Hong Kong Baptist University
Faculty of Science - Department of Physics

Title (Units): **PHYS 4016** **RENEWABLE ENERGY MATERALS AND DEVICES (3, 3, 1)**

Course Aims: This course provides students an insight on understanding the renewable energy materials and devices with emphasis on semiconductor science and photovoltaic technologies for application in energy harvesting. Topics cover the principles of semiconductor physics, basic energy bands, carrier transport, *p-n* junctions, photovoltaic effect, device structures, applications and recent advances in solar cell technologies.

Pre-requisite: PHYS 3015 Structure and Properties of Matter or consent of instructor

Course Reviewed by: Prof. Fu-rong Zhu and Prof. Shu-kong So

Course Intended Learning Outcomes (CILOs):

No.	**Upon successful completion of this course, students should be able to:**
1.	Explain the basic principles of semiconductor physics, solar cells and different photovoltaic technologies outlined in the course content.
2.	Describe processes of charge generation, recombination, transport properties in photoactive semiconductor materials and the basic equations of device physics.
3.	Explain quantitatively the operation of a semiconductor *p-n* junction and a heterojunction.
4.	Explain the device physics of light harvesting processes in solar cells, power conversion efficiency limits, losses and the key parameters that determine the performance of solar cells, relating to the choice of materials and device architectures.
5.	Discuss the physics of photoelectron generation and recent advances in various types of solar cell technologies and their applications.

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Teaching & Learning Activities (TLAs)

CILOs	TLAs will include the following:
1-5	Students will learn the basic concepts and principles of semiconductor materials and semiconductor physics by attending lectures, reviewing lecture notes, reading references and doing assignments.
2	Students will compute carrier concentration as functions of temperature and impurity concentrations. They also need to draw energy diagrams indicating the relation of the of the Fermi levels to the energy band edges.
3	Students will learn the junction theory and analyze *p-n* junction using energy band diagrams both under forward and reverse biased conditions.
4	Emphasis is placed on understanding principles of photoelectron generation, light harvesting processes, efficiency limits, losses, measurement, device physics relating to the choice of semiconductor materials and the device design.
1-5	Tutorials are organized to train and improve the problem-solving skills of the students. Students will have a good background of different photovoltaic techniques, and a good understanding of the advantages and limitations of each.

Assessment Methods (AMs):

No.	Assessment Methods	Weighting	CILOs to be addressed	Remarks
1	Test and Continuous Assessment	50%	1-5	Tests and Continuous assessments are designed to measure how well the students have learned the basic concepts of renewable energy materials and devices from topics 1-6. The test is to check students' understanding for the fundamental concepts, especially in topics 1-4, and their applications to topics 5-6.
2	Final Examination	50%	1-5	Final Examination questions are designed to give a comprehensive assessment of all topics listed from 1-6.

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Learning Outcomes and Weighting:

Content	CILO No.	Teaching (in hours)
I. Solar cells and Sunlight	1	2
II. Semiconductor Science	2	8
III. *p-n* Junction Principles	1,2	6
IV. Photovoltaic Devices	1-3	6
V. Efficiency Limits, Losses and Measurement	1-4	6
VI. Photovoltaic Technologies	1-5	8

References:

1. S.M. Sze, Semiconductor Devices – Physics and Technology, 2nd Ed., Wiley, 2002
2. Y. Hamakawa Thin-Film Solar Cells: Next Generation Photovoltaics and Its Applications, Springer, 2010
3. D.A. Neaman, Semiconductor Physics and Devices, McGraw Hill, 2003
4. R.F. Pierret, Advanced Semiconductor Fundamentals, Prentice Hall, 2004
5. C. J. Brabec, V. Dyakonov, J. Parisi and N. S. Sariciftci, Organic Photovoltaics: Concepts and Realization, Springer, 2003

Course Content in Outline:

	Topic	Hours
I.	Solar Cells and Sunlight	2
	A. Overview of Solar Cell Development.	
	B. Physical Source of Sunlight.	
	C. Solar Intensity at the Earth's Surface.	
	D. Direct and Diffused Radiation.	
II.	Semiconductor Science	8
	A. Semiconductor Concepts and Energy Bands.	
	B. Intrinsic Carrier Concentrations.	
	C. Donors and Acceptors.	
	D. Carrier Transport Phenomena.	

III.	*p-n* Junction Principles	6
	A. *p-n* Junction Theory.	
	B. Schottky Barriers and Ohmic Contact.	
	C. Heterojunction.	
IV.	Photovoltaic Devices	6
	A. Photovoltaic Effect.	
	B. The Basic Equations of Device Physics.	
	C. Characteristics of Solar Cells.	
	D. Solar Cell Output Parameters.	
V.	Efficiency Limits, Losses and Measurement	6
	A. Power Conversion Efficiency Limits.	
	B. Effect of Temperature.	
	C. Efficiency Losses.	
	D. Efficiency Measurement.	
VI.	Photovoltaic Technologies	8
	A. Standard Silicon and III-V Compound Semiconductor Solar Cells.	
	B. Thin Film Silicon Solar Cells.	
	C. Thin Film Solar Cells based on II-VI Compound Semiconductors.	
	D. Organic Solar Cells.	