UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Plazemska nanoznanost
Course title:	Plasma Nanoscience

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:	NANO3-650

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
15	**15**			**15**	**105**	**5**

**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. Uroš Cvelbar
Jeziki / Languages:	**Predavanja / Lectures:**	slovenščina, angleščina / Slovenian, English
	Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Izpolnjeni morajo biti pogoji za vpis na doktorski študij: zaključena druga stopnja bolonjskega študija ali diploma univerzitetnega študijskega programa. Potrebna so tudi osnovna znanja iz trdne snovi.	Student must fulfil the formal requirements for enrolling to the doctoral study program: completed Bologna second level study program or an equivalent pre-Bologna university study program. Basic knowledge of solid state physics is also requested.

Vsebina:	**Content (Syllabus outline):**
Predmet predstavi osnove plazemske nanoznanosti, ki vključuje uporabo reaktivne plazme v procesih nanostrukturiranja površin, različnih plazemskih metod in procesnih tehnik za pripravo nanomaterialov ter procesov, ki potekajo na površinah med plazemsko interakcijo.	The course introduces the basics of plasma nanoscience including the use of reactive plasma in processes for nanostructuring surfaces, different plasma-assisted methods and techniques for preparation of nanomaterials as well as processes which run on surfaces during plasma interaction.
Predstavljene so osnovne interakcije na meji plazma-površina in nastanek 1D, 2D ali 3D nanostruktur ter vloga plazemskih delcev kot osnovnih gradnikov.	The basic interactions on interphase plasma-surface which enable creation of 1D, 2D or 3D nanostructures are presented. Moreover, the role of plasma radicals in these

Nove metode in procesi, ki omogočajo nastanek ali pripravo nanostruktur in temeljijo na plazemsko-podprtih procesih, vključno z jedkanjem, neposredno rastjo nanostruktur na različnih faznih mejah, nanosom iz plinske faze, modifikacijami struktur na osnovi plazemskih delcev, dopiranje, ipd. Nove tehnologije z uporabo različnih plazem in sistemov, ki se uporabljajo za izdelovanje nanostrukturnih površin in nanomaterialov. Trenutni in bodoči izzivi na področju plazemske nanoznanosti.	processes is unrevealed. New methods and processes which enable nanofabrication based on plasma-assisted processes are introduced including etching, direct growth of nanostructures on different interphases, deposition from gas phase, modifications of nanostructures with plasma radicals, doping, etc. New technologies for nanofabrication which are based on different plasmas and systems. Current and grand challenges on the field of plasma nanoscience are presented.

Temeljni literatura in viri / Readings:

Izbrana poglavja iz naslednjih knjig: / Selected chapters from the following books:

- M. Sankaran, "Plasma Processing of Nanomaterials", 2017, CRC, ISBN: 9781138077430
- K. Ostrikov, "Plasma Nanoscience: Basic Concepts and Applications of Deterministic Nanofabrication", 2008, Wiley, ISBN: 978-3-527-40740-8.
- M. Keidar, I. Beilis, "Plasma Engineering – Applications from Aerospace to Bio and Nanotechnology", 2013, Elsevier, ISBN 9780123859785

Ciljani izbor in razprava o aktualnih znanstvenih objavah, predvsem v revijah Science, Nature, Advanced Materials, Nanotechnology, ipd. / Targeted selection and discussion of scientific publications, particularly from Science, Nature, Advanced Materials, Nanotechnology, etc.

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je posredovati študentom obstoječa znanja iz plazemske nanoznanosti in njene uporabe. Študenti se bodo spoznali z osnovami plazemske nanoznanosti, s sodobni postopki za pripravo nanomaterialov ali nanostrukturiranja površin, naprednim jedkanjem za izdelavo nanostrukturiranih vzorcev, neposredno rastjo nanostruktur na faznih mejah, nanosom iz plinske faze in drugimi modifikacijami, ki jih omogoča plazma. Spoznali bodo tudi osnovne postopke in mehanizme, ki omogočajo takšno pripravo površin in vlogo plazemskih delcev pri tem. Študenti bodo razvili sposobnost samostojnega raziskovalnega in razvojnega dela na področju plazemsko podprtega nanostrukturiranja površin in nanomaterialov, ki vključuje osnovno razumevanje, pravilno izbiro postopkov za pripravo površin in	The objective of the course is to deliver to the students the existing knowledge from plasma nanoscience and its applications. Students will learn the basic concepts of plasma nanoscience, modern processes for preparation of nanomaterials or nanostructuring of surfaces including nanofabrication processes like plasma etching for development of nanostructured patterns, direct growth of nanostructures on different interphases, depositions from vapour phase as well as other modifications enabled by plasma. The plasma-assisted processes and mechanisms that enable such surface preparations will be outlined and connected to the roles of plasma radicals. Students will develop the ability to solve independent research and development tasks in the field of plasma-assisted nanostructuring of surfaces and nanomaterials, which includes basic concepts,

rasti nanomaterialov s plazmo. Cilj se navezuje na kompetence: • obvladovanje metod in tehnik • 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.	proper selection of processes for preparation of surfaces and growth of nanomaterials with plasma. This objective is related to competences: • mastering of methods and techniques of sensor technologies, • 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:	**Intended learning outcomes:**
Študent bo z uspešno opravljenimi obveznostmi tega predmeta: • spoznal osnovne plazemske nanoznanosti; • razumel nove koncepte in pristope na področju plazemske nanoznanosti, ki vključujejo uporabo naprednih metod, procesov in tehnologij za izdelavo ali oblikovanje nanostruktur s pomočjo plazme; • izbral primerno metodo za sintezo ali spreminjanje nanomaterialov; • znal interpretirati rezultate meritev; • sledil stanju raziskav in razvoja na področju plazemske nanoznanosti in povezanih tehnologij; • vzpostavil sposobnost komunikacije v angleškem jeziku na področju plazemske nanoznanosti.	Students successfully completing this course will: • learn the basic knowledge of plasma nanoscience; • understand the new concepts and approaches in the field of plasma nanoscience, including advanced methods, processes and technologies for building or modifying nanostructures with plasma; • select a suitable data method for synthesis or modification of nanomaterials; • interpret the results of a measurements; • track the state-of-the-art in research and development in the field of plasma nanoscience and connected nanofabrication technologies; • establish the ability to communicate in English in the field of plasma nanoscience.

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	50 %	Seminar work
Ustni zagovor seminarske naloge	50 %	Oral defense of seminar work

Reference nosilca / Lecturer's references:

- K. Ostrikov, **U. Cvelbar**, A.B. Murphy, "Plasma nanoscience: Setting directions, tackling grand challenges", *J. Phys.D: Appl. Phys*, vol.44, art.no. 174001, 2011.
- O. Baranov, K. Bazaka, H. Kersten, M. Keidar, **U. Cvelbar,** S. Xu, I. Levchenko. "Plasma under control: advanced solutions and perspectives for plasma flux management in material

treatment and nanosynthesis. ” *Applied physics reviews*, vol. 4, no. 4, 041302, 2017.
- G. Filipič, U. Cvelbar, “Copper oxide nanowires: a review of growth”, Nanotechnology, vol. 23, no.11, art.no. 194001, 2012.
- U. Cvelbar, “Towards large-scale plasma-assisted synthesis of nanowires”, J. Phys. D: Appl. Phys., vol. 44, art. no. 174014, 2011.
- U. Cvelbar, et al., »Sub-oxide-to-metallic, uniformly-nanoporous crystalline nanowires by plasma oxidation and electron reduction«, *Chem.Comm.,* vol. 48, no. 90, pp. 11070-11072, 2012.