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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Nanoelektronika | | | | | | | | | | | | | | |
| **Course title:** | | | Nanoelectronics | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| doktorski študijski program tretje stopnje Elektrotehnika | | | | | Ni smeri | | | | | | | | 1 | |  | | |
| 3rd cycle: doctoral study programme Electrical Engineering | | | | |  | | | | | | | |  | |  | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | izbirni / elective | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64813 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **30** | **15** | | | **0** | | |  | | | | **5** | | | **75** | |  | **5** |
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| **Nosilec predmeta / Lecturer:** | | | | | Prof. dr. Franc Smole | | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | **slovenski / Slovene** | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | **slovenski / Slovene** | | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v prvi letnik doktorskega programa (3. stopnja) in priporočeno osnovno poznavanje polprevodniške elektronike | | | | | | | | |  | Enrolment in the 1st year of PhD programme (Level III) and recommended basic knowledge of semiconductor electronics | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Definicije nanoelektronike in nanotehnologij. Obeti na področju nanoznanosti. Klasični in kvantni delci in valovanja. Prosti in ujeti elektroni. Coulombova blokada. Kvantne pike, jame in žice. Tuneliranje, tunelski spoji in elementi na osnovi tuneliranja. Oblikovanje od zgoraj navzdol in od spodaj navzgor. Skaliranje in lastnosti klasičnih elementov pri mejnih dimenzijah. Hitri elementi na osnovi kvantnih učinkov in superrešetk. Kvantni tranzistorji in integrirani sklopi s tankoplastnimi heterospojnimi strukturami. Enoelektronski tranzistor. Postopki izdelave nanostruktur. Samosestavljanje. Molekularna nanoelektronika. Novi modeli stikal in pomnilnikov. Arhitektura nanoelektronskih vezij. Arhitektura nanoračunalnikov. Magnetne, optične in elektronske lastnosti nanodelcev. Nanoprevodniki. Transportne lastnosti polprevodniških nanostruktur. Balistični transport. Nanomagnetika in spintronika. Nanofotonika. Polimerna elektronika. Organski aktivni in pasivni elementi in vezja. 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 nano sistemov. | | | | | | | |  | | Definition of nanoelectronics and nanotechnology. An outlook of nanoscience. Classical and quantum particles and waves. Free and confined electrons. Coulomb blockade. Quantum dots, quantum wells and quantum wires. Tunneling, tunnel junctions and applications of tunneling. The top-down approach. The bottom-up approach. Device scaling and nonideal effects. Electronic devices based on quantum heterostructures and superlattices. Single-electron transistor. Growth, fabrication, and measurement techniques for nanostructures. Manipulation and assembly. Self-assembly. Molecular nanoelectronics. Computer architectures based on molecular electronics. Switches and complex molecular devices. Nanoelectronic circuit architectures. Electromagnetic, optical and electronic properties of nanostructures. Transport properties of semiconductor nanostructures. Ballistic transport. Nanomagnetics and spintronics. Nanophotonics. Polymer electronics. Organic active and passive devices and circuits. 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. | | | | | | | |

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| **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. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Cilj predmeta je usvojiti definicije in koncepte, se seznaniti s smermi razvoja in raziskav na področju nanoelektronike ter spoznati karakteristike že raziskanih struktur, elementov in sistemov. Pridobljeno znanje bo študentu omogočilo lažje uvajanje v široko interdisciplinarno področje nanoelektronike in nanotehnologij. | |  | | 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.  Gained knowledge will enable students easier involvement in broad interdisciplinary field of nanoelectronics and nanotechnology. | |
| **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. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| predavanja, seminarji | | |  | lectures, seminars | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Seminar in ustni izpit.  Pogoj za pristop k ustnemu izpitu je uspešno predstavljen seminar. | Seminar 40 %,  ustni izpit 60 %.  Seminar 40 %,  oral exam 60 %. | | | | Seminar and oral exam.  Prerequisite for an oral exam is a successfully defended seminar. |
| **Reference nosilca / Lecturer's references:** | | | | | |
| **1.** Seif JP, Descoeudres A, Filipič M, Smole F, Topič M, Holman ZC, De Wolf S, Ballif C (2014) Amorphous silicon oxide window layers for high-efficiency silicon heterojunction solar cells. Journal of applied physics 115:1-8  **2.** Filipič M, Holman Z, Smole F, De Wolf S, Ballif C, Topič M (2013) Analysis of lateral transport through the inversion layer in amorphous silicon/crystalline silicon heterojunction solar cells. Journal of applied physics 114:1-7  **3.** Holman Z, Filipič M, Lipovšek B, De Wolf S, Smole F, Topič M, Ballif C (2014) 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 120, part A:426-430  **4.** Filipič M, Berginc M, Smole F, Topič M (2012) Analysis of electron recombination in dye-sensitized solar cell. Current applied physics 12, no. 1:238-246  **5.** Nerat M, Smole F, Topič M (2011) 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 519, no. 21:7497-7502 | | | | | |