

## UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	Kemija materialov
<b>Course title:</b>	Chemistry of Materials

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 <sup>rd</sup> cycle	/	1	1

**Vrsta predmeta / Course type** Izbirni / Elective

**Univerzitetna koda predmeta / University course code:** NANO3-806

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 transferred to individual work.*

**Nosilec predmeta / Lecturer:** Doc. dr. Matjaž Spreitzer

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

**Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** Prerequisites:  
Razumevanje osnov anorganske kemije. Understanding of basics of inorganic chemistry.

### Vsebina:

1. Osnove kristalne strukture:
  - simetrijski elementi,
  - točkovne in prostorske grupe,
  - osnove rentgenske in elektronske difrakcije,
  - difrakcijske tehnike,
  - metode prilagajanja modela kristalne strukture.
2. Napake v kristalih:
  - termodinamika točkastih napak,
  - Kroeger-Vink notacija točkovnih napak,
  - kvazi kemijski pristop k ravnotežju napak,
  - Brouwer-jevi diagrami,
  - interakcija med točkastimi napakami,
  - določanje točkastih napak,
  - linijske in ploskovne napake.
3. Kemijska kinetika v trdnem stanju:
  - makroskopski opis difuzije,
  - atomistični opis difuzije,
  - nerecipročna difuzija,

### Content (Syllabus outline):

1. Introduction to crystal structures
  - symmetry elements,
  - point and space groups,
  - fundamentals of X-ray and electron diffraction,
  - diffraction techniques,
  - crystal structure refinement.
2. Defects in crystals:
  - thermodynamics of point defects,
  - Kroeger-Vink notation of point defects,
  - quasi-chemical approach to point-defect equilibrium,
  - Brouwer diagrams,
  - point-defect interactions,
  - determination of point defects,
  - line and planar faults.
3. Solid-state chemical kinetics:
  - macroscopic description of diffusion,
  - atomistic description of diffusion,

- tipi in določevanje difuzijskih koeficientov.

#### 4. Fazna ravnotežja v trdnih sistemih:

- osnove termodinamskega ravnotežja,
- binarni fazi diagrami,
- ternarni fazni diagrami.

#### 5. Mikrostruktura:

- osnove keramičnih materialov,
- teorija sintranja v trdnem stanju,
- razvoj mikrostrukture v volumski keramiki in tankih plasteh.

- non-reciprocal diffusion,
- types and determination of diffusion coefficients.

#### 4. Phase equilibria in solid systems:

- basics of thermodynamic equilibrium,
- binary phase diagrams,
- ternary phase diagrams.

#### 5. Microstructure:

- basics of ceramic materials,
- theory of solid-state sintering,
- development of microstructure in bulk ceramics and thin films.

### Temeljni literatura in viri / Readings:

- A. R. West. Solid State Chemistry and Its Applications. John Wiley & Sons (2014). ISBN-13: 978-1119942948.
- C. Giacovazzo, H. L. Monaco, G. Artioli, et al. Fundamentals of Crystallography. Oxford University Press (2011). ISBN-13: 978-0199573660.
- G. Friedbacher, H. Bubert. Surface and Thin Film Analysis. Wiley-VCH (2011). ISBN: 978-3-527-32047-9.
- C. Barry Carter, M. Grant Norton. Ceramic Materials: Science and Engineering. Springer (2013). ISBN: 978-1-4614-3523-5
- V. Pecharsky, P. Zavalij. Fundamentals of Powder Diffraction and Structural Characterization of Materials. Springer Science+Business Media (2009). ISBN-13: 978-0387095783.

ter izbor literature za specifično področje iz mednarodne znanstvene periodike / and international scientific articles.

### Cilji in kompetence:

Po opravljenem izpitu študentje iz različnih dodiplomskih programov predvidoma razumejo osnove kristalnih struktur, napak v kristalih, termodinamike trdnega stanja, difuzije v trdnem ter razvoja mikrostrukture materialov. Pridobljeno znanje omogoča razumevanje razlik in podobnosti med posameznimi skupinami funkcionalnih materialov.

#### Splošne kompetence:

- Študent bo razumel osnove raziskovalnih metod in postopkov na področju znanosti o materialih.
- Razvoj kritične presoje pri ocenjevanju eksperimentalnih in literaturnih podatkov.
- Razvoj komunikacijskih spretnosti za predstavitev rezultatov v mednarodnem okolju.

#### Kompetence, specifične za predmet:

Predmet seznanja študente z osnovnimi principi kemije trdnega stanja in karakterizacijskih metod.

### Objectives and competences:

The objective is that upon successful completion of the course students from different undergraduate programs understand basics of crystal structures, defects in crystals, solid-state thermodynamics, diffusion in solids and microstructure development in materials. The acquired knowledge should enable understanding of similarities and differences between individual groups of functional materials.

