|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Nanoelektronika | | | | | | | | | | | | | |
| **Course title:** | | | Nanoelectronics | | | | | | | | | | | | | |
|  | | | | |  | | | | | | |  | |  | | |
| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Podiplomski magistrski študijski program druge stopnje Elektrotehnika | | | | | Elektronika | | | | | | | 1 | | 2 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | Electronics | | | | | | | 1 | | 2 | | |
|  | | | | | | | | | | | | | | | | |
| **Vrsta predmeta / Course type** | | | | | | | | | | | Obvezni-strokovni /  Compulsory professional | | | | | |
|  | | | | | | | | | | |  | | | | | |
| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | 64226 | | | | | |
|  | | | | | | | | | | | | | | | | |
| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** |  | | | **30** | |  | | | |  | | | **75** | |  | **6** |
|  | | | | | | | | | | | | | | | | |
| **Nosilec predmeta / Lecturer:** | | | | | Franc Smole | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | |
| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovenski/Slovene | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | slovenski/Slovene | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik. | | | | | | | |  | Enrolment in the year of the course. | | | | | | | |
| **Vsebina:** | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Definicija nanoelektronike in nanotehnologij. Obeti na področju nanoznanosti.  Pregled postopkov izdelave nanostruktur. Oblikovanje od zgoraj navzdol in od spodaj navzgor. Skaliranje in lastnosti klasičnih elementov pri mejnih dimenzijah. Samosestavljanje. Molekularna nanoelektronika. Novi modeli stikal in pomnilnikov. Arhitektura nanoelektronskih vezij. Arhitektura nanoračunalnikov. Magnetne, optične in elektronske lastnosti nanodelcev. Nanoprevodniki.  Transportne lastnosti polprevodniških nanostruktur. Nanoelementi. Enoelektronski elementi. Spintronika. Polimerna elektronika.  Organski aktivni in pasivni elementi in vezja. Nanofotonika. Kvantne pike in kvantne žice. Ogljikove nanocevke in nanožice.  Zgradba in lastnosti ogljikovih nanocevk. Elektronske, optoelektronske, magnetne, kemijske in termoelektrične lastnosti ogljikovih nanocevk. Elektronski elementi in vezja na osnovi nanocevk. Kemijski in biološki nanosenzorji. Nano in mikronaprave. Modeliranje in simulacija kvantnih in nanosistemov. | | | | | | |  | | Definition of nanoelectronics and nanotechnology. An outlook of nanoscience. Review processes for manufacturing nanostructures. The top-down approach. The bottom-up approach. Device scaling and nonideal effects. Self-assembly. Molecular nanoelectronics. Switches and complex molecular devices. Nanoelectronic circuit architectures. Computer architectures based on molecular electronics. Electromagnetic, optical and electronic properties of nanostructures.  Transport properties of semiconductor nanostructures. Single-electron transistor. Nanomagnetics and spintronics. Polymer electronics. Organic active and passive devices and circuits. Nanophotonics. Quantum dots, quantum wells and quantum wires. Carbon nanotubes and nanowires. Structure and properties of carbon nanotubes. Electronic, optoelectronic, magnetic, chemical and thermoelectrical properties of carbon nanotubes. Electronic devices and circuits based on nanotubes. Chemical and biological nanosensors. Nano- and micromachines. Modeling and simulation of quantum- and nanosystems. | | | | | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Temeljni literatura in viri / Readings:** | | | |
| 1. William A. Goddard, Donald W. Brenner, Sergey Edward Lyshevski, Gerald J. Iafrate, Nanoscience, Engineering, and Technology, CRC Press LLC, 2012. 2. Paul Harrison, Quantum Wells, Wires and Dots, Theoretical and Computational Physics of Semiconductor Nanostructures, John Wiley & Sons, Ltd, 2009. 3. Edward L. Wolf, Nanophysics and Nanotechnology, Wiley-VCH Verlag GmbH & Co. KGaA, 2008. 4. M. Meyyappan, Carbon Nanotubes, Science and Applications, CRC Press LLC, 2005. 5. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Prentice Hall, 2008. 6. F. Smole, Nanoelektronika, Založba FE in FRI, 2014, 355 str., ISBN 978-961-243-250-8. | | | |
