Germanium Semiconductor Testing
Using a Photoluminescence System

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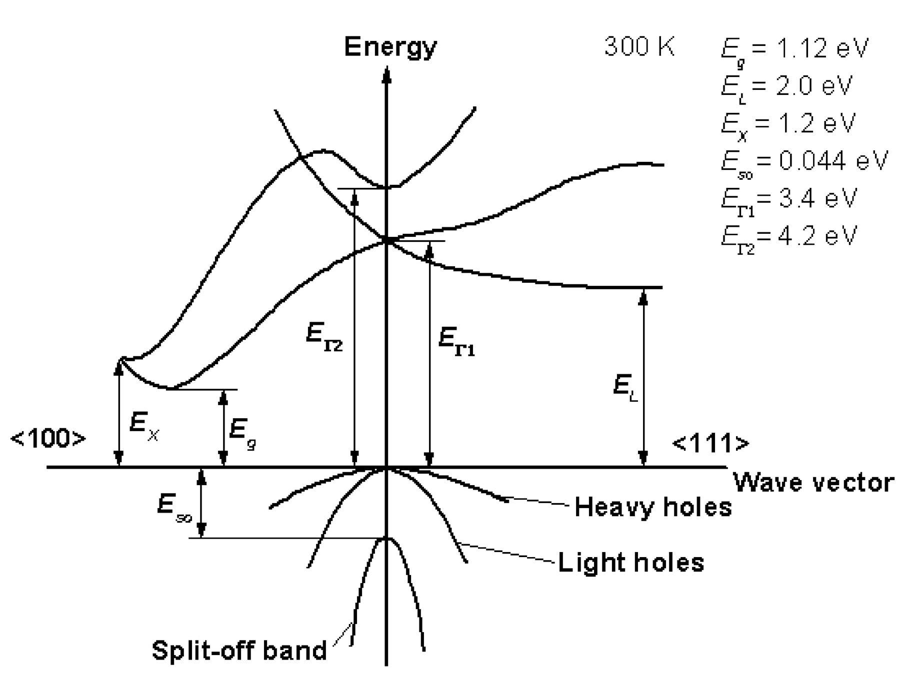
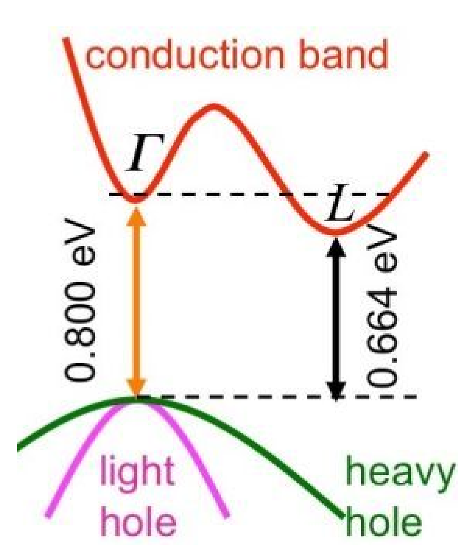
ABSTRACT

Semiconductors are neither an insulator nor a conductor, but can take on characteristics of both types of materials. We can control the properties of semiconductors based on the type of material we use. The most commonly used semiconductor is silicon because of its abundance, low cost, chemical stability and high quality interfaces. In Dr. Wistey's group they are using germanium semiconductors, which can improve performance over silicon for photovoltaic applications. By exploiting how electrons behave in germanium, photons can be absorbed more efficiently than in silicon, while retaining a comparable ability to extract electrons for energy generation. To test the quality of germanium, I assembled and fine-tuned a photoluminescence setup, which probes the efficiency of optical processes in the material. The system is composed of a spectrometer, an infrared detector, a lock-in amplifier, beam guiding optics and a laser to excite electrons in germanium. I was responsible for aligning the optics, interfacing the software with the spectrometer and obtaining optical data from semiconductor samples. The curriculum plan is showing the students how difficult solar cells are to create. The model is a titanium dioxide-doped conducting glass with a berry dye to absorb the sunlight in the visible range. They will test their results in the classroom and then we will take the cells to Notre Dame to test their efficiency in the Kamat Lab. The students will also get a tour of the lab and have the opportunity to see research first hand.