#### General Competences:

- The student will understand basic principles of the research methods and procedures in the field of materials science.
- The student will develop critical thinking in assessment of experimental and literature data.
- The student will develop communications skills to present research achievements in the international environment.

#### Course Specific Competences:

This course teaches students basic principles of solid-state chemistry and characterization methods.

**Predvideni študijski rezultati:**

<p><u>Znanje in razumevanje:</u></p> <ul style="list-style-type: none"> <li>• Ionskih kristalov – koncepti,</li> <li>• Strukturnih defektov in nestehiometričnosti,</li> <li>• Difuzije,</li> <li>• Termodinamike trdin,</li> <li>• Mikrostrukture.</li> </ul> <p>Pridobljeno znanje bo študentom omogočilo načrtovanje materialov s specifičnimi funkcionalnimi lastnostmi.</p>
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**Intended learning outcomes:**

<p>Knowledge and understanding:</p> <ul style="list-style-type: none"> <li>• Ionic crystals – concepts,</li> <li>• Structural defects and nonstoichiometry,</li> <li>• Diffusion,</li> <li>• Thermodynamics of solids,</li> <li>• Microstructure.</li> </ul> <p>The acquired knowledge will enable students to engineer materials with specific functional properties.</p>
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**Metode poučevanja in učenja:**

<ul style="list-style-type: none"> <li>• Predavanja</li> <li>• Seminarji</li> <li>• Konzultacije</li> <li>• Laboratorijsko delo</li> </ul>
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**Learning and teaching methods:**

<ul style="list-style-type: none"> <li>• Lectures</li> <li>• Seminars</li> <li>• Consultations</li> <li>• Laboratory practice</li> </ul>
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**Načini ocenjevanja:**

Delež (v %) /  
Weight (in %)

**Assessment:**

<ul style="list-style-type: none"> <li>• ustni izpit</li> <li>• predstavitev seminarske naloge</li> </ul>	<p>50 %</p> <p>50 %</p>	<ul style="list-style-type: none"> <li>• oral exam</li> <li>• seminar presentation</li> </ul>
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**Reference nosilca / Lecturer's references:**

<ul style="list-style-type: none"> <li>• SPREITZER, Matjaž, MEDEN, Anton, SUVOROV, Danilo. High-temperature solid-state reactions in the <math>(1-x)\text{Na}_0.5\text{Bi}_0.5\text{TiO}_3-x\text{SrTiO}_3</math> system. <i>Journal of the European ceramic society</i>, ISSN 0955-2219. [Print ed.], [in press] 2017, 8 str., doi: 10.1016/j.jeurceramsoc.2017.09.043. [COBISS.SI-ID 30961959]</li> <li>• FELIX, Anderson A., BEZZON, Vinícius, ORLANDI, Marcelo O., VENGUST, Damjan, SPREITZER, Matjaž, LONGO, Elson, SUVOROV, Danilo, VARELA, José A. Role of oxygen on the phase stability and microstructure evolution of <math>\text{CaCu}_3\text{Ti}_4\text{O}_{12}</math> ceramics. <i>Journal of the European ceramic society</i>, ISSN 0955-2219. [Print ed.], 2017, vol. 37, no. 1, str. 129-136, doi: 10.1016/j.jeurceramsoc.2016.07.039. [COBISS.SI-ID 29680679]</li> <li>• DIAZ-FERNANDEZ, Daniel, SPREITZER, Matjaž, PARKELJ, Tjaša, KOVAČ, Janez, SUVOROV, Danilo. The importance of annealing and stages coverage on the epitaxial growth of complex oxides on silicon by pulsed laser deposition. <i>RSC advances</i>, ISSN 2046-2069, 2017, vol. 7, issue 40, str. 24709-24717, doi: 10.1039/C7RA02820B. [COBISS.SI-ID 30486055]</li> <li>• LI, Lei, SPREITZER, Matjaž, SUVOROV, Danilo. The microstructure, dielectric abnormalities, polar order and microwave dielectric properties of <math>\text{Ag}(\text{Nb}_{1-x}\text{Ta}_x)\text{O}_3</math> (<math>x = 0-0.8</math>) ceramics. <i>Journal of the European ceramic society</i>, ISSN 0955-2219. [Print ed.], 2016, vol. 36, no. 14, str. 3347-3354, doi: 10.1016/j.jeurceramsoc.2016.05.017. [COBISS.SI-ID 29547815]</li> <li>• JOVANOVIĆ, Zoran, SPREITZER, Matjaž, GABOR, Urška, SUVOROV, Danilo. Control of SrO buffer-layer formation on Si(001) using the pulsed-laser deposition technique. <i>RSC advances</i>, ISSN 2046-2069, 2016, vol. 6, issue 85, str. 82150-82156, doi: 10.1039/c6ra16311d. [COBISS.SI-ID 29705255].</li> </ul>
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