

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Površine in mejne plasti
Course title:	Surfaces and Interfaces

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, 3 rd cycle	/	1	1

Vrsta predmeta / Course type

Izbirni / Elective

Univerzitetna koda predmeta / University course code:

NANO3-821

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	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 transferred to individual work.*

Nosilec predmeta / Lecturer:

Prof. dr. Albert Prodan

Jeziki /

Predavanja / Lectures: slovenščina ali angleščina / Slovenian or English

Languages:

Seminar: slovenščina ali angleščina / Slovenian or English

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

Osnovno znanje iz druge stopnje študija fizike, kemije ali druge naravoslovne ali tehniške smeri, ali zaključen študij druge stopnje drugih smeri z dokazanim poznavanjem osnov področja predmeta (pisna dokazila, pogovor).

Prerequisites:

Basic knowledge from the first and second degree in physics, chemistry or other natural sciences or engineering, or completed second level studies in other fields with proven knowledge of fundamentals in the field of this course (certificates, interview).

Vsebina:

- Struktura kristalnih površin;
- Adsorpcija in rast tankih plasti iz parne faze;
- Elektronske lastnosti površin;
- Fazni prehodi in rekonstrukcija trdnih površin;
- Površinska energija trdnin in kapljevin, adhezija;
- Mejne plasti tekočin in mehkih snovi;
- Sile med površinami, DLVO-teorija in stabilnost koloidov;
- Uporaba sipalnih metod v analizi površin;
- Augerjeva (AES), rentgenska fotoemisijska (XPS) in masna spektroskopija sekundarnih ionov

Content (Syllabus outline):

- The structure of crystal surfaces;
- Adsorption and growth of thin films from the gas phase;
- Electronic properties of surfaces;
- Phase transitions and reconstructions at solid surfaces;
- Surface energy of solids and liquids, adhesion;
- Interfaces of liquids and soft matter;
- Forces between surfaces, DLVO-theory and stability of colloids;
- The use of diffraction methods in surface analysis;

(SIMS);

- Transmisijska elektronska mikroskopija;
- Tunelska mikroskopija (STM) in mikroskopija na atomsko silo (AFM).

- Auger (AES), X-ray photoemission (XPS) and secondary ion mass (SIMS) spectroscopies;
- Transmission electron microscopy;
- Scanning tunneling (STM) and atomic force (AFM) microscopies.

Temeljna literatura in viri / Readings:

- H. Luth, Solid surfaces, interfaces and thin films, Springer, 6th ed., 2015.
- H. Ibach, Physics of surfaces and interfaces, Springer, 2006.
- J. Israelachvili, Intermolecular and Surface Forces, Academic Press, 3rd ed., 2011.
- B. Voigtländer, Scanning Probe Microscopy: AFM and STM, Springer, 2015.
- G. Friedbacher, Surface and Thin Film Analysis: A Compendium of Principles, Instrumentation, and Applications, Wiley-VCH, 2nd ed., 2011.

Cilji in kompetence:

Cilj predmeta je omogočiti študentom boljše razumevanje osnovnih fizikalnih lastnosti površin in mejnih plasti. Podan bo tudi obširen pregled pomembnejših eksperimentalnih metod in merilnih tehnik za analizo površin.

Cilj se navezuje na kompetence:

- obvladovanje metod in tehnik znanstvenega raziskovanja lastnosti in strukture površin in mejnih plasti,
- sposobnost za samostojno in skupinsko raziskovalno in razvojno delo,
- sposobnost uporabe znanja o površinah v praksi in
- delno tudi razvoj integralnega načina mišljenja ter sposobnost za komunikacijo s strokovnjaki drugih disciplin in področij.

Predmetnospecifične kompetence:

- Predmet daje potrebno teoretično znanje in pripravlja študente za samostojno raziskovalno delo.

Objectives and competences:

The objective of the course is to allow students to acquire a better understanding of the basic physical properties of surfaces and interfaces. An overview will also be given of the important experimental methods and measuring techniques for surface analysis.

This objective is related to competences:

- mastering of methods and techniques of scientific research of properties and structure of surfaces and interfaces,
- ability to carry out independent as well as team R&D work,
- ability to use the knowledge on surfaces 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.

Course Specific Competences:

- The course provides necessary theoretical knowledge and prepares the students for independent research work.

