DEPARTMENT OF ENERGY SCIENCE AND TECHNOLOGY
COURSE SYLLABUS

Course Details

Code	Academic Year			Semester
EBT315	3			Fall
Title	**T**	**A**	**L**	**ECTS**
Physics of Solar Cells	2	1	0	6

Language	German						
Level	**Undergraduate**	**X**	**Graduate**		**Postgraduate**		
Department / Program	Energy Science and Technology						
Forms of Teaching and Learning	Face-to-face						
Course Type	**Compulsory**	**X**	**Elective**				
Objectives	To explain the structures of solar cells, interactions, electron-hole production methods and mechanisms in solar cells, parameters of solar cells in electrical energy production; to teach semiconductor properties and efficiency calculation of solar cells.						
Content	Solar cell types, structures and materials used. Electron-hole formation mechanisms and electricity generation in solar cells. Doping types and calculations, physical interactions and operating principles in solar cells. Power calculations in cell-to-array and array-to-module transition.						
Prerequisites	None						
Coordinator	Asist Prof.Dr. Gülsüm Gündoğdu						
Lecturer(s)	Asist Prof.Dr. Gülsüm Gündoğdu						
Assistant(s)	Research Assist. Elvan Burcu Koşma						
Work Placement	None						

Recommended or Required Reading

Books / Lecture Notes	Semiconductor Physics and Devices Basic Principles, Fourth Edition, Donald A. Neamen
Other Sources	Grundlagen der Halbleiterphysik, Springer, Jürgen Smoliner Photovoltaik, Wie Sonne zu Strom wird, Viktor Wesselak Sebastian Voswinckel Physik der Sollarzellen, Spektrum, Peter Würfel

Additional Course Material

Documents	-
Assignments	-
Exams	-

Course Composition

Mathematics und Basic Sciences	10	%
Engineering	30	%

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Engineering Design		%
Social Sciences		%
Educational Sciences		%
Natural Sciences	30	%
Health Sciences		%
Field Knowledge	30	%

Assessment

Activity	Count	Percentage (%)
Midterm Exam	-	-
Quiz	-	-
Assignments	-	-
Attendance	-	-
Recitations	-	-
Presentation	1	40
Final Exam	1	60
	Total	**100**

ECTS Points and Work Load

Activity	Count	Duration	Work Load (Hours)
Lectures	14	2	28
Self-Study	14	7	98
Assignments	10	3	30
Presentation / Seminar Preparation	1	16	16
Midterm Exam	0	0	0
Recitations	0	0	0
Laboratory	0	0	0
Projects	0	0	0
Final Exam	1	2	2
		Total Work Load	**174**
		ECTS Points (Total Work Load / Hour)	**6**

Learning Outcomes

1	To be able to use basic knowledge about solar radiation, photoelectric effect and energy conversion
2	To be able to express and analyze the structure of semiconductors and electron-vacancy transport in semiconductors physically and mathematically
3	Understanding the structure of solar cells, basic mechanisms, p-n junction characteristics and semiconductor-metal contacts
4	To be able to model energy conversion in solar cells, the dependence of conversion efficiency on material and operating parameters, to be able to follow basic research on solar cells

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Weekly Content	
1	Solar cells, photoelectric effect and photovoltaic energy conversion principles
2	Photon, blackbody radiation, photon density, photon energy distribution, solar spectrum, absorption and emission, atmospheric effects on the spectrum
3	Energy flux, Stefan-Boltzmann radiation law, Kirchoff's law for materials other than blackbody, concentration of solar radiation, Abbe sine condition, geometric optics
4	Electron behavior in semiconductors, distribution function, density of states, vacancies, doping, Fermi energy, energy bands, work function
5	Interactions of radiation with semiconductors, absorption of photons in semiconductor structures, generation of electrons and vacancies, direct and indirect transitions, radiative and non-radiative recombinations, lifetime of electron-vacancy pairs
6	Electron-vacancy transport, field current, diffusion current, diffusion length, relaxation, Diffusion length of minority carriers, dielectric relaxation, ambipolar diffusion, Dember effect
7	Diffusion length of minority carriers, dielectric relaxation, ambipolar diffusion, Dember effect
8	Basic mechanisms in a solar cell, pn-junction, electrochemical equilibrium of electrons in a pnjunction in the dark, potential distribution across the pn-junction and current-voltage characteristics of the pn-junction, Presentation
9	Derivation of saturation and short-circuit currents, semiconductor-metal contacts, Schottky contact, MIS contact, role of electric field in solar cells
10	Limits of energy conversion in solar cells, maximum efficiency, efficiency as a function of energy gap, optimal silicon solar cells
11	Thin film solar cells, equivalent circuits, temperature dependence of open circuit voltage, dependence of efficiency on radiation intensity, efficiencies of energy conversion processes in solar cells
12	Concepts of efficiency enhancement in solar cells, tandem cells, electrical connections of tandem cells, concentrator cells, thermal-photovoltaic energy conversion
13	Energy conversion by collisional ionization, hot electron and vacancy
14	Two-stage excitation in three-level systems, impurity photoelectric effect, future of research in solar cells
15	Final exam

Contribution of Learning Outcomes to Program Objectives (1-5)

	P1	P2	P3	P4	P5	P6	P7	P8	P9
1	3	4	4	5			5		5
2	3	3	4	4			5		5
3	5	5	4	4			5		5
4	3	3	4	5			5		5

Contribution Level	1: Low 2: Low-intermediate 3: Intermediate 4: High 5: Very High

Program Learning Outcomes: With the successful completion of this program, students will be able to

1 : Awareness of the necessity of lifelong learning; accessibility, monitoring and self-adaptation in science and technology.
2 : Capability to identify, define, formulate and solve energy systems problems; the ability to select and apply appropriate analysis methods for this purpose.
3 : Ability to utilize scientific and engineering knowledge.
4 : Ability to design and conduct experiments and to analyze and interpret data.
5 : Ability to work in groups and perform interdisciplinary research.
6 : The capability to design a system, component, or process to meet applicable constraints (economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability).
7 : The opportunity to gain theoretical and practical knowledge in the field of energy, as well as the ability to contribute to it by keeping up with the developments.
8 : The ability to have the necessary tools in academic and professional settings, as well as effective communication and responsibility.
9 : Opportunity to gain German language skills to the extent of reading, interpreting, and presenting academic texts.

Compiled by:	Res. Asst. Elvan Burcu Kosma

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