

## UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	Plinski senzorji
<b>Course title:</b>	Plinski Senzorji

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Senzorske tehnologije, 3. stopnja	/	1	1
Sensor Technologies, 3 <sup>rd</sup> cycle	/	1	1

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

**Univerzitetna koda predmeta / University course code:** ST3-651

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 transferred to individual work.*

**Nosilec predmeta / Lecturer:** Prof. dr. Uroš Cvelbar

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

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

Zaključena druga stopnja bolonjskega študija ali diploma univerzitetnega študijskega programa. Potrebna so tudi osnovna znanja iz senzorskih tehnologij.

**Prerequisites:**

Completed Bologna second level study program or an equivalent pre-Bologna university study program. Basic knowledge of sensor principles and technologies is also requested.

**Vsebina:**

Prepoznavanje uporabe in načina delovanja različnih vrst plinskih senzorjev, kot so katalitični, elektrokemični, infrardeči in polprevodniški, ter določitev njihove uporabe za zaznavo različnih vrst plinov. Novi postopki za zajemanje signalov na katalitičnih in polprevodniških plinskih senzorjih: potenciometrični, amperometrični, uporovni in resonančni. Nove metode in matematična orodja za obdelavo signalov iz plinskih senzorjev ter njihova analiza.

**Content (Syllabus outline):**

Identification of gas sensor application and detection of different gases. Basics of gas sensor operation in respect to different gas sensor type including catalytic, electrochemical, infrared and semi-conductor sensors. New techniques in signal processing on catalytic and semi-conductor gas sensors: potentiometric, amperometric, resistive and resonant. New methods and mathematical tools for signal processing from gas sensor and their analysis.

Nove tehnologije za izdelavo katalitičnih in polprevodniških plinskih senzorjev, načrtovanje elektrod in materiali za njihovo izdelavo.

Napredni sistemi za zaznavo plinskih molekul, večvrstni sistemi senzorjev in določanje selektivnosti, uporaba nanomaterialov in kvantnih pik.

New technologies for building catalytic and semiconductor gas sensors, design of electrodes and materials for their manufacturing.

Advanced systems for detection of gaseous molecules, multi-array sensor systems and determination of selectivity, use of nanomaterials and quantum dots.

### Temeljni literatura in viri / Readings:

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

- R. Jaaniso, O.K. Tan, Semiconductor Gas Sensors, Elsevier, 2013, ISBN:9780857092366
- C-D. Kohl, T. Wagner, Gas Sensing Fundamentals, 2014, Springer, ISBN:978-3-642-54519-1
- G. Sberveglieri (ed.), Gas Sensors: Principles, Operation and Developments, 2012, Springer, ISBN: 9780792320043
- M. Fleischer, M. Lehmann (ed.), Solid State Gas Sensors – Industrial Applications, 2014, Springer, ISBN: 978-3-642-28093-1
- A. Mandelis, C. Christofides, Physics and Chemistry of Solid State Gas Sensor Devices, 1993, Wiley, ISBN: 978-0-471-55885-9
- G. Korotcenkov, Handbook of Gas Sensor Materials (vol.1/2), 2013, Springer, ISBN: 978-1-4614-7165-3, 978-1-4614-7387-9
- Izbrani znanstveni članki

### Cilji in kompetence:

Cilj predmeta je posredovati študentom obstoječa znanja iz plinskih senzorjev in njihove uporabe.

Študenti bodo seznanjeni s sodobni plinskimi senzorji, kjer bodo izpostavljeni predvsem katalitični in polprevodniški plinski senzorji. Spoznali bodo njihovo uporabo za zaznavo specifičnih plinskih molekul, postopke zajemanja in obdelave signalov, novimi tehnologijami za njihovo izdelavo, določanje selektivnosti in uporabo novih materialov za zaznavo plinov.

Študenti bodo razvili sposobnost samostojnega raziskovalnega in razvojnega dela na področju plinskih senzorjev, ki vključuje načrtovanje, izdelavo, preskušanje in vrednotenje njihovega delovanja.