BACKGROUND

- Semiconductors for use in photo-voltaic applications.
- Silicon is commonly used because of abundance, cost, and stability.
- Germanium is being researched because of improved performance over silicon.
- A photo-luminescence system is used to test the efficiency of the optical processes of the material.



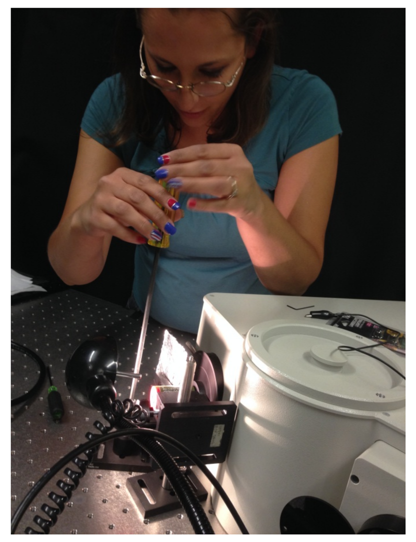


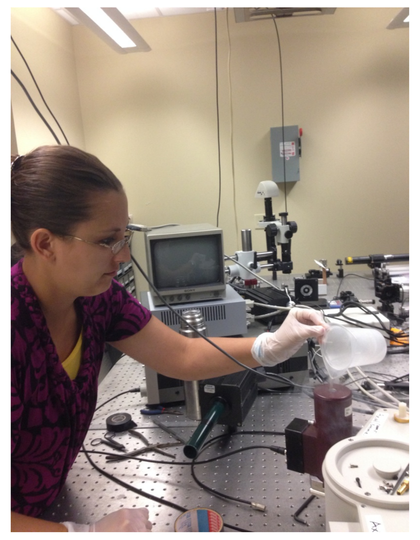
OBJECTIVES

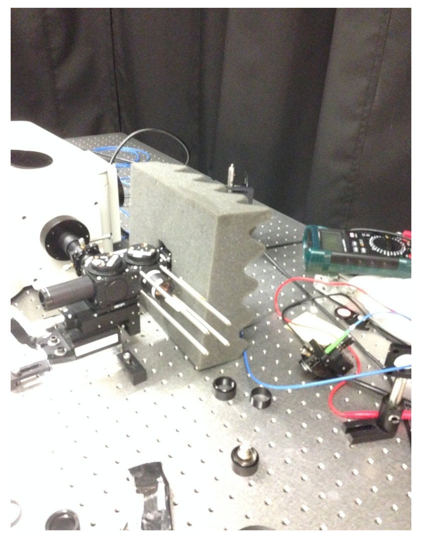
- Software integration with spectrometer and lock-in
- Set-up of optics table
- Alignment of optics table
- Set-up and alignment of photoluminescence system
- Control runs of photoluminescence set-up
- Testing germanium semiconductor samples

METHODS

- Connecting spectrometer, lock-in amplifier, computer, and white light.
- Configuring software to set standards of experiments that will be run.
- Running a white light control to adjust initial alignment and confirm software use.
- Alignment of optics to spectrometer.
- Alignment of detector to whole system .
- Alignment of laser and cage to spectrometer.
- Running a control sample in the infrared spectrum for experimental use



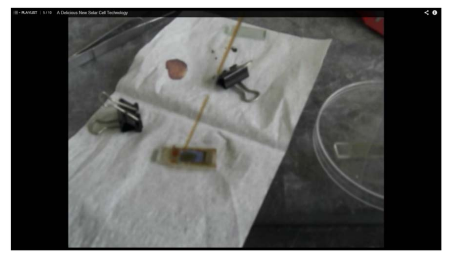


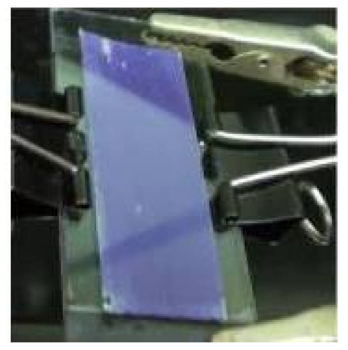


- Alignment of the spectrometer and white light to run control experiments.
- Liquid nitrogen for the InGaAs detector
- Quick thinking to get cage alignment to spectrometer

