Specification for the book of courses

Study program	Electronics and Microsystems		
Module	Electronics and Microsystems		
Type and level of studies	Master studies		
The name of the course	Basics of Photovoltaic conversion		
Lecturer (for lectures)	Aleksić M. Sanja		
Lecturer/associate (for exercises)	Aleksić M. Sanja		
Lecturer/associate (for OFE)	Aleksić M. Sanja		
Number of ECTS	5	**Course status (obligatory/elective)**	Elective
Prerequisites	No		
Course objectives	The objective of the course is for students of master studies to learn more about the characteristics of solar radiation and the principles of solar energy conversion in order to understand the principle of solar cell operation and to acquire basic knowledge about the materials used in the production of solar cells.		
Course outcomes	After fnishing the course, the student fully understands the characteristics of solar radiation and the principle of photovoltaic conversion, the basics of semiconductor physics and photovoltaic cells, the processes of generation and recombination of carriers in the semiconductor, as well as the characteristics of the pn-bond in equilibrium and under the influence of light. Also, knowledge about different types of solar cells (mc-Si, GaAs, a-Si, thin-film, organic), methods of solar cell design and techniques for increasing their efficiency are acquired.		
Course outline			
Theoretical teaching	Introduction to renewable energy sources. Solar energy, solar radiation, solar radiation spectrum, solar constant, average solar radiation, direct, reflected and diffused radiation. Sun-Earth geometry, relative motion and determination of the position of the Sun relative to the defined location. Radiation of the black body, Plankov law, spectral distribution of extraterrestrial and radiation on the surface of the Earth. Properties of a semiconductor, crystal structure, energy zones, dynamics of the electron and cavities in the crystal structure, the density of the energy states, the concentration of electrons and cavities. Light absorption, direct and indirect semiconductors, light absorption coefficient, reflection and reflection losses. Absorption of light in the function of photon energy, surface states and defects. Recombination processes, carrier transport. Density of donors and acceptors, system of basic semiconductor equations. pn-connection, spatial charge region, impoverishment region, built-in potential, concentrations of minority and majority charge carriers, carrier injection, current-voltage characteristic of unexposed and illuminated joints. The principle of solar cell work. Basic structure of the solar cell. Speed of generation and recombination of bearers, current of darkness, current generated by the light, current-voltage characteristic. Electrical parameters of the solar cell, open circuit voltage, short circuit current, maximum power, fill factor, efficiency. The influence of geometry on the characteristics of the solar cell, maximum thermodynamic efficiency. Equivalent solar cell. Practical efficiency constraints, short circuit currents, open circuit voltage, fill factor and efficiency. The influence of temperature on the characteristics of the solar cell, the influence of parasitic resistances. Spectral response and quantum efficiency. Measurement of current-voltage characteristics and solar cell efficiency. Optimal design of the solar cell based on the minimization of optical and recombination losses. Simulation of electrical characteristics of different types of solar cells.		
Practical teaching (exercises, OFE, study and research work)	Modeling of extraterrestrial solar radiation. Modeling global solar radiation. Modeling the position of the Sun relative to the defined location. Modeling the electrical characteristics of the solar cell under standard test conditions. Determination of open circuit voltage VOC and short-circuit current of the ISC solar cell, depending on the intensity of solar radiation. Measurement of open circuit voltage VOC and short-circuit current of the ISC solar cell, depending on the incident angle of the solar air. Measurement of open circuit voltage VOC and short circuit current of ISC solar cell, depending on temperature. Simulation of the technological array for the production and electrical characteristics of the mc-Si solar cell. Simulation of the technological array for the production and electrical characteristics of high-efficiency Si solar cells.		
Textbooks/references			

1	Photovoltaic Devices, Systems and Applications CD-ROM, C. Honsberg and S. Bowden, (free online resource)
2	Solar Cell Device Physics, Stephen Fonash, Academic Press, 2010.
3	Physics of Solar Cell, Peter Würfel, WILEY-VCH Verlag GmbH & Co., 2005.
4	The Physics of Solar Cell, Jenny Nelson, Word Scientific, 2003.
5	Lectures and exercises (http://mikro.elfak.ni.ac.rs/osnove-fotonaponske-konverzije/)

Number of classes of active education per week during semester/trimester/year				
Lectures	**Exercises**	**OFE**	**Study and research work**	**Other classes**
2	2	1		

Teaching methods	Lectures, independent studio research work, computational exercises, laboratory exercises, consultations. Lectures are conducted in combination. The lectures present the theoretical part of the material, supported by characteristic examples for easier understanding of matter. Through student research work, a student studying available literature, doing a seminar work or a team project. Practical examples of semiconductor and solar cell physics are used in computational exercises, and in laboratory exercises, using computer and available software, simulate and model electrical characteristics of different types of solar cells and optimize their geometries in order to increase their efficiency.

Grade (maximum number of points 100)			
Pre-exam duties	**Points**	**Final exam**	**Points**
Activity during lectures	5	**Written exam**	25
Exercises	15	**Oral exam**	25
Colloquia	30		
Projects			