**Name of the module: Physics of solar cells**

**Number of coorse:** 001-2-4045

BGU Credits: 3

ECTS credits: 4

Academic year: 2022-2023

Semester: Fall semester

Hours of instruction: 3 hours per week

Location of instruction: will be defined

Language of instruction: English

Cycle:

Position: an advanced course for graduate students

Field of Education: Semiconductor Materials Science and Physics of semiconductors and semiconductor devices: basic principles of photovoltaic conversion of solar energy; materials & devices for efficient conversion.

General prerequisites: none

Grading scale: the grading scale would be determined on a scale of 0 – 100 (0 would indicate failure and 100 complete success 0 to 100), passing grade is 75.

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Office hours:

Course Description:

The course will explore the application of the semiconductor materials science and physics of semiconductors and semiconductor devices for understanding basic principles of efficient photovoltaic (PV) conversion of solar energy.

The first part of the course is related to general principal of operation of photovoltaic devices and learning main output parameters of solar cells. Experimental methods of PV characterization are considered.

The second part describes the modern material and device realization approaches for efficient PV conversion.

The third part is related to so-called 3rd generation PV. Concepts for overcoming the Shockley–Queisser efficiency will be discussed together with such advanced approaches as organic PV, perovskite-based solar cells, thermophotovoltaics, etc.

Aims of the course:

On the basis of understanding operation mechanisms of PV conversion to familiarize students with advanced approaches for development photovoltaic materials and efficient solar cells.

Learning outcomes of the module:

On successful completion of the course the students should be able to:

1. Understand basic operation principle of a solar cell
2. Understand which materials' properties limit the PV performance
3. Explain and in some cases predict light intensity and temperature dependences of the PV performance
4. Analyze mechanism of the PV efficiency losses in various types of solar cells.

Attendance regulation: attendance and participation in class is mandatory (at least 80%).

Teaching arrangement and method of instruction: lectures, which include the description of basic principles of photovoltaic conversion of solar energy; examples of materials & devices for efficient conversion.

Assessment:

Final Exam (oral): 100%

Work and assignments: will be defined

Time required for individual work: in addition to attendance in class, the students are expected to do their assignment and individual work: at least 2hours per week.

Module Content\ schedule and outlines:

Introduction and motivation of the course, short review of semiconductor properties important for photovoltaic conversion (3h)

P-n junction in the dark and under light illumination (3h)

Current-voltage characteristics and main output parameters of solar cells; spectral sensitivity, internal and external quantum efficiency of solar cells; experimental methods for measurements of these parameters (3h)

Classification of photovoltaic materials and devices; Device architectures of solar cells (3h)

Light intensity effect on the solar cell performance; concentrated photovoltaics (materials, devices, systems) (3h)

Silicon solar cells (3h)

Temperature dependence of PV efficiency (3h)

Fundamental limit of PV efficiency (thermodynamic limit and Shockley–Queisser limit) (3 h)

3rd generation photovoltaics; concepts for overcoming the Shockley–Queisser efficiency limit: multi-junction PV, hot-carrier solar cells, up- and down conversion(6 h)

Organic semiconductors and organic solar cells: prospectives, limits and challenges; other approaches for thin film solar cells (perovskites, etc) (3h)

Photon recycling for ultra-high efficiency PV; Thermophotovoltaics (3 h)

Perovskite-based solar cells (3h)

Required reading:

S. M. Sze “Physics of semiconductor devices”, 2nd ed., Wiley, 1981.

M. A. Green “Solar Cells”, University of South Wales, 1986.

M.A. Green. Third Generation Photovoltaics. Advanced Solar Energy Conversion. Springer. 2006.

Additional literature: -

P. Würfel, Physics of Solar Cells: From Basic Principles to Advanced Concepts, 1st ed. Wiley-VCH, 2009.

Next Generation Photovoltaics, A. Marti and A. Luque, Eds. Taylor & Francis, 2003.

A. J. McEvoy, T. Markvart, and L. Castañer, Practical Handbook of Photovoltaics: Fundamentals and Applications. Academic Press, 2011.