Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

New designs and characterization techniques for thin-film solar cells

By

Yutong Pang

This thesis presents a fundamentally new thin-film photovoltaic design, and develops several novel characterization techniques that improve the accuracy of thin-film solar cell computational models by improving the accuracy of the input data.

We first demonstrate a novel organic photovoltaic (OPV) design, termed a "slot OPV", that applies the principles of slot waveguides to confine light within the ultrathin (< 50nm) active layer of an OPV. Our calculations demonstrate that a slot OPV can be designed with guided-mode absorption for a 10nm thick active layer equal to the absorption of normal incidence on an OPV with a 100nm thick active layer. These results, together with the expected improvement in charge extraction for ultrathin layers, suggest that slot OPVs can be designed with greater power conversion efficiency than today's state-of-art OPV architectures if practical challenges, such as the efficient coupling of light into these modes, can be overcome.

We then demonstrate a new nondestructive optoelectronic method to analyze the internal quantum efficiency (IQE) data that are measured on copper indium gallium di-selenide (CIGS) solar cells. We further improve the method with a parameter-independent regularization approach. Then we introduce the Self-Constrained Ill-Posed Inverse Problem (SCIIP) method, which improves the signal-to-noise of the solution by using the regularization method with system constraints and optimization via an evolutionary algorithm.

In order for a thin-film solar cell optical model to be an accurate representation of reality, the measured refractive index profile of the solar cell used as input to the model must also be accurate. We describe a new method for reconstructing the depth-dependent refractive-index profile with high spatial resolution in thin photoactive layers. This novel technique applies to any thin film, including the photoactive layers of a broad range of thin-film photovoltaics.

Together, these methods help us improve the measurement accuracy of the depth profile within thin-film photovoltaics for optical and electronic properties such as refractive index and charge collection probability, which is critical to the understanding, modeling and optimization of these devices.

Date: August 03 (2016)
Time: 1:00pm
Place: P-119 (Physics)

Program: Physics
Dissertation Advisor: Matthew Eisaman