

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet	Funkcionalni materiali
Course name	Functional materials

Študijski program in stopnja Study program and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika in Astrofizika II. stopnja	Fizika trdne snovi	2	/
Physics and Astrophysics II. level	Fizika trdne snovi	2	/

Vrsta predmeta / Course type	obvezni / mandatory
Univerzitetna koda predmeta / University course code	2FTS09

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Lab. work	Teren. vaje Field work	Samost. delo Indiv. work	ECTS
30	/	30	/	/	120	6

Nosilec predmeta / Lecturer	doc. dr. Andraž Mavrič	
Jeziki / Languages	Predavanja / Lectures	slovenščina / English
	Vaje / Tutorial	slovenščina / English

Pogoji za opravljanje študijskih obveznosti

Prerequisites

Osnove kristalografije in splošne kemije	Basics of crystallography and general chemistry
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Vsebina	Syllabus outline
<ol style="list-style-type: none"> Kristalni defekti in difuzija v trdnem Materiali za pasivne elektronske komponente (kondenzatorji, induktorji, MW elementi...) Polarni dielektriki (piezoelektriki, feroelektriki, piroelektriki ...) Multiferoični materiali Polprevodniki, (foto)katalizatorji Kristalna struktura tankih filmov in karakterizacija (defekti v strukturi, nanokristaliničnost, polikristaliničnost, epitaksija, homoepitaksija, heteroepitaksija, čezmrežne strukture, rentgenska difrakcija in mikroskopija tankih filmov) Fizikalne metode nanosa tankih filmov (PVD naprševanje, MBE, PLD, e-beam naprševanje) Kemijske metode nanosa tankih filmov (CVD, PECVD, MOCVD, ALD) Izbrana poglavja iz funkcionalnih materialov (seminarska naloga) 	<ol style="list-style-type: none"> Crystal defects and solid-state diffusion Materials for passive electronic components (capacitors, inductors, MW elements...) Polar dielectrics (piezoelectric, ferroelectrics, pyroelectrics...) Multiferroic materials Semiconductors, (photo)catalysts Crystal structures of thin films and characterization of crystal structure (defects in thin films, nanocrystalline, polycrystalline thin films, epitaxy, homoepitaxy and heteroepitaxy; superlattice structures, x-ray diffraction and microscopy of thin films) Physical methods for thin film growth (PVD sputtering, MBE, PLD, e-beam evaporation) Chemical methods for thin film growth (CVD, PECVD, MOCVD, ALD) Selected topics from functional materials (written report)

Temeljni literatura in viri / Basic readings
<p>1) William D. Callister Jr., David G. Rethwisch, Fundamentals of Materials Science and Engineering: An Integrated Approach, 6th Edition, John Wiley and Sons, Inc., New York (2021). 2.) S. Banerjee, A. Tyagi, Functional Materials Preparation, Processing and Applications, Elsevier Inc. (2012) 3) Milton Ohring, Materials Science of Thin Films: Deposition and Structure , 2nd Edition , Elsevier Inc. (2002).</p>

Cilji in kompetence	Objectives and competences
<p>Cilji: osvojitev osnovnih pojmov s področja funkcijskih materialov; osvojitev splošnih principov priprave funkcijskih materialov, pridobitev znanj o strukturi funkcionalnih materialov in njenem vplivu na lastnosti, pridobitev znanj o nanosu in karakterizaciji funkcionalnih tankih filmov, pridobitev znanj o funkciji materialov v različnih sodobnih napravah. Kompetenca: Študent bo sposoben uporabljati pridobljeno znanje pri študiju in raziskovalnem delu povezanem s konstrukcijo različnih elektronskih naprav oziroma pri razvoju novih funkcijskih materialov, znal bo uporabiti pridobljeno znanje za razlago ali analizo fizikalnih problemov povezanih s pripravo, delovanjem in vlogo funkcionalnih materialov.</p>	<p>Objectives: understanding of basic concepts of functional materials; understanding of basic principles of functional material synthesis; gaining knowledge on the structure of the functional materials and its influence on properties; gaining knowledge on the preparation and characterization of functional thin films; gaining knowledge on functional materials as a component of modern devices Competences: the student will be capable of using the acquired knowledge for studying and performing research work related to construction of different electronic devices and development of new functional materials. The student will be able to use the acquired knowledge for interpretation and analysis of physical problems related to preparation and operating principles of functional materials.</p>

