PHYS 6980: Fundamentals of Solar Cells

PHYS 4400: Principles and Varieties of Solar Energy

Instructors: Profs. R. Ellingson and M. Heben

Tuesday & Thursday 12:30 – 1:45 pm; Location: R1, 2000N

Syllabus, updated March 20, 2012

General advice and things to remember

1. Keep current with the coursework. Complete the reading assignment before the lecture – this will help you follow the class. Read the assignment again after lecture – this will help you to consolidate your knowledge. Please ask questions during class (we'll address some questions outside of lecture).

2. Do the assigned homework on time and right after you have read the assignment the second time -- this will help to solidify your understanding.

3. Follow the University's Missed Class/Excused absence policy; the simplest link may be this one: [http://www.utoledo.edu/facsenate/missed_class_policy.html].

4. Turn cell-phones and pagers off when in class.

5. Know the University's class withdrawal rules: Students may withdraw from the course until March 23, 2012 according to [http://www.utoledo.edu/offices/registrar/registration_dates_spring.html]. You must withdraw either on-line or in person at the Registrar's Office.

GRADING and EXAMS

Only material covered in class or in homework will be used for exams. There will be 3 types of exam:

1. Quiz

The quizzes will be short (5 minutes) and multiple choices (MCQ). Quizzes are intended to make sure you have understood the basic concepts taught during the previous 3-4 classes. Quizzes are closed-book, closed-notes.

2. Take-home mid-term exam

The mid-term exam will require solution of several photovoltaics problems. Planned take-home dates: starts February 28, due March 13 at the start of class.

3. Project

Projects will be assigned to groups of students immediately no later than March 1st. Each project will consist of a summary report and a presentation.

4. Final exam

The Final exam will be a combination of MCQ and problems. The Final exam will be open-book, open-notes.

Grading

Grades will be determined according to: Project: 20%, Seven in-class quizzes: 35%, Mid-term exam: 20%, Final exam: 25%

Textbook: The primary text will be "The Physics of Solar Cells", by Jenny Nelson:
http://www.amazon.com/Physics-Solar-Properties-Semiconductor-Materials/dp/1860943497/ref=sr_1_1?ie=UTF8&qid=1326207348&sr=8-1

Secondary texts you may be interested in accessing (do not feel compelled to purchase the books below, unless you wish to do so):

1. Thin Film Solar Cells: Fabrication, Characterization and Applications, ed. Poortmans and Arkhipov:
http://www.amazon.com/gp/product/0470091266/ref=oss_product

2. Practical Photovoltaics: Electricity from Solar Cells, Richard Komp:
http://www.amazon.com/gp/product/093794811X/ref=oss_product

3. Third Generation Photovoltaics: Advanced Solar Energy Conversion, Martin Green:
http://www.amazon.com/gp/product/3540265627/ref=oss_product

Note: There will be no class January 26.

Week(s) of	**Topic(s)**
Jan. 10	Introduction; Earth's energy; the solar resource (the Sun's extraterrestrial and terrestrial spectra, blackbody approximation, atmospheric absorption and scattering, direct vs. indirect insolation, integrating the solar spectrum); solar energy conversion (PV vs. solar thermal vs. photoelectrochemical)
Jan. 17	Solar cell economics: efficiency, production costs, BOS, ageing and durability, goal of <1$ per Watt (total installed cost).
Jan. 24-31	Detailed balance (in the dark, and under illumination); Band gap influence on efficiency; concentrator solar cells (effect on efficiency, practical considerations – tracking, direct insolation, thermal load); p-n homojunction, heterojunctions. Other types of junctions (metal-semiconductor, semiconductor-semiconductor, organics).
Feb. 7-14	Photovoltaic effect and fundamental solar cell properties; diode equation, dark current, light current; efficiency, J_{SC}, V_{OC}, internal and external QE, maximum power point. Review of semiconductor physics: bonds and bands in crystals; electrons and holes, valence/conduction bands, HOMO-LUMO concepts; n- and p-type doping; drift and diffusion; photogenerated carriers (direct vs. indirect gap); recombination mechanisms. Calculation of model J-V curves. Calculation of photocurrent density from quantum efficiency.
Feb. 21	Crystalline and polycrystalline Si PV technology.
Feb. 28	Thin-film Si solar cells
Mar. 6	Spring Break

Mar. 13	CdTe solar cells; March 15 guest lecture by Distinguished University Professor (Emeritus) A. Compaan on CdTe/CdS solar cells.
Mar. 20	Guest lecture March 20, Dr. Aarohi Vijh of Xunlight Corporation, Toledo, OH: a-Si solar cell technology and manufacturing. CIGS and related solar cell technology; Introduction to thin film deposition: (CdTe, CIGS, CdS) semiconductor and metal films.
Mar. 27	Characterization of solar cell materials and devices. Glass for modern photovoltaics (March 29 guest lecture by Dr. David Strickler, Pilkington).
Apr. 3	Materials for nanostructured solar cells: e.g. quantum dots, carbon nanotubes, molecular and polymeric absorbers. Shapes, syntheses, surface chemistry, quantum confinement effects, single-wall carbon nanotube species. Evolving materials considerations: Earth-abundance, toxicity.
Apr. 10	High-efficiency concepts (hot carrier conversion, MEG, …)
Apr. 17	Molecular photoconversion and dye-sensitized solar cells. Nanostructured solar cells (incl. DSSC, OPV, coupled NC absorbers, and NC-Si).
Apr. 24	Project presentations
May 1	Finals Week