

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Nanomateriali
Course title:	Nanomaterials

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Znanost o materialih (2. stopnja)	/	2	3
Materials science (2nd level)	/	2	3

Vrsta predmeta / Course type

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
20			10		120	6

Nosilec predmeta / Lecturer:

Jeziki / Languages: **Predavanja / Lectures:**
Vaje / Tutorial:

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

Prerequisites:

Vsebina:

1. Definicija nanomaterialov
2. Vpliv nano-dimenzij na fizikalno-kemijske lastnosti nanomaterialov ter primerjava z volumenskimi/grobozrnatimi materiali (električne, magnetne in optične lastnosti, površinske in strukturne lastnosti, kemijska reaktivnost)
3. Fizikalne tehnike (litografija, pulzirajoče lasersko nanašanje, epitaksija z elektronskimi žarki, kemijsko nanašanje v parni fazi) za izdelavo nanomaterialov (nanodelci, tanke plasti, sestavljene nanostrukture)
4. Kemijska sinteza (soobarjanje, sol-gel, termični razkroj organo-kovinskih spojin, hidrotermalna, sonokemijska in mikrovalovna sinteza) nanomaterialov (nanodelci, tanke plasti)
5. Funkcionalizacija površin nanomaterialov in njihovo oplaščenje
6. Vrednotenje nanomaterialov (problematika s stališča nano velikosti)
7. Interakcije med nanodelci z osnovami koloidne

Content (Syllabus outline):

1. Definition of nanomaterials
2. Effect of the nano-size on physico-chemical properties of nanomaterials and comparison with bulk/coarse-grained materials (electrical, magnetic and optical properties, surface and structural properties, chemical reactivity)
3. Fabrication of nanomaterials (nanoparticles, thin films, complex nanostructures) with physical techniques (lithography, pulsed laser deposition, electron beam epitaxy, chemical vapour deposition)
4. Chemical synthesis (coprecipitation, sol-gel, thermal decomposition of organo-metallic compounds, hydrothermal, sonochemical and microwave synthesis) of nanomaterials (nanoparticles, thin films)
5. Functionalization and coating of nanomaterials' surfaces
6. Characterization of nanomaterials (issues related to the nano size)

kemije

8. Urejanje nanodelcev (samourejanje, urejanje pod vplivom zunanjega polja) v sestavljene strukture (kompoziti, plasti, volumenski materiali)
9. Uporaba nanomaterialov
10. Nano-varnost (toksičnost in varno ravnanje z nanodelci)

7. Interactions between nanoparticles with basics of colloidal chemistry

8. Assembly of nanoparticles (self-assembly, directed assembly) into complex structures (composites, films, bulk materials)
9. Application of nanomaterials
10. Nanosafety (toxicity issues and safety precautions for handling with nanoparticles)

Temeljna literatura in viri / Readings:

- C. P. Poole Jr., F. J. Owens, "Introduction to Nanotechnology", John Wiley & Sons, Inc., 2003
- T. Sugimoto, "Monodispersed Particles", Elsevier, 2001.
- M.-I. Baraton, "Synthesis, Functionalization and Surface Treatment of Nanoparticles" American Science Publications, 2003.
- G. Schmid, "Nanoparticles - From Theory to Application" Wiley-VCH, 2004.
- K. S. Suslick, "Ultrasound and its Chemical, Physical, and Biological Effects", VCH, Publishers, Inc. 1988
- J. N. Israelachvili, "Intermolecular and Surface Forces", Academic Press Inc. LTD, 1985
- R. Pugh, L. Bergstrom, "Surface and Colloid Chemistry in Advanced Ceramic Processing" ,Marcel Dekker Inc., 1994,
- M. Hosokawa, K. Nogi, M. Naito and T. Yokoyama (Eds.), "Nanoparticle Technology Handbook", Elsevier BV., 2008
- R. F. Probstein, "Physicochemical Hydrodynamics", John Wiley & Sons, 2003
- F. Caruso (Ed.), "Colloids and Colloid Assemblies", Wiley-VCH, 2006
- B. Fadeel, A. Pietroisti, A. A. Shvedova, "Adverse Effects of Engineered Nanomaterials", Elsevier, 2012
- Novejši pregledni članki/Up-to-date review articles

Cilji in kompetence:

Študentje spoznajo pomen izraza "nano" v povezavi z materiali – razumejo pomen njihove velikosti v primerjavi z volumenskimi materiali, atomi in molekulami.

Seznanijo se s posebnimi fizikalno-kemijskimi lastnostmi nanomaterialov, in, s temi povezano, uporabnostjo nanomaterialov. Naučijo se osnovnih fizikalnih tehnik in kemijskih sinteznih metod za pripravo nanomaterialov ter osnovnih postopkov funkcionalizacije in oplaščenja površin nanomaterialov. Pridobijo vpogled v vrednotenje nanomaterialov. Naučijo se osnov koloidne kemije in razumejo interakcije med nanodelci, kar nadgradijo z znanjem o urejanju nanodelcev v sestavljene materiale. Seznanjeni so z varnostnimi vidiki in možno toksičnostjo nanomaterialov, s poudarkom na nanodelcih.

