scientific research ability to carry out independent as well as team R&D work,

raziskovalno in razvojno delo, • sposobnost uporabe znanja v praksi in • delno tudi razvoj integralnega načina mišljenja ter sposobnost za komunikacijo s strokovnjaki drugih disciplin in področij.	• ability to use the knowledge in practice, • and partially also to the development of an integral way of thinking and the ability to communicate with experts from other disciplines and fields.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Poznati, razumeti: procese interakcije atom/površina na atomski skali, med dinamičnim procesom rasti tanke plasti iz parne faze ali adsorbirane, segregirane tanke plasti, za kontrolirano mikrokemijo, mikrostrukturo in od tod načrtovane fizikalne lastnosti kovinskih materialov. Poznati in razumeti termodinamiko in kinetiko razvoja mikrostrukture, konstitucije faznih diagramov ter temperaturno odvisne lastnosti in premene v kovinskih materialih. Poznati in razumeti sodobne kovinske biomateriale, biokompatibilne in mehansko kompatibilne kovine in zlitine za uporabo v medicini. Poznati in razumeti zlitine z oblikovnim spominom; zlitine z martenzitno premeno. Poznati in razumeti vmesne površine med biokompatibilnimi materiali in organskim tkivom. Poznati osnove biokorozije, karakterizacijo korozijskih produktov z različnimi preiskovalnimi metodami za analizo površin.	Know and understand the theory of atom/surface interactions during the dynamic process of vapor- phase or adsorption/ segregation thin and ultra thin film growth in order to control, manipulate microchemistry of metallic materials, microstructure, and, hence, physical properties of metallic materials. To know and understand the materials classification and the basics of advanced metallic materials , microstructure evolution of metals and alloys, to know the basic metallurgical thermodynamics and phase diagrams constitution. To know and understand the temperature dependent properties and phase transformation of metallic materials. To know the basics of advanced metallic biomaterials, bio and mechanical compatibility; shape memory alloys, materials with martensite phase transition. To know and undestand the influence of biometrials-biointerfaces To know the basics of biocorrosion, tribo corrosion and characterization of corrosion products by different methods for surface characterization

Metode poučevanja in učenja:	**Learning and teaching methods:**
Uvodna predstavitev. Seminarsko skupinsko delo. Vključevanje v projekte za razvoj sposobnosti uporabe opreme. Uporaba raziskovalne opreme v reševanju izbranega problema, analiza rezultatov, priprava seminarske predstavitve.	Introductory presentation. Seminar team work. Participation in projects for the development of ability to use research equipment. Solving selected problem with research equipment, analysis of results, preparation of the seminar presentation.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminarska naloga. Zagovor seminarske naloge, pri katerem dokaže osvojitev vseh študijskih izidov z vsaj po enim konkretnim primerom.	50 % 50 %	Seminar work. Defense of the seminar work where the student demonstrates the achievement of all learning outcomes with at least one specific case for each outcome.

Reference nosilca / Lecturer's references:

- JENKO, Monika, GORENŠEK, Matevž, GODEC, Matjaž, HODNIK, Maxinne, ŠETINA, Barbara, DONIK, Črtomir, GRANT, John T., DOLINAR, Drago. Surface chemistry and microstructure of metallic biomaterials for hip and knee endoprostheses. *Applied Surface Science*, ISSN 0169-4332. [Print ed.], Avg. 2017, vol. 427, str. 584-593, ilustr. http://www.sciencedirect.com/science/article/pii/S0169433217323206, doi: 10.1016/j.apsusc.2017.08.007. [COBISS.SI-ID 1331882].
- PUKŠIČ, Nuša, JENKO, Monika, GODEC, Matjaž, MCGUINESS, Paul J. A comparison of the uniaxial deformation of copper and nickel (1 1 19) surfaces: a molecular dynamics study. *Scientific reports*, ISSN 2045-2322, Feb. 2017, vol. 7, str. 1-7, ilustr. http://www.nature.com/articles/srep42234?WT.feed_name=subjects_physics, doi: 10.1038/srep42234. [COBISS.SI-ID 1283498].
- GERVASONI, J. L., JENKO, Monika, PONIKU, Besnik, BELIČ, Igor, JUAN, A. Effects of the electron-hole pair in Auger and X-ray photoemission spectroscopy from surfaces of Fe-Si. *Nuclear instruments & methods in physics research. Section B, Beam interactions with materials and atoms*, ISSN 0168-583X. [Print ed.], 2015, vol. 354, str. 313-316, ilustr. http://www.sciencedirect.com/science/article/pii/S0168583X1500035X, doi: doi:10.1016/j.nimb.2015.01.022. [COBISS.SI-ID 1111466].
- JOKANOVIĆ, Vukoman, VILOTIJEVIĆ, Miroljub, ČOLOVIĆ, B., JENKO, Monika, ANŽEL, Ivan, RUDOLF, Rebeka. Enhanced adhesion properties, structure and sintering mechanism of hydroxyapatite coatings obtained by plasma jet deposition. *Plasma chemistry and plasma processing*, ISSN 0272-4324. [Print ed.], Jan. 2015, vol. 35, iss. 1, str. 1-19. http://link.springer.com/article/10.1007%2Fs11090-014-9599-0, doi: 10.1007/s11090-014-9599-0. [COBISS.SI-ID 18312214].
- CARDOSO SCHWINDT, V., ARDENGHI, J. S., ŠETINA, Barbara, BECHTHOLD, P., GONZÁLEZ, E. A., JASEN, P. V., JUAN, A., JENKO, Monika. Selenium adsorption at different coverages on Fe(1 0 0) and Fe(1 1 1) : a DFT study. *Applied Surface Science*, ISSN 0169-4332. [Print ed.], Oct. 2014, vol. 315, str. 252-260, ilustr. http://www.sciencedirect.com/science/article/pii/S0169433214016596, doi: 10.1016/j.apsusc.2014.07.131. [COBISS.SI-ID 1062826].