CURRICULUM

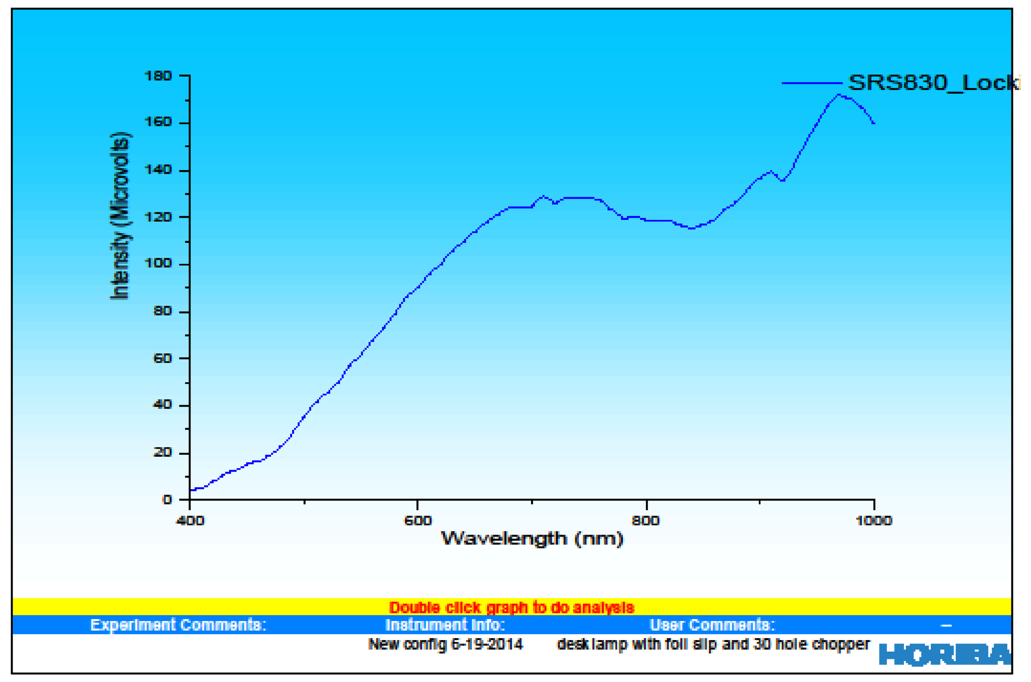
- Lecture on general solar energy given with unit information.
- Article research on current solar cell production.
- Discussion on article found and what that research means
- Lab procedure created from video on dye sensitized solar cells with TiO_2 doped conducting class using berry dye for light absorption.
- Create solar cell from procedure written.
- Test solar cell and take cell to Notre Dame for efficiently testing.