Objectives and competences:

Students get to know the meaning of the "nano" in correlation to materials – they understand the meaning of their size in comparison to bulk materials, atoms and molecules. They learn about specific physico-chemical properties of nanomaterials and related applications. They learn basic physical techniques and chemical synthesis methods for the preparation of nanomaterials, and basic procedures for surface functionalization and coating of nanomaterials. They get an insight into characterization methods for nanomaterials. They learn basics of colloidal chemistry in correlation to interparticle interactions. This knowledge is further upgraded with the knowledge on the assembly of nanoparticles into complex materials. They are acquainted with safety issues of handling with nanomaterials, specifically with nanoparticles, and their potential toxicity.

Predvideni študijski rezultati:

Razumevanje izraza nanomateriali v primerjavi z volumenskimi materiali, molekulami in atomi

Razumevanje fizikalno-kemijskih lastnosti nanomaterialov v primerjavi z volumenskimi

Intended learning outcomes:

Understanding of the meaning of the expression nanomaterials in comparison to bulk materials, atoms and molecules

Understanding of the physico-chemical properties of

materiali.
 Poznavanje osnovnih fizikalnih in kemijskih postopkov za izdelavo in sintezo nanomaterialov
 Poznavanje osnov funkcionalizacije in oplaščenja površin nanomaterialov
 Poznavanje metod vrednotenja nanomaterialov, njihovih omejitev zaradi dimenzije nanomaterialov ter interpretacije rezultatov
 Znanje o interakcijah med nanodelci in njihovo urejanje v sestavljene strukture/materialie
 Poznavanje možnosti uporabe nanomaterialov
 Poznavanje varnostnih vidikov ravnanja z nanomateriali, predvsem z nanodelci, in njihove možne toksičnosti

nanomaterials in comparison to bulk materials, atoms and molecules
 Basic knowledge on physical and chemical procedures for the fabrication and synthesis of nanomaterials
 Knowledge of basic surface functionalization and coating procedures for nanomaterials
 Knowledge of the characterization methods of nanomaterials, the limitations related to their size and interpretation of the results
 Knowledge on interparticle interactions and assembly of nanoparticles into complex structures/materials
 Insight in the potential applications of nanomaterials
 Insight in the safety issues related to handling with nanomaterials, especially with nanoparticles, and their potential toxicity

Metode poučevanja in učenja:

Predavanja, laboratorijsko delo (sinteza, funkcionalizacija, interakcije med nanodelci in urejanje, vrednotenje), seminarska naloga

Learning and teaching methods:

Lectures, lab work (synthesis, functionalization, interparticle interactions and assembly, assembly, characterization), seminar work

	Delež (v %) / Weight (in %)	Assessment:
Načini ocenjevanja:		
<ul style="list-style-type: none"> seminar udeležba pri laboratorijskem delu ustni izpit 	40 20 40	<ul style="list-style-type: none"> seminar work participation in laboratory work oral exam

Reference nosilca / Lecturer's references:

Doc. dr. Darja Lisjak:

Docentka za področje nanoznanosti na Mednarodni podiplomski šoli IJS
 Assistant Professor of Nanosciences at Jožef Stefan International Postgraduate School

Izbrane objave / Selected publications:

- LISJAK, Darja, PLOHL, Olivija, PONIKVAR-SVET, Maja, MAJARON, Boris. Dissolution of upconverting fluoride nanoparticles in aqueous suspensions. *RSC Adv.*, 2015, 5, 27393-27397.
- LISJAK, Darja, OVTAR, Simona, KOVAČ, Janez, GREGORATTI, Luca, ALEMAN, Belen, AMATI, Matteo, FANETTI, Mattia, MAKOVEC, Darko. A surface-chemistry study of barium ferrite nanoplates with DBSa-modified surfaces. *Appl. Surf. Sci.*, 2014, 305, 366-374.
- LISJAK, Darja, JENUŠ, Petra, MERTELJ, Alenka. The influence of the morphology of ferrite nanoparticles on the directed assembly into magnetically anisotropic hierarchical structures. *Langmuir*, 2014, 30, 6588-6595.
- MERTELJ, Alenka, LISJAK, Darja, DROFENIK, Mihael, ČOPIČ, Martin. Ferromagnetism in suspensions of magnetic platelets in liquid crystal. *Nature*, 2013, 504, 237-241.
- LISJAK, Darja, DROFENIK, Mihael. Chemical substitution - an alternative strategy for controlling the particle size of barium ferrite. *Cryst. Growth Design*, 2012, vol. 12, 5174-5179.
- LISJAK, Darja, OVTAR, Simona. Directed assembly of BaFe₁₂O₁₉ particles and the formation of magnetically oriented films. *Langmuir*, 2011, 27, 14014-14024.