UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Osnove sinteze nanomaterialov
Course title:	Fundamentals of Synthesis of Nanomaterials

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 2. stopnja	/	1	2
Nanosciences and nanotechnologijes, 2nd cycle	/	1	2

Vrsta predmeta / Course type	Izbirni / Elective
Univerzitetna koda predmeta / University course code:	NANO2-266

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. Barbara Malič Doc. dr. Tadej Rojac Doc. dr. Miha Čekada

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski, angleški Slovenian, English
	Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Zaključen študij prve stopnje s področja naravoslovja ali tehnike ali zaključen študij prve stopnje na drugih področjih z znanjem osnov s področja predmeta.	Completed first cycle studies in natural sciences or engineering or completed first level studies in other fields with knowledge of fundamentals in the field of this course.

Vsebina:

Splošno o nanomaterialih:
- razmerje površina/volumen,
- termodinamske osnove,
- delitve nanomaterialov po dimenzionalnosti in po metodah sinteze.

Sinteza nanodelcev v raztopini:
- termodinamske osnove nukleacije in rasti nanodelcev,
- koloidne metode sinteze,
- alkoksidna sol-gel sinteza nanodelcev (SFB postopek),
- sežigalna sinteza,
- sinteza z ultrazvočno aktivacijo.

Priprava plasti iz parne faze:

Content (Syllabus outline):

General introduction:
- surface/volume ratio,
- thermodynimcs,
- grouping of nanomaterials according to dimensionality and synthetic approach.

Synthesis of nanoparticles in solution:
- thermodynamics of nucleation and growth,
- colloidal methods of synthesis of nanparticles,
- alkoxide sol-gel synthesis (SFB),
- combustion synthesis,
- ultasonic synthesis.

Vapour phase deposition of thin films:
- vacuum science and technology,

- vakuum, vakuumska tehnologija,
- napršev anje,
- naparevanje, epitaksija z molekularnim snopom,
- laserska depozicija.

Priprava plasti iz raztopin:

- sinteza plasti iz raztopin (sol-gel),
- oprema.

Kserogeli, aerogeli.
Metode karakterizacije nanomaterialov.

- sputtering,
- evaporation, molecular beam epitaxy,
- laser ablation.

Solution deposition of thin films:

- sol-gel, chemical solution deposition,
- equipment.

Xerogels, aerogels.
Methods of characterization of nanomaterials.

Temeljni literatura in viri / Readings:

G. Cao, Nanostructures and Nanomaterials, Imperial College Press, London, 2004.

D. Mitzi (Ed.), Solution Processing of Inorganic Materials, Wiley, Hoboken, 2009.

T. Schneller, R. Waser, M. Kosec, D. Payne (Eds.), Chemical solution deposition of functional oxide thin films, Springer, Wien, 2013.

S.D.Hoath (ed.), Fundamentals of Inkjet Printing, The Sicence of Inkjet and Droplets, Wiley, Weinheim, 2016.

Ciljani izbor in razprava o aktualnih znanstvenih objavah, predvsem v revijah Science, Nature (Nature Nanotechnology, Nature Materials), Advanced Functional Materials, Chemistry of Materials, ACS Nano. / Targeted selection and discussion of scientific publications, particularly from Science, Nature (Nature Nanotechnology, Nature Materials), Advanced Functional Materials, Chemistry of Materials, ACS Nano.

Cilji in kompetence:

Cilj predmeta je seznaniti študente z različnimi metodami sinteze nanomaterialov.
Študent bo znal izbrati primerno metodo sinteze izbranega nanomateriala, poznal bo eksperimentalne omejitve ter prednosti oziroma slabosti posamezne metode.

Cilj se navezuje na kompetence:

- obvladovanje metod in tehnik sinteze nanomaterialov,
- sposobnost za samostojno in skupinsko 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.

Objectives and competences:

The objective of the course is to introduce to students methods of synthesis of nanomaterials. The student will be able to select a suitable method of synthesis of a given nanomaterial, he will recognize experimental limitations, and advantages / disadvantages of a selected method.

This objective is related to competences:

- mastering of methods and techniques of synthesis of nanomaterials,
- ability to carry out independent as well as team R&D work,
- 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:

Študent bo:

- obvladal principe različnih metod sinteze nanomaterialov,
- razumel mehanizme metod sinteze nanomaterialov,

Intended learning outcomes:

The student will:

- master the principles of different methods of synthesis of nanomaterials,
- understand the mechanisms of different methods of synthesis of nanomaterials,

• izbral primerno sintezno metodo sinteze glede na eksperimentalne omejitve, • uporabil primerno metodo karakterizacije, • interpretiral rezultate karakterizacije, • vzpostavil sposobnost komunikacije v angleškem jeziku na področju sinteze nanomaterialov.	• select a suitable method of synthesis for a given nanomaterial considering experimental limitations, • use a suitable method of characterization, • interpret results of characterization, • establish the ability to communicate in English in the field of synthesis of nanomaterials.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Interaktivna predavanja Seminar Delo v laboratoriju Konzultacije	Interactive lectures Seminar Work in laboratory Consultations

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminarska naloga.	30 %	Seminar work.
Zagovor seminarske naloge, pri katerem študent dokaže osvojitev vseh študijskih izidov z vsaj po enim konkretnim primerom.	30 %	Defense of the seminar work where the student demonstrates the achievement of all learning outcomes with at least one specific case for each outcome.
Ustni izpit.	40 %	Oral examination

Reference nosilca / Lecturer's references:

MALIČ, Barbara, SUZUKI, Hisao. Low-temperature processing of solution-derived ferroelectric thin films. *Journal of the Ceramic Society of Japan*, ISSN 1882-0743, 2014, vol. 122, no. 1421, pp. 1-8, doi: 10.2109/jcersj2.122.1.

LI, Shunyi, FRUNZĂ, Raluca C., URŠIČ, Hana, MALIČ, Barbara, et al. Intrinsic energy band alignment of functional oxides. *Physica status solidi, Rapid research letters*, ISSN 1862-6270, 2014, vol. 8, issue 6, pp. 571-576, doi: 10.1002/pssr.201409034.

NOSHCHENKO, Oleksandr, KUŠČER, Danjela, MOCIOIUL, Oana Catalina, ZAHARESCU, Maria, BELE, Marjan, MALIČ, Barbara. Effect of milling time and pH on the dispersibility of lead zirconate titanatein aqueous media for inkjet printing. *Journal of the European ceramic society*, ISSN 0955-2219. [Print ed.], 2014, vol. 34, no. 2, pp. 297-305, doi: 10.1016/j.jeurceramsoc.2013.08.002.

MALIČ, Barbara, GLINŠEK, Sebastjan, SCHNELLER, Theodor, KOSEC, Marija. Mixed metallo-organic precursor systems. In: SCHNELLER, Theodor (ed.), et al. *Chemical solution deposition of functional oxide thin films*. Wien [etc.]: Springer, cop. 2013, str. 51-70.

MALIČ, Barbara, KUPEC, Alja, KOSEC, Marija. Thermal analysis. In: SCHNELLER, Theodor (ed.), et al. *Chemical solution deposition of functional oxide thin films*. Wien [etc.]: Springer, cop. 2013, pp. 163-180.