Predvideni študijski rezultati:

Znanje in razumevanje:

- poznavanje in razumevanje različnih fizikalnih in kemijskih pojavov na površinah in mejnih plasteh;
- zmožnost nadzorovane uporabe zahtevnih eksperimentalnih tehnik;
- sposobnost kritičnega vrednotenja postopkov in procesov ter razvoja kritične in samokritične presoje pridobljenih rezultatov;
- sposobnost predstaviti in pojasniti dobljene

Intended learning outcomes:

Knowledge and Understanding:

- knowledge and understanding of different physical and chemical processes at surfaces and interfaces;
- ability of controlled use of sophisticated experimental techniques;
- ability to critically evaluate the procedures and processes and to acquire critical and self-critical judgment of the acquired results;

rezultate;

- sposobnost nadaljnega izpopolnjevanja in uporabe pridobljenega znanja v praksi;
- razvoj komunikacijskih sposobnosti in spretnosti, tako v domačem kot v mednarodnem okolju;
- sodelovanje in skupinsko delo.

- ability to present and clarify acquired results;
- ability to acquire additional knowledge and to apply it in solving practical problems;
- improvement of communication abilities within domestic and international communities;
- collaboration and team work.

Metode poučevanja in učenja:

- Predavanja
- Individualni seminarji
- Laboratorijsko delo (uporaba raziskovalne opreme v reševanju izbranega problema, obdelava in kritično ovrednotenje dobljenih rezultatov, analiza, izdelava predstavitve v obliki seminarja.)

Learning and teaching methods:

- Lectures
- Individual seminar work
- Laboratory work (Solving selected problem with use of research equipment, analysis and critical evaluation of acquired results, analysis and preparation of seminar presentation).

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Ustni izpit	100 %	Oral exam
ali		or
Seminarska naloga.	50 %	Seminar work.
Zagovor seminarske naloge, pri katerem dokaže osvojitve vseh študijskih izidov z vsaj po enim konkretnim primerom.	50 %	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:

- PRODAN, Albert, DUŠIĆ HREN, Ram, VAN MIDDEN, Marion, MIDDEN, Herman J. P. van, ZUPANIČ, Erik. The equivalence between unit-cell twinning and tiling in icosahedral quasicrystals. *Scientific reports*, ISSN 2045-2322, 2017, vol. 7, str. 12474-1-12474-6, doi: [10.1038/s41598-017-12669-w](https://doi.org/10.1038/s41598-017-12669-w).
- ZYBTSEV, S. G., ZUPANIČ, Erik, MIDDEN, Herman J. P. van, ŠTURM, Sašo, TCHERNYCHOVA, Elena, PRODAN, Albert, et al. NbS3 : a unique quasi-one-dimensional conductor with three charge density wave transitions. *Physical review. B*, ISSN 2469-9950, 2017, vol. 95, no. 3, str. 0351101-035110-14, doi: [10.1103/PhysRevB.95.035110](https://doi.org/10.1103/PhysRevB.95.035110).
- ZUBKO, Maciej, KUSZ, Józef, PRODAN, Albert, ŠTURM, Sašo, MIDDEN, Herman J. P. van, BENNETT, J. Craig, DUBIN, Grzegorz, ZUPANIČ, Erik, BÖHM, Horst. Structural phase transition and related electronic properties in quasi-one-dimensional (NbSe₄)_{10/3I}. *Acta crystallographica. Section B, Structural science*, ISSN 0108-7681, 2013, vol. 69, no. 3, str. 229-237, doi: [10.1107/S2052519213010336](https://doi.org/10.1107/S2052519213010336).
- PRODAN, Albert, MIDDEN, Herman J. P. van, ZUPANIČ, Erik, ŽITKO, Rok. Nanostructured and modulated low-dimensional systems. V: *Proceedings of the XXII Conference on Applied Crystallography, 2-6 September 2012, Targanice, Poland*, (Solid state phenomena, ISSN 1012-0394, Vol. 203/204, 2013). Zürich: Scitec Publications. 2013, vol. 203-204, str. 42-47, doi: [10.4028/www.scientific.net/SSP.203-204.42](https://doi.org/10.4028/www.scientific.net/SSP.203-204.42).
- ŽITKO, Rok, MIDDEN, Herman J. P. van, ZUPANIČ, Erik, PRODAN, Albert, MAKRIDIS, S. S., NIARCHOS, Dimitrios, STUBOS, A. K. Hydrogenation properties of the TiBxTiBx structures. *International journal of hydrogen energy*, ISSN 0360-3199. [Print ed.], 2011, vol. 36, no. 19, str. 12268-12278, doi: [10.1016/j.ijhydene.2011.06.087](https://doi.org/10.1016/j.ijhydene.2011.06.087).