Predvideni študijski rezultati	Intended learning outcomes
<p>Po opravljenem izpitu je študent seznanjen z osnovami priprave in delovanja funkcionalnih materialov, njihovi strukturi in njenem vplivu na lastnosti. Študent je sposoben kritične analize pridobljenih podatkov ter uporabe primernih konceptov. Študent pridobi vpogled v sodobne funkcijske naprave, njihovo delovanje in vlogo materialov kot aktivnih oziroma pasivnih komponent naprave</p>	<p>After this course the student is familiar with fundamentals functional materials preparation, working principle, their structure, and influence of structure on their properties. The student is able of critical analysis of the available data and the appropriated use of concepts. The student obtains insight into a modern functional device their operational principle and the role of materials as a passive or active component.</p>

Metode poučevanja in učenja	Learning and teaching methods
<p>- predavanja - seminarske vaje</p>	<p>- lectures - tutorial</p>

Načini ocenjevanja	Utež / Weight (%)	Assessment
- seminarska naloga	50	- written report
- ustni izpit	50	- oral exam

Reference nosilca / references of the course principal

Doc. dr. Andraž Mavrič je docent za področje kemije na Univerzi v Novi Gorici.
Doc. dr. Andraž Mavrič is an assistant professor of chemistry at the University of Nova Gorica.

1. MAVRIČ, Andraž, ŽERJAV, Gregor, BELEC, Blaž, ROŠKARIČ, Matevž, FINŠGAR, Matjaž, PINTAR, Albin, VALANT, Matjaž. Structural disorder of AlMg-oxide phase supporting Cu/ZnO catalyst improves efficiency and selectivity for CO₂ hydrogenation to methanol. *ChemCatChem*. Jul. 2023, vol. 15, issue 13 article no. e202300428. [COBISS.SI-ID [154353923](#)]

2. BELTRAMI, Marco, MAVRIČ, Andraž, DAL ZILIO, Simone, FANETTI, Mattia, KAPUN, Gregor, LAZZARINO, Marco, SBAIZERO, Orfeo, ČEKADA, Miha. A comparative study of nanolaminate CrN/Mo₂N and CrN/W₂N as hard and corrosion resistant coatings. *Surface & coatings technology*. 25 Feb. 2023, vol. 455, article no. 129209. [COBISS.SI-ID [137328899](#)]

3. ROZMAN, Martin, MAVRIČ, Andraž, KRAVANJA, Gregor, VALANT, Matjaž, PAKSERESHT, Amirhossein. Ultra-low-cost, flexible and durable electrochromic tape device based on aluminum foil. *Electrochimica Acta*. 2022, vol. 404, article no. 139760. [COBISS.SI-ID 91666691]

4. JIANG, Jiexuan, MAVRIČ, Andraž, PASTUKHOVA, Nadiia, VALANT, Matjaž, ZENG, Qiugui, FAN, Zeyu, ZHANG, Beibei, LI, Yanbo. Coevaporation of doped inorganic carrier-selective layers for high-performance inverted planar perovskite solar cells. *Solar RRL*. Jul. 2022, vol. 6, iss. 7, article no 2200091. [COBISS.SI-ID [101303811](#)]

5. MAVRIČ, Andraž, FANETTI, Mattia, LIN, Yiting, VALANT, Matjaž, CUI, Chunhua. Spectroelectrochemical tracking of nickel hydroxide reveals its irreversible redox states upon operation at high current density. *ACS catalysis*. 2020, vol. 10, iss. 16, p. 9451-9457. [COBISS.SI-ID [25099011](#)]