Spring 2011

MSE/ERG C226 Photovoltaic Materials:

Lectures: Tues/Thurs 2-3:30 20 Barrows
Office Hours: Tues,Thurs 3:30-4:30 348/50 HMMB

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Course Purpose / Overview

This technical course focuses on the fundamentals of photovoltaic (PV) energy conversion with respect to the physical principles of operation and design of efficient semiconductor solar cell devices. Incorporating ideas from a variety of disciplines, the course aims to equip students with the concepts and analytical skills necessary to assess the utility and viability of various modern PV technologies in the context of a growing global renewable energy market. Traditional materials science and device physics are integrated with the practical issues of connectivity, cost and market analysis, and policy considerations to provide a complete picture of the engineering and development of modern PV systems.

Nontechnical students will have more conceptual questions on problem sets, and instead will be expected to take leading roles in class projects.

Curriculum for MSE/ER 226 will be primarily taught collaboratively by the Graduate Student Instructors with additional lectures contributed by Professor Haller and guest lecturers. The course will consist of two 1.5 hour lectures per week. Assessment will be based on graded homework assignments and completion of a final project.

This class fulfills one of the requirements for the Management of Technology program as well as the Designated Emphasis in Energy Science and Technology.

Prerequisites

Technical students: Background in solid state physics or semiconductor electronics is strongly recommended.

Nontechnical students: Background in economics, business, or policy.

Texts

Required:

* Nelson, Jenny. The Physics of Solar Cells. Imperial College Press, 2003.

Optional:

* Green, Martin. Solar Cells: Operating Principles, Technology & System Applications. Prentice Hall, 1982. (First five chapters posted on b-space)
* The Power of the Sun DVD - http://www.ucsbstuff.com/MerchDetail.aspx?MerchID=254313
* Additional readings to be posted on b-space

Homework

Homework will be assigned and posted onto bspace two weeks before it is due. Homework will be assigned on Tuesdays and due on ***Fridays***. Homework will be accepted in class on Thursday, but otherwise should be placed in the labeled box outside D45 Hildebrand by 4pm Friday.

Homework will be accepted late, but only in class, with one full letter grade reduced for each class beyond the Friday it is due. Regrade requests will be accepted within one week of the date assignments/midterms are returned, and must be accompanied by a written explanation of why you would like your paper regraded. When your paper is regraded, the whole assignment will be regraded, and the score may possibly go up, down, or remain unchanged.

Grading

Final course grades will be based on the following deliverables:

- Homework (25%): 4 assignments posted onto bspace
- Midterm Exam (15%) (For nontechnical students this will be a report on preliminary research for project topic)

- Class Project (50%): More information will be provided on topics and deliverables for this group project that will constitute the major portion of your final grade
- Attendance and participation in lectures. (10%) Attendance will be taken during each class. Please inform the instructors if you will be missing class.

Schedule of Classes and Topics Addressed

Week 1: Solar cell operation overview (1/18/11 – 1/20/11)

Lecture 1: Course overview & solar resource (Jessy)
Lecture 2: Properties of intrinsic semiconductors, direct & indirect bandgaps (Prof. Haller)
Readings: Nelson Chap 1.1-1.3, 3.1-3.5, Haller MSE 223 reader - Chap 1 (posted online)
Assignments: Problem set 1 posted online
Optional:

Week 2: Absorption & Transport (1/25/11 – 1/27/11)

Lecture 3: Transport; effective mass (Prof. Haller)
Lecture 4: PN-Junctions (Prof. Haller)
Readings: Nelson - Ch 3.7, 5.5, 6, Haller Ch. 1 (posted online)
Assignments: Problem set 1 due Friday, Problem set 2 posted online
Optional: Green - Ch. 2-4

Week 3: Charge Separation I (2/1/11 – 2/3/11)

Lecture 5: Biased Junctions (Sebastien)
Lecture 6: I-V curves, intro to efficiency (Sebastien)
Readings: Nelson - Ch. 1.4.2-1.5, 5.5, 6
Assignments:
Optional: Green - Ch 4

Week 4: Efficiency (2/8/11 – 2/10/11)

Lecture 7: Theoretical solar cell efficiency (Jessy)
Lecture 8: External Quantum Efficiency (Jesse)
Readings: Nelson - Ch. 2, 1.4, 10.1-10.3
Assignments: Problem set 2 due Friday, problem set 3 posted online
Optional: Green – Ch. 5

