Materials Science & Engineering Doctoral Defense

Correlating Copper Defects to CdTe Solar Cell Performance Before, During, and After Operation

School for Engineering of Matter, Transport and Energy

Trumann Walker
Advisor: Mariana Bertoni

Abstract

This work correlates microscopic material changes to short- and long-term performance in modern, Cu-doped, CdTe-based solar cells. Past research on short- and long-term performance emphasized the device-scale impact of Cu, but neglected the microscopic impact of the other chemical species in the system (e.g., Se, Cl, Cu), their distributions, their local atomic environments, or their interactions/reactions. Additionally, technological limitations precluded nanoscale measurements of the Cu distributions in the cell, and microscale measurements of the material properties (i.e. composition, microstructure, charge transport) as the cell operates.

The aim of this research addresses the following questions: (1) what is the spatial distribution of Cu in the cell, (2) how does its distribution and local environment correlate with cell performance, and (3) how do local material properties change as the cell operates? This work employs a multi-scale, multi-modal, correlative-measurement approach to elucidate microscopic mechanisms. Several analytical techniques are used -- including and especially correlative synchrotron X-ray microscopy -- and a unique state-of-the-art instrument was developed to access the dynamics of microscopic mechanisms as they proceed.

The work shows Cu segregates around CdTe grain boundaries, and Cu-related acceptor penetration into the CdTe layer is crucial for well-performing cells. After long-term operation, the work presents strong evidence of Se redistribution. This redistribution correlates with microstructural changes in the CdTe layer, an increase in Cl density around the grain boundaries, and limited charge-transport around the metal-CdTe interface. Finally, the work showcases correlations between the change in microstructure, large variations in Cu local environment, and decreasing local charge collection as a cell operates at field-relevant temperatures. The results suggest that, as the cell ages, a change to Cu local environment limits charge transport through the metal-CdTe interface, and this change could be influenced by redistribution of Se and Cl in Se-alloyed CdTe cells.

August 4, 2022; 10 AM; ERC 4189;
Zoom Link: https://asu.zoom.us/j/81057637316