

PS1.05

(Student) Optical Prosperities of Different Stacking Orders in ReS₂ Yongjian Zhou and Yaguo Wang; The University of Texas at Austin, United States

Two stacking orders, AA stacking and AB stacking, of ReS₂ are identified by scanning transmission microscopy. The Raman spectrum of these two stacking orders can be an excellent tool to differentiate them. The photoluminescence spectrum shows different exciton positions and widths, which suggests that the dielectric environment is different. The First-principles calculations reveal that the two stacking orders are the two energy minimum when shifting the upper layer along the *a* axis. To better understand the excitons, polarization-dependent fs-second pump-probe are performed, which shows drastically different carrier dynamics when laser polarization perpendicular to the *b* axis.

PS1.06

(Student) Local Photovoltaic Measurements of CdTe Solar Cells Using Microscale Point Back-Contacts Kaden Powell, Yu-Lin Hsu, David J. Maggini and Heayoung P. Yoon; The University of Utah, United States

Cadmium telluride (CdTe) thin-film semiconductors exhibit many desirable properties for low-cost and high-efficiency photovoltaic (PV) technology, including inherent robustness of the inorganic absorber, a direct bandgap that allows full absorption of the solar spectrum with thicknesses of only a few microns, and inexpensive and high-throughput manufacturing processes. At the best efficiency of 22 %, the power conversion efficiency of CdTe PVs is still well below the maximum theoretical limit (approximately 30 %). It has been suggested that the inferior efficiency is mainly due to the inherent polycrystalline nature of the CdTe absorber (e.g., grains, grain boundaries). Understanding local photocarrier dynamics is vital to overcoming roadblocks toward higher efficiency CdTe PVs. However, conventional cell-level PV measurements often limit the microstructural analysis. In this work, we present a local PV characterization technique using point back-contacts. The thin-film CdTe solar cells used in this work were prepared by CSS (close-spaced sublimation) on a stack of *n*-type window layer (e.g., CdS) / transparent conductive layer (TCO; e.g., SnO₂) / glass substrate. To fabricate microscale point back-contacts, we used conventional photolithography or a shadow mask technique. In the first method, CdTe samples were spin-coated with photoresist (Microposit 1813; ≈1.5 μm) and patterned using a laser writer (375 nm, 10 mW power laser with 60 % pixel energy). After development, an O₂ plasma descum was performed. The contact metal (Au or Au-Pd) was deposited onto CdTe via either evaporation or sputtering. Liftoff was then performed, leaving localized metal back-contacts on the CdTe surface. For the second method, a shadow mask with an array of square holes (40 μm × 40 μm) was used. An evaporated Au film was deposited onto the sample through the openings in the shadow mask, forming microscale point contacts. For both contact patterning methods, the front contact was formed by exposing the TCO and applying melted indium. A control CdTe cell with contacts 0.8 cm × 0.6 cm was also used for the comparison of PV parameters (e.g., open-circuit voltage [*V*_{oc}], short-circuit current [*J*_{sc}], fill-factor [*FF*], efficiency [*η*]). We collected dark and light current-voltage (*I*-*V*) characterizations by probing the microscale back-contacts and the TCO front contact. CdTe samples were illuminated under 1-sun (AM 1.5G) to extract the PV parameters. The photolithography samples showed significantly inferior *I*-*V* characteristics. The series resistance was higher than expected, and a poor light response was observed. We speculate that photoresist residue remaining between the rough surface of CdTe and the metal contact layer is likely to cause the undesirable carrier behaviors. By contrast, the microscale back-contacts formed with a shadow mask displayed good diode characteristics and light responses. We measured the *V*_{oc} of 0.66 V, *FF* of 0.37, and *I*_{sc} of 0.43 μA for the 40 μm square contacts. The estimated *J*_{sc}

is 27.0 mA/cm². This measured *J*_{sc} value is consistent with the control CdTe device (*J*_{sc} ≈ 26), and over three-times higher than that of the photolithography devices (*J*_{sc} ≈ 8.1). We will discuss our on-going fabrication methods to produce the point back-contacts with sizes of 1 μm, improving series resistance of the contacts, and subsequent local PV characterizations.

This work was supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the DE-FOA-0002064 program award number DE-EE0008983. We also acknowledge the support by the National Science Foundation (NSF) under Grant No. 1711885. We thank Dr. C. Lee and Dr. G. Xiong at First Solar for providing part of the CdTe samples studied in this work.

PS1.07

(Student) Electrical Behavior of CNT Epoxy Composites Under Simulated Space Environments Joel Hubbard¹, Claudia Luhrs^{1,1}, Brian Earp^{1,2}, Alexander Tracy¹ and Dan Sakoda¹; ¹Naval Postgraduate School, United States; ²U.S. Naval Academy, United States

The properties of CNT composites are known to suffer changes when exposed to space conditions or simulated space environments. An in-depth understanding of the magnitude of those changes could help improve the design of systems that contain them, produce more accurate predictions of their performance, or even open the possibility of new applications. In this study, the electrical properties of CNT epoxy conductive composites containing low CNT loadings (<1%) were measured in-situ while the specimens were exposed to diverse simulated space conditions. A thermal vacuum chamber was employed to produce the low pressures and temperatures associated with low earth orbit. A solar simulator was used to replicate solar irradiance. A convection oven was used to determine the effects that could only be attributed to temperature variations. The changes in resistivity exhibited by the composite specimens are reported for each scenario along with possible mechanisms that could explain the observed behavior. The microstructural and thermogravimetric characterization of the composites for the diverse loadings is also presented. Resistivity reductions of up to 40% were observed by the simultaneous application of high temperatures and low pressures, while the application of simulated sunlight with the concomitant surge in temperature, showed a maximum decrease of 58%. Outgassing and an increase in the number of charge carriers at the higher temperatures promoted by the simulated sunlight treatment are believed to be responsible for the recorded reductions in resistivity. A qualitative analysis of the resistivity changes noted when the composites are exposed back to atmospheric conditions is included.

PS1.08

(Student) Mechanical and Electrical Properties Study of a Composite Biomaterial of PVA-Chitosan / PPy / PEDOT:PSS / MWCNT / CB Alfredo Olarte-Paredes, Jessica N. Salgado-Delgado, Areli M. Salgado-Delgado, René Salgado-Delgado, Zuluy Vargas-Galarza and Edgar García-Hernández; Tecnológico Nacional de México/Instituto Tecnológico de Zacatepec, Mexico

Technologies based on conductive polymers have been development in recent years. these conductive materials have adequate mechanical and electrical properties to generate new high impact materials than existing materials. These materials have a wide variety of applications, such as in photovoltaic appliances, storage and transportation of electric charge, etc. The most conductive polymers, polythiophene derivative poly (3,4-ethylenedioxythiophene)-polystyrene sulfonate (PEDOT:PSS), carbon black (CB), have high conductivity, electrochemically and thermally stable, multiwall carbon nanotubes (MWCNT) and polypyrrole (PPy) have high mechanical properties compared to conventional materials. These materials improve the transfer kinetics of electrons and the magnitude of the analytical signal