PHYS 4580: Photovoltaic Device and Materials Physics Laboratory
Lecture: Tuesday, 1:00 – 1:50 pm; Location: R1, 2000N
Lab: Tuesday, 2:00 – 5:50 pm; Location: R1, 1070

Instructors: Profs. R. Ellingson and M. Heben

Syllabus (draft) updated November 12, 2012

**General advice and things to remember**

1. Keep current with the lecture material, lab experiments, and lab reports.

2. Complete any reading assignments as soon as possible – these will help you follow the class. Review the reading material to gain the best possible understanding; this will help you consolidate your knowledge.

3. Follow the University's Missed Class/Excused absence policy.

4. Turn cell-phones and pagers off when in class and lab (please don't take calls during lab unless urgent).

5. Know the University's class withdrawal rules:
http://www.utoledo.edu/offices/registrar/registration_dates_fall.html

**GRADING and EXAMS**

Only material covered in class or in lab experiments will be used for quizzes. Final grades will be based on:

1. Quizzes: We plan three quizzes during the semester, addressing previous kills and information from lectures, labs, or assigned reading. Quizzes will be short (5 minutes), multiple choice, and closed book, closed notes.

2. Lab Reports: Lab Reports will be due following certain labs. Although lab experiments will be conducted in Teams, you should each prepare your own report, in your own words, and with your own graphs of what may (or may not) be based on data shared with teammates. ***Important***: bring your laboratory notebooks with you to lab. Take careful notes on procedures, physical parameters during deposition and measurement, etc. -- to facilitate with the preparation of your lab report. Note how the measurement works in detail, and what information you need to reach the experimental goals.

Please include the following sections in each lab report:

1. **Title Page** with (a) Title of your Report, (b)Name and Lab Partners names, (c) Date, and (d) Abstract (Purpose of Experiment(s) and major conclusions - approximately 100 - 200 words).
2. **Introduction** (more information on the need for, and value of, the experiments, and discussion of the general approach)
3. **Experimental** (details of samples and equipment, including a sketch of the layout and a few words on the function of each major component)
4. **Results and Discussion** (analysis, appropriate graphs, a thoughtful explanation of the significance of the results, sources of uncertainty, and strengths and weaknesses of the measurement approach)
5. **Conclusion**
6. **References**

3. Final Project: Your final project will be based on a single 2-hour laboratory session in which you'll be asked to perform or describe specific measurements on a specific photovoltaic material or sample using the equipment, capabilities, and skills you develop during the semester. Each student will be tested individually on all aspects of the hardware, software, and principles of the measurement system, as well as the materials physics relevant to photovoltaic devices. We may, or may not, need to use Finals week to schedule some of these Project exams.

**Grading**

Grades will be determined according to: Quizzes: 15%, Lab Reports: 60%, and Final Project: 25%. Note that undergraduate and graduate students work together on teams in this course. While graduate students are

graded on a steeper curve, with increased expectations of (a) in-depth analysis of data and (b) demonstrated understanding of the key physical phenomena addressed in the laboratory experiments, undergraduates are expected to focus on very careful description of the experiments and physical concepts.

**Projected Schedule:**

| **Weeks of** | **Topic(s)** |
|---|---|
| **Aug. 20** | Introduction to Igor Pro graphing and analysis software. Lab Report – 5 points. |
| **Aug. 27** | Introduction to LabView "virtual instrumentation" – instrument control software and data acquisition hardware. Lab Report – 5 points. |
| **Sept. 3** | Additional Igor and LabView assignment – 5 points. |
| **Sept. 10 – Sept. 24** (Quiz #1 Sept. 25th) | Setup of the optical system, working with a tungsten-halogen bulb coupled to a monochromator, troubleshooting new equipment, starting development of LabView control of the tunable light source. Lenses, optical mounts, thermopile detector, optical modulation, and phase-sensitive (lock-in) detection. Lab Report (parts 1 and 2, total of 10 points; part 3, 10 points) due Oct. 3rd. First Quiz Sept. 25th. |
| **Oct. 1-15** | Characterization of transparent conductors (TEC-15, TEC-8, and thin Cr films – all on soda lime glass (SLG)): transmission and reflection measurements; determination of absorption coefficient vs. wavelength. TCO/metal film thickness measurement (profilometry); sheet resistance measurements (four-point probe). Compare sheet resistance to bulk resistivity for different metal film thicknesses. Fall Break Oct. 1-2; lab open Oct. 3-5. Lab report (20 points) due Oct. 23rd. |
| **Oct. 22-29** (Quiz #2 Oct. 23rd) | Optical and electrical characterization of semiconductor thin films (CdS, CdTe, c-Si, a-Si, and CdS/CdTe solar cell stack). Absorption measurements and calculation of wavelength-dependent absorption cross-section. Quiz #2 Oct. 23rd. Team lab report (10 points) due Nov. 6th. Hall measurements: individual lab reports (5 points) due Nov. 13th. |
| **Nov. 5 – 19** (Quiz #3 Nov. 20th) | Solar cell performance characterization (requires LabView development): Current-voltage; spectral response (quantum efficiency). Quiz #3 - Nov. 20th. Team-based lab report (20 points) due Nov. 27th. X-ray diffraction of CdS and CdTe thin films. The report for the X-ray diffraction will be an individual report (10 points), due Nov. 27th. |
| **Nov. 26** | TBD. |
| **Dec. 3** | Final Review Dec. 4th; Final project/exams scheduled individually Dec. 4, 5, 6. |
| **Dec. 10** | Finals Week (no exam) |