



*Knowledge to Go Places*

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Bolko von Rodern  
National Center for Photovoltaics  
National Renewable Energy Laboratory  
1617 Cole Boulevard  
Golden, CO 80401

RE: Quarterly Report X (May - July 2007)  
"Characterization and Analysis of CIS and CdTe Cells"  
Subcontract XXL-5-44205-03

For additional information: [www.physics.colostate.edu/groups/photovoltaic](http://www.physics.colostate.edu/groups/photovoltaic)

Dear Bolko,

During the past quarter, two students completed their PhD and one other is preparing for his defense. At the same time, we expanded our work on the analysis of cells with non-uniformities, we began a collaboration on CIGS made with laser-assisted deposition, and we continued several measurement and analysis projects in collaboration with other laboratories.

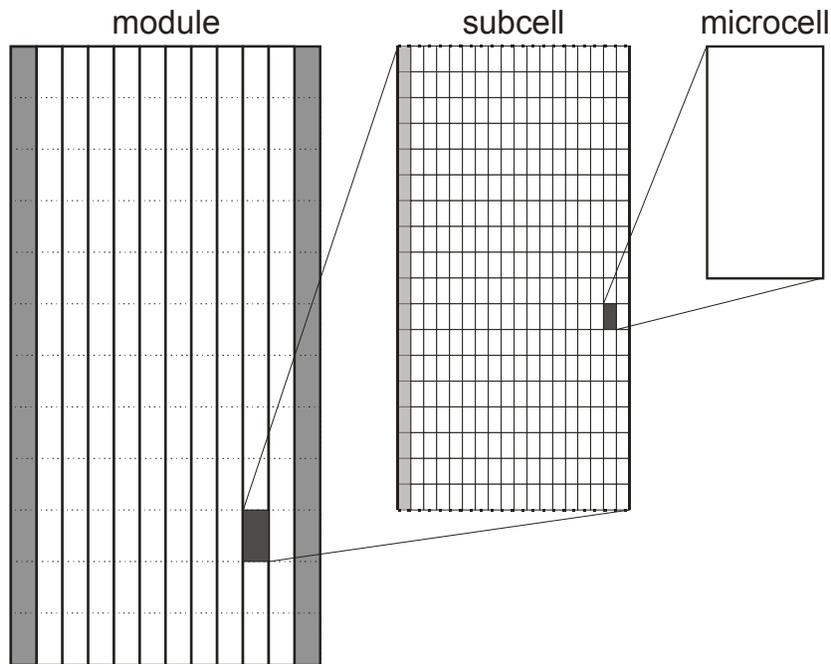
**PhD Completion.** In June, Jun Pan successfully defended her PhD thesis, which was entitled "Impact of lifetime variations and secondary barriers on CdTe solar-cell performance." Her work included the role of electron lifetime in determining collection near maximum power, the interaction of lifetime and back barrier to enhance forward current and reduce voltage, and the critical role of a back electron reflector if voltage is to be significantly increased. Jun is continuing to work at CSU for a short time, and we are writing what I think will be an important paper on how to extract a true collection efficiency from light and dark QE measurements.

In July, Ana Kanevce also completed her PhD. Her thesis title was "Anticipated performance of Cu(In,Ga)Se<sub>2</sub> solar cells in the thin-film limit." As the title implies, she calculated device performance as a function of CIGS absorber thickness for a variety of conditions. She also calculated the impact of weak-diode regions on

solar-cell performance, which was presented at Spring 2007 MRS, and she calculated expected current-voltage for rear illumination, which becomes viable for thicknesses below 1 micron. Ana also is continuing short term at CSU and will begin a postdoc position at NREL in mid-October. While here, she will be working with the laser-assisted-deposition cells described below, and she will be writing a more thorough paper on rear illumination of CIGS cells.

Tim Nagle's defense is scheduled for September. His thesis will describe the use of QE measurements under a variety of conditions and the use of LBIC for extracting solar-cell information. Tim has accepted a postdoc position at CSIRO in Newcastle, Australia, where he will work on dye-sensitized cells. He also will begin his postdoc in mid-October.

**Non-uniformity Analysis.** In collaboration with Marko Topič of the University of Ljubljana in Slovenia, we have begun a comprehensive program to connect micro-nonuniformities to module performance. Marko spent 8 weeks at CSU this summer so we could work together to initiate the program. The figure below gives a schematic representation of the strategy.



The assumption is that most of a subcell, similar in size to a typical laboratory test cell, is uniform and consists of microcells with common, well-defined parameters. The subcell can be analyzed by LBIC down to the micron scale to determine the existence of small, but troublesome, microcells that can be identified as partial local shunts or weak-diode areas, defects which impact a much larger area than their physical extent. The combination of LBIC at different voltages and PSpice modeling appears to be sufficient to connect the parameters of the defective

microcells with the J-V curve of the subcell. Such a J-V curve does not in general follow a simple equation, and the PSpice result must be retained as a data file. It can, however, with a second level of PSpice modeling be used to calculate the J-V curve of the module and be used for direct comparison with the measured performance.

**CIGS with Laser-Assisted Deposition.** We have a three-way collaboration with Tokio Nakada, Aoyama Gakuin University, and Sho Shiraka, Ehime University, to explore the value of laser-assisted deposition (LAD) of CIGS. For LAD, short-wavelength light is applied at various intensities during selected phases of the three-stage deposition. Sho, who makes PL measurements on CIGS and other materials in his laboratory, is also spending 8 weeks at CSU. He and Ana Kanevce are making a variety of device measurements, including LBIC, on several sets of the Japanese cells.

**Other Collaborative Work.** During the past quarter, we made additional QE, capacitance, and LBIC measurements on sulfide cells fabricated at FSEC. The collaboration with HelioVolt Solar has focused on discussions of how to replicate some of our characterization and analysis techniques, LBIC in particular, and similar discussions are taking place with AVA Technologies. We also made LBIC measurements in collaboration with SoloPower, Inc., and here also we have had discussions on how they might build an LBIC system.

**Invited Presentations.** In May, I gave one of the invited presentations at the 2nd Organic and Nano-Electronics (ONE) workshop held at McGill University. The audience of 200 was primarily students from a number of Canadian universities, and my talk was, "Device physics of thin-film polycrystalline solar cells." In December, I have an invited talk scheduled at PVSEC-17 in Fukuoka, Japan, and I have also been invited to speak to the Taiwan PV Industry Association in Taipei and at the Industrial Technology and Research Institute in Hsinchu, Taiwan.

Sincerely,

James R. Sites  
Professor

Cc: NREL Subcontracts  
CSU Office of Sponsored Programs