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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Fotovoltaika | | | | | | | | | | | | | | |
| **Course title:** | | | Photovoltaics | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| podiplomski doktorski študij tretje stopnje Elektrotehnika | | | | | Ni smeri | | | | | | | | 1. | |  | | |
| post-graduate docgtoral study (3. cycle) programme Electrical Engineering | | | | |  | | | | | | | | 1. | |  | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | izbirni / elective | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64812 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **30** | **15** | | |  | | |  | | | | **5** | | | **75** | |  | **5** |
|  | | | | | | | | | | | | | | | | | |
| **Nosilec predmeta / Lecturer:** | | | | | Prof. dr. Marko Topič | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovenski / Slovene  (foreign students - consultations in English) | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | slovenski / Slovene | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| * vpis v 1. letnik podiplomskega doktorskega študija * priporočeno je poznavanje polprevodniških elementov in osnov optoelektronike | | | | | | | | |  | * enrolment in the 1st academic year of post-graduate doctoral study * recommended is knowledge on semiconductor devices and basics of optoelectronics | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Sončna energija in pregled konceptov pretvarjanja sončne energije v električno.  Sončne celice: principi delovanja in strukture, materiali in tehnologije, lastnosti celic iz kristalnega silicija in na osnovi galijevega arzenida, tankoplastnih celic (silicijevih, halkopiritnih in kadmijteluridnih), mezoskopskih in organskih sončnih celic, tandemskih in večspojnih celic ter celic termofotovoltaike; analiza optičnih in električnih izgub, modeliranje, simulacije in karakterizacija; napredni koncepti in tehnološki trendi.  Fotonapetostni moduli: značilnosti in lastnosti, tehnološki trendi in standardi kristalnosilicijevih, tankoplastnih in koncentratorskih PV modulov. Vrednotenje zmogljivosti, analiza izgub in energijskega izplena, preskušanje, zanesljivost in življenjska doba. Modeliranje, simulacije in karakterizacija.  Fotonapetostni sistemi: omrežni in samostojni PV sistemi, načrtovanje, gradnja in vzdrževanje; močnostni regulatorji in razsmerniki, zaščitni elementi; hranilniki energije; zanesljivost in vzdrževanje; priključevanje na omrežje, ekonomika PV sistemov. | | | | | | | |  | | Solar energy and review of conversion concepts to electrical energy.  Solar cells: principles of operation, structures, materials and technologies, properties of crystalline silicon and gallium arsenide cells, thin-film (silicon, chalcopyrite, cadmium telluride), mesoscopic and organic solar cells; tandem and multijunction solar cells; thermophotovoltaic cells; analysis of optical and electrical losses, modeling, simulations and characterization; advanced concepts and technological trends.  Photovoltaic modules: properties and performance, technology trends of crystalline silicon and GaAs, thin-film and concentrating PV modules. Performance and loss analysis, energy yield, testing, certification and standards, reliability and lifetime. Modeling, simulation and characterization.  Photovoltaic systems: grid-connected and stand-alone PV systems; design and planning, operation and maintenance; power regulators and inverters, protection elements; energy storage concepts; reliability and maintainability; grid-connection, economics of PV systems. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| [1] A. Luque, S. Fonash: Handbook of Photovoltaic Science and Engineering, 2nd Ed, Wiley, 2011.  [2] M.A.Green: Third Generation Photovoltaics: Advanced Solar Energy Conversion, Springer, 2005.  [3] R. A. Messenger and J. Ventre, Photovoltaic Systems Engineering, 3rd Ed., CRC Press (2010)  [4] A. Luque and V. M. Andreev: Concentrator Photovoltaics. Springer, 2007.  [5] Janez KRČ, Marko TOPIČ*. Optical modeling and simulation of thin-film photovoltaic devices*. CRC Press, 2013. XIII, 258 str. ISBN 978-1-4398-1849-7 [COBISS.SI-ID [9762644](http://cobiss.izum.si/scripts/cobiss?command=DISPLAY&base=COBIB&RID=9762644)]. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| * poznavanje pregleda sodobnih gradnikov, tehnologij in trendov v fotovoltaiki * nadgradnja znanja o principih delovanja  fotonapetostnih gradnikov * sposobnost nadaljnjega samostojnega raziskovalnega dela na področju | |  | | * an overview knowledge on contemporary devices, technologies and trends in photovoltaics (PV) * upgrade of knowledge on operational principles of PV devices * ability of further research work in the field | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| * predznanja za nadaljnji razvoj in raziskave na področju fotovoltaične znanosti in inženirstva * razumevanje delovanja in uporabe sodobnih fotonapetostnih gradnikov * specifično raziskovalno delo na ožjem segmentu fotovoltaike (seminarska naloga) | | |  | * pre-knowledge for further research and development in PV science and engineering * understanding of operational principle and usage of photovoltaics devices * specific research work in a selected topic from photovoltaics (seminar work) | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| * predavanja:  v primeru manj kot 7 študentov se na začetku v enem ali dveh terminih izvede samo strnjen sklop predavanj –pregled tematike in trendi;   v primeru več kot 6 študentov se izvede razširjen del predavanj   * konzultacije (predvsem v okviru seminarske naloge) * samostojno delo in seminarska naloga: iz ožjega področja fotovoltaike - študent preuči izbrano tematiko (izbor tematike po posvetu s predavateljem) in izdela seminarsko nalogo, ki jo nato zagovarja | | |  | * lectures:   in case of less than 7 students attending the course only an introductory lecture is given (in one or two days). In the case of more than 6 students extended lectures are provided   * consultations (mostly in the frame of seminar work) * individual work and seminar work: from a specific field of photovoltaics, defined based on agreement between lecturer and student, seminar work is then presented and defended | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| * končna oceno se določi na osnovi izdelane seminarske naloge in ustnega zagovora (pretežno iz tematike seminarske naloge)   Pozitivne ocene: 6 (zad.) – 10 (odl.) | 60% (seminarska naloga / seminar work)  40% (ustni zagovor / oral defense) | | | | * Final grade is based on evaluation of seminar work and oral defense (mainly based on the topic of seminar work) * Positive grades: from 6 to 10 (excellent) |
| **Reference nosilca / Lecturer's references:** | | | | | |
| KRČ, Janez, **TOPIČ, Marko** (2013)Optical modeling and simulation of thin-film photovoltaic devices. CRC Press, New York. 258 str., ISBN 978-1-4398-1849-7.  FILIPIČ, Miha, HOLMAN, Zachary, SMOLE, Franc, DE WOLF, Stefaan, BALLIF, Christophe, **TOPIČ, Marko** (2013) Analysis of lateral transport through the inversion layer in amorphous silicon/crystalline silicon heterojunction solar cells. *Journal of applied physics*, 114: 1-7.  SEVER, Martin, LIPOVŠEK, Benjamin, KRČ, Janez, ČAMPA, Andrej, SÁNCHEZ PLAZA, Guillermo, HAUG, Franz-Josef, DUCHAMP, Martial, SOPPE, Wim J., **TOPIČ, Marko** (2013) Combined model of non-conformal layer growth for accurate optical simulation of thin-film silicon solar cells. *Solar energy materials and solar cells*, 119: 59-66.  FILIPIČ, Miha, BERGINC, Marko, SMOLE, Franc, **TOPIČ, Marko** (2012) Analysis of electron recombination in dye-sensitized solar cell. *Current applied physics*, 12: 238-246.  KRČ, Janez, LIPOVŠEK, Benjamin, BOKALIČ, Matevž, ČAMPA, Andrej, OYAMA, T., KAMBE, M., MATSUI, T., SAI, H., KONDO, M., **TOPIČ, Marko** (2010) Potential of thin-film silicon solar cells by using high haze TCO superstrates. *Thin Solid Films*, 518: 3054-3058. | | | | | |