### Objectives and competences:

The objective of the course is to deliver to the students the existing knowledge of advanced gas sensors.

Students will be acquainted with modern gas sensors with special emphasis on catalytic and semiconductor gas sensors. They will learn about the gas sensor use for detection of specific gaseous molecules, advanced signal acquisition and processing techniques, new technologies for their manufacturing, determination of selectivity and use of new materials for gas sensing.

Students will develop the ability to solve independent research and development tasks in the field of advanced gas sensors, including design, building, testing, and performance evaluation.

### Predvideni študijski rezultati:

Študenti bodo z uspešno opravljenimi obveznostmi tega predmeta pridobili:

- osnovno znanje in razumevanje sodobnih plinskih senzorjev;
- nove koncepte in pristope na področju plinskih senzorjev, ki vključujejo napredne metode, tehnologije in arhitekture;

### Intended learning outcomes:

Students, successfully completing this course will acquire:

- basic knowledge and understanding of existing gas sensors,
- new concepts and approaches in the field of gas sensing, including advanced methods, technologies, and architecture,

- pregled nad stanjem raziskav in razvoja na področju plinskih senzorjev in tehnologij za zaznavo molekul.

- state-of-the-art in research and development in the field of gas sensors and technologies for sensing gaseous molecules.

**Metode poučevanja in učenja:**

predavanja, konzultacije, individualno delo

**Learning and teaching methods:**

lectures, consultancy, individual work

**Načini ocenjevanja:**

Seminarska naloga  
Ustni zagovor seminarske naloge

Delež (v %) /

Weight (in %)

**Assessment:**

Seminar work  
Oral defense of seminar work

**Reference nosilca / Lecturer's references:**

PULIYALIL, Harinarayanan, SLOBODIAN, Petr, SEDLACIK, Michal, BENLIKAYA, Ruhan, ŘÍHA, Pavel, OSTRIKOV, Kostya, CVELBAR, Uroš. Plasma-enabled sensing of urea and related amides on polyaniline. *Frontiers of Chemical Science and Engineering*, ISSN 2095-0179, 2016, vol. 10, iss. 2, str. 265-272, doi: [10.1007/s11705-016-1570-6](https://doi.org/10.1007/s11705-016-1570-6). [COBISS.SI-ID [29500967](#)]

SLOBODIAN, Petr, CVELBAR, Uroš, RIHA, Pavel, OLEJNIK, Robert, MATYAS, J., FILIPIČ, Gregor, WATANABE, H., TAJIMA, S., KONDO, H., SEKINE, M., HORI, Masaru. High sensitivity of a carbon nanowall-based sensor for detection of organic vapours. *RSC advances*, ISSN 2046-2069, 2015, vol. 5, no. 110, str. 90515-90520, doi: [10.1039/C5RA12000D](https://doi.org/10.1039/C5RA12000D). [COBISS.SI-ID [28986151](#)]

SLOBODIAN, Petr, ŘÍHA, Pavel, CAVALLO, Pamela, BARBERO, C. A., BENLIKAYA, R., CVELBAR, Uroš, PETRAS, D., SÁHA, Petr. Highly enhanced vapor sensing of multiwalled carbon nanotube network sensors by n-butylamine functionalization. *Journal of nanomaterials*, ISSN 1687-4110, 2014, vol. 2014, str. 589627-1-589627-8, doi: [10.1155/2014/589627](https://doi.org/10.1155/2014/589627). [COBISS.SI-ID [28512551](#)]

OLEJNIK, Robert, SLOBODIAN, Petr, CVELBAR, Uroš, ŘÍHA, Pavel, SÁHA, Petr. Plasma treatment as a way of increasing the selectivity of carbon nanotube networks for organic vapor sensing elements. *Key engineering materials*, ISSN 1013-9826, vol. 543, 2013. [COBISS.SI-ID [27163687](#)]