# Specification for the book of courses

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| **Study program** | Electrical Engineering and Computer Science | | |
| **Module** | Electron Devices and Microsystems | | |
| **Type and level of studies** | Undergraduate Academic Studies | | |
| **The name of the course** | Solid State Electronics | | |
| **Lecturer (for lectures)** | Prijić P. Aneta | | |
| **Lecturer/associate (for exercises)** | Prijić P. Aneta, Stojković S. Aleksandra | | |
| **Lecturer/associate (for OFE)** | | | |
| **Number of ECTS** | 6 | **Course status (obligatory/elective)** | Elective |
| **Prerequisites** | | | |
| **Course objectives** | Objectives of the course are focused on:<br>- Introduction to the crystalline structure of the semiconductor;<br>- Representation of the concept of energy zones, Fermi level, distribution functions and effective mass of carriers in semiconductors;<br>- Understanding the properties of intrinsic and doped semiconductors;<br>- Definition of the drift and diffusion transport of the carriers inside the semiconductor;<br>- Getting aqcuinted with the recombination of carriers;<br>- Definition of equations that describe carrier transport and equilibrium in a semiconductor;<br>- Understanding of the carriers behavior in a high electric fields;<br>- Study of the properties of the P-N junction (built-in voltage, depletion region and capacitance);<br>- Study of the properties of MOS structures (threshold voltage and C-V plots). | | |
| **Course outcomes** | Learning outcomes allow a student to:<br>- Visualize the concept of energy bands and position of the Fermi and doping levels;<br>- Explain the dependence of the charge carriers distribution functions on the semiconductor type, temperature and doping concentration;<br>- Determine the concentration of free charge carriers in the semiconductor, depending on the concentration of the dopants;<br>- Analyze the effects of drift, diffusion and recombination of carriers in the semiconductor;<br>- Formulates the transport and continuity equations within the semiconductor;<br>- Determine the built-in voltage, depletion region width and the capacitance of the defined P-N junction;<br>- Determine the threshold voltage of the defined MOS structure;<br>- Define the difference between the low-frequency and high-frequency C-V plots of the MOS structure. | | |
| **Course outline** | | | |
| **Theoretical teaching** | Introduction. Structure of the atom and types of bonds in materials. Crystal structure of a semiconductor. Energy bands. Intrinsic semiconductor. Doped semiconductors. Fermi level. Charge carriers distribution functions. Dual nature of the electron. E(k) dependencies. The effective mass of carriers. Concentrations of free carriers. Lightly and moderately doped semiconductor. Heavily doped semiconductor. Ionization of the dopants. Drift velocity and mobility of charge carriers. The electric conductivity of a semiconductor. Drift and diffusion currents. Einstein's relation. Transport equations. Quasi-Fermi levels. Recombination of carriers in semiconductors. Equation of continuity. Conductivity in high fields. Tunnel and avalanche breakdown. P-N junction: abrupt and linear. Built-in voltage, depletion region width and capacitance of the P-N junction. Contact metal-semiconductor. Heterojunction. MOS structure (capacitor). Threshold voltage and C-V plots of the MOS structure. | | |
| **Practical teaching (exercises, OFE, study and research work)** | Computer simulation of physical phenomena in semiconductor structures under different technological, thermal and electrical conditions: Distribution functions of charge carriers and ionization of dopants; Fermi-Dirac distribution and Fermi level in semiconductors; drift velocity and dependence of carrier mobility on temperature and doping concentrations; drift currents presented through energy zones; Haines-Schokley experiment; drift, diffusion and recombination of carriers; P-N junction: built-in voltage, depletion region width, energy bands and capacitance; MOS capacitor - the influence of gate material, the effect of bias on carriers in the substrate, the influence of oxide thickness and charge in oxide; MOS capacitor - C-V plots. | | |
| **Textbooks/references** | | | |
| 1 | S. Dimitrijev, "Principles of Semiconductor Devices", Oxford University Press, 2011. | | |
| 2 | D. Neaman, "Semiconductor Physics and Devices", 4th Edition, McGrawHill, 2011 - selected chapters. | | |

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| 3 | PC excercises manual. |
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| **Number of classes of active education per week during semester/trimester/year** | | | | |
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| **Lectures** | **Exercises** | **OFE** | **Study and research work** | **Other classes** |
| 2 | 2 | 0 | 0 | 0 |

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| **Teaching methods** | Theoretical lectures - using slides; PC exercises |

| **Grade (maximum number of points 100)** | | | |
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| **Pre-exam duties** | **Points** | **Final exam** | **Points** |
| **Activity during lectures** | 30 | **Written exam** | 40 |
| **Exercises** | | **Oral exam** | 30 |
| **Colloquia** | | | |
| **Projects** | | | |