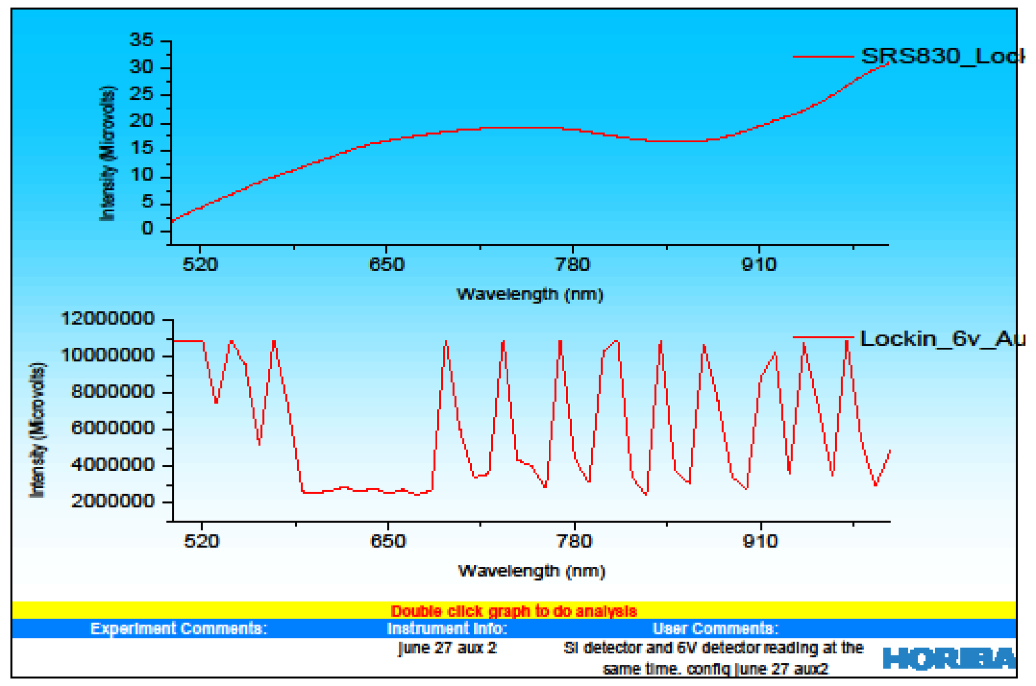


- TiO_2 from powdered donuts. Dissolved, filter, and dry.
- Solar cell assembly
- Final solar cell ready for testing

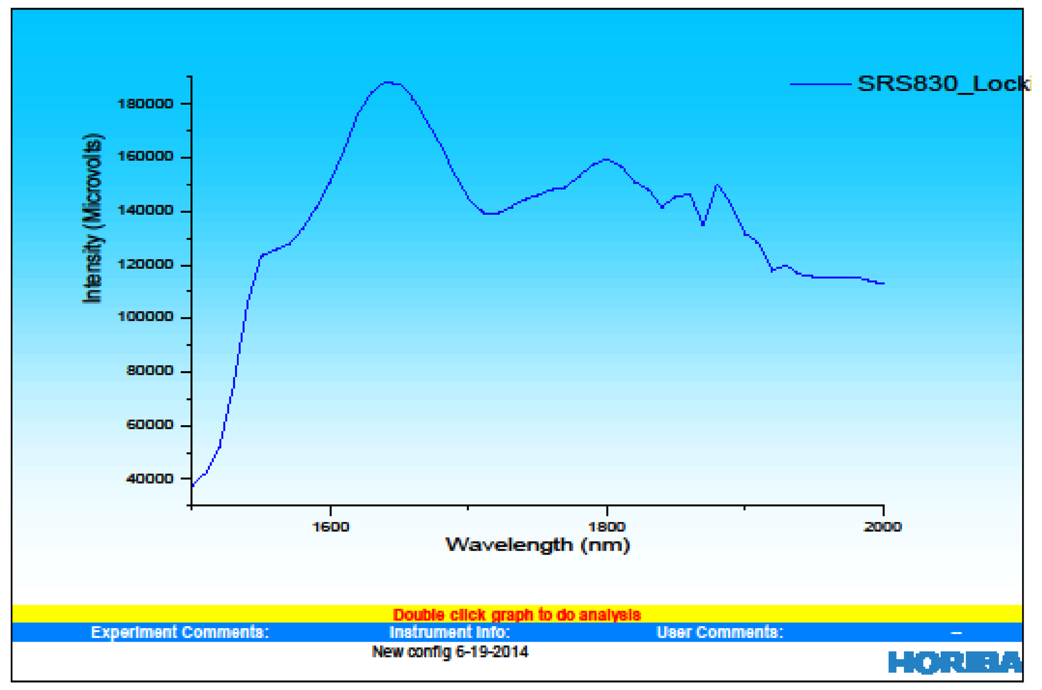
RESULTS



White light control of PL set-up



Software set up reading two detectors



Detector alignment and control run with white light

CONCLUSIONS

- The software is very user friendly and the manual is well written
  - Double check units
- A photoluminescence system is very difficult to set up.
  - It has a large set of variables that you have to eliminate as you align it.
  - It takes patience, small adjustments, and many control tests.
- Always have more parts than you think you need
- Epoxy is a good way to set the cage but bad to take it apart.
- Research is frustrating but turning that frustration into motivation makes you a good scientist