| **Cilji in kompetence:** |  | | **Objectives and competences:** |
| Cilj predmeta je usvojiti osnovne definicije in koncepte, se seznaniti s smermi razvoja in raziskav na področju nanoelektronike ter spoznati karakteristike že raziskanih struktur, elementov in sistemov. |  | | The aim of the course is to upgrade definitions and concepts and to introduce students with research trends in the field of nanoelectronics and to survey characteristics of already investigated structures, devices and systems. |
| **Predvideni študijski rezultati:** | |  | **Intended learning outcomes:** |
| Študent bo usvojil temeljna znanja s hitrorazvijajočega se področja nanoelektronike in nanotehnologij. Razumel bo osnovne koncepte nanoelektronike, vključno z enoelektronskimi pojavi in elektronskim transportom v nanoskopskih sistemih. Razumel bo kvantne jame, pike, in žice ter njihove nanoelektronske aplikacije. | |  | Student will acquire knowledge from rapidly developing field of nanoelectronics and nanotechnologies through gained ability to understand the concepts of nanoelectronics, including one-electron phenomenons and electronic transport in nanoscopic systems. In addition, the nanoelectronic applications of quantum wells, dots and wires will be explained. |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Metode poučevanja in učenja:** | |  | **Learning and teaching methods:** | | |
| predavanja, laboratorijske vaje | |  | lectures, laboratory assignments | | |
| **Načini ocenjevanja:** | Delež (v %)  Weight (in %) | | | **Assessment:** | |
| Način: laboratorijske vaje, seminar, pisni izpit, ustni izpit.  Opravljene laboratorijske vaje in seminar so pogoj za pristop h končnemu izpitu.  Ocene od 1 do vključno 5 so negativne, ocene od vključno 6 do 10 so pozitivne.  Prispevki k oceni:   * seminar * pisni izpit * ustni izpit | 30%  40%  30% | | | Type: laboratory exercises, seminar, written exam, oral exam.  Conducted laboratory assignments and seminar present a condition for undertaking the final exam.  Negative grades: from 1 to 5, positive grades: from 6 to 10.  Contributions to final grade:   * seminar * written exam * oral examination | |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. SEIF, Johannes Peter, DESCOEUDRES, Antoine, FILIPIČ, Miha, SMOLE, Franc, TOPIČ, Marko, HOLMAN, Zachary Charles, DE WOLF, Stefaan, BALLIF, Christophe. Amorphous silicon oxide window layers for high-efficiency silicon heterojunction solar cells. *Journal of applied physics*, 2014, vol. 115, no. 2, str. 1-8. 2. FILIPIČ, Miha, HOLMAN, Zachary, SMOLE, Franc, DE WOLF, Stefaan, BALLIF, Christophe, TOPIČ, Marko. Analysis of lateral transport through the inversion layer in amorphous silicon/crystalline silicon heterojunction solar cells. *Journal of applied physics*, 2013, vol. 114, no. 7, str. 1-7. 3. HOLMAN, Zachary, FILIPIČ, Miha, LIPOVŠEK, Benjamin, DE WOLF, Stefaan, SMOLE, Franc, TOPIČ, Marko, BALLIF, Christophe. Parasitic absorption in the rear reflector of a silicon solar cell: simulation and measurement of the sub-bandgap reflectance for common dielectric/metal reflectors. *Solar energy materials and solar cells*, [Print ed.], Jan. 2014, vol. 120, part A, str. 426-430. 4. FILIPIČ, Miha, BERGINC, Marko, SMOLE, Franc, TOPIČ, Marko. Analysis of electron recombination in dye-sensitized solar cell. *Current applied physics*, Jan. 2012, vol. 12, no. 1, str. 238-246. 5. NERAT, Marko, SMOLE, Franc, TOPIČ, Marko. A simulation study of the effect of the diverse valence-band offset and the electronic activity at the grain boundaries on the performance of polycrystalline Cu(In,Ga)Se2 solar cells. *Thin Solid Films*, [Print ed.], 2011, vol. 519, no. 21, str. 7497-7502. | | | | | |