Week 5: Charge Separation & Transport (2/15/11 – 2/17/11)

Lecture 9: Recombination (Jesse)
Lecture 10: Resistance (Jesse)
Readings: Nelson – Ch 4.1, 4.2, 4.5
Assignments:
Optional: Green – Ch 3.4, 8.1-8.5 (especially 8.2.3)

Week 6: Charge extraction (2/22/11 – 2/24/11)

Lecture 11: Project intros
Lecture 12: Wafer Si, light trapping (Jessy)
Readings: Green – Ch 5.4, 8.2.3, 8.3
Assignments: Problem set 3 due Friday; Submit top 3 choices for projects
Optional:

Week 7: Technologies (3/1/11 – 3/3/11)

Lecture 13: Emerging Technologies (Jesse+Nair) <projects assigned>

Lecture 14: Thin Film PV (Bert Brown, Stion)

Readings: Nelson – Ch. 8, Ch. 10

Assignments: Project teams assigned

Optional:

Week 8: (3/8/11 – 3/10/11)

Lecture 15: Organic PV & excitonic solar cells (Topinka & Millstone)

Lecture 16: review session for exam / overflow topics

Readings: TBD

Assignments:

Optional:

Week 9: General (3/15/11 – 3/17/11)

Lecture 17: mid-term exam (& interim project report due from non-technical students)

Lecture 18: Units, Land Area, LCOE and Tech. Framework (Jimmy Nelson)

Readings: Masters Ch. 5.3 (Energy Economics)

Assignments: Problem set 4 posted online, Interim project report due (non-technical students)

Optional:

Spring Recess (3/22/11 – 3/24/11)

Week 10: (3/29/11 – 3/31/11)

Lecture 19: Module Reliability, Installation and Life Cycle Analysis (Libby Wayman - Alion)

Lecture 20: PV markets & support mechanisms, finance (Matt Eggers - SunRun)

Readings:

Assignments:

Optional:

Week 11: Intro to markets (4/5/11 – 4/7/11)

Lecture 21: project work

Lecture 22: project work <in-class status report>

Readings:

Assignments: Problem set 4 due Friday.

Optional:

Week 12: Energy economics/Policy (4/12/11 – 4/14/11)

Lecture 23: Guest Lecture - Policy/Econ/Industry (Seth Zimring - Panel Claw & PG&E)

Lecture 24: Guest Lecture - Policy/Econ/Industry in China (Polly Shaw – Suntech)

Readings:

Assignments:

Optional:

Week 13: (4/19/11 – 4/21/11)

Lecture 25: Guest Lecture - Policy/Econ/Industry (Becca Jones - Solar Junction CPV)

Lecture 26: Project work

Readings:

Assignments:

Optional:

Week 14: (4/26/11 – 4/28/11)

Lecture 27: Industry snapshot - major companies (Matt Campbell– Sunpower)

Lecture 28: Summary lecture (Dan Kammen)

Readings:

Assignments:

Optional:

Week 15: (5/3/11 – 5/5/11)

Lecture 29: Project presentations

Lecture 30: Project presentations

Readings:

Assignments: Final project papers due May 9.

Optional:

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Group Project

A major element of this course will be your participation in a team project related to the skills and concepts presented in class. Students will form interdisciplinary teams of 3-5 members to address a topic related to photovoltaics technology, economics, marketing, and/or policy. Several companies and organizations in the Bay Area have contributed projects for this course that are of direct and consequential importance to their initiatives in PV technology, business, and policy. The scope of these assignments will vary from project to project, and will be described in more detail below. Students will have the option to join one of the preexisting projects or develop their own topic of research, to be approved by the course instructors no later than Feb 24, 2011. Feel free to approach GSIs about project ideas if you have your own.

Groups are encouraged to begin work on this project immediately, and to meet with the instructors and project advisors regularly during the semester to verify that their work meets the requirements of the assignment. Groups will be required to present two status reports to the instructors over the course of the project:

1. **Email update: In place of a midterm exam, nontechnical students will email a preliminary status report to slounis@berkeley.edu no later than March 15, 2011**

2. **In-class status report: Teams will meet with instructors for an in-depth status report on April 14, 2011**

Work product

a. 15 minute presentation to the class + Q&A. Your presentation will be in open discussion format, with questions from the class encouraged.

b. An abstract of you research results and an electronic copy of the materials presented in class for presentation on the course website.

c. Teams must submit an electronic copy of this report on or before May 9 to **jbaker@berkeley.edu**.