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Towards high efficiency CZTS thin film solar cells

Abstract

Thin film solar cell research at the Center for Autonomous Solar Power (CASP center) focuses on promising thin film solar cells with three absorbers, copperzinc-tin-sulfide (CZTS), iron sulfide (FeS2), and zinc phosphide (Zn3P2) whose energy band gaps and light absorption coefficients are in the optimal range for efficient conversion of sunlight into electricity. In this seminar, I will present results, in particular, on the Cu2ZnSnS4 (CZTS) thin film solar cell, which has shown an efficiency of 6.2% (without anti-reflection coating), near the record for efficiency for this material. Initially, the CZTS precursor film is obtained by cosputtering from three different targets; copper (Cu), tin sulfide (SnS) and zinc sulfide (ZnS). The as-grown CZTS film is then annealed in a sulfur environment to improve sulfur content and also to achieve larger grain size. Current-voltage (IV), quantum efficiency (QE), and capacitance-voltage (CV) measurements were performed to characterize parasitic effects common to thin film solar cells. The IV characteristics of the cell were modeled by various methods to estimate cell properties such as series and shunt resistances, ideality factor, and reverse saturation current. With the help of IV modeling, it was possible to predict the enhancement in efficiency by reducing the series resistance. Measurements of QE of the device under zero and negative biasing were carried out to study the defects in the absorber layer and recombination at the hetero-junction interface. Doping density and built-in-voltage at the cell junction were derived from 1/C2 vs. V plot of CV data. These studies have helped to identify the loss mechanisms and revealed more fundamental properties of the device to pave the way toward achieving a much higher efficiency.

Bio

Tara P. Dhakal received his B.S. and M.S. degrees in Physics and Material Science from Tribhuvan University, Kathmandu, Nepal and Shimane University, Matsue Japan in 1998 and 2001, respectively. He received his Ph.D. degree in Physics from the University of Florida, Gainesville, FL in 2008 where he studied magnetic oxide thin films. He joined the University of South Florida as a postdoctoral researcher and was involved in the areas of spintronics, solar and thermoelectric materials. He has been working at the Center for Autonomous Solar Power (CASP) at Binghamton University since April 2010 as a research scientist. His research includes thin film solar device fabrication using earth abundant absorbers such as CZTS and FeS2. His interests also include transparent conducting oxides to be used in the thin film solar cell and display devices and atomic layer deposition of oxides and sulfides. Dr. Dhakal has published more than 40 peer-reviewed journal articles. He is a member of IEEE,

American Physical Society (APS), Material Research Society (MRS), American Vacuum Society (AVS), and Japanese Physical Society.