Back Contact CdSe/CdTe Photovoltaics

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I present back contact geometry chalcogenide photovoltaics that place the CdTe absorber layer at the front of the device to create an analog of silicon back contact devices. I detail fabrication of the three-dimensionally structured devices starting with two interdigitated comb electrodes, followed by selective electrodeposition of n-type semiconductor on one electrode then deposition of p-type absorber over the entire device. A single patterning process thus permits differentiation of the two interdigitated combs into positive and negative electrodes in the electrodes-first, semiconductors-last process. Placement of the n-type semiconductor behind the CdTe absorber permits devices with n-type CdSe (Fig. 1) as well as the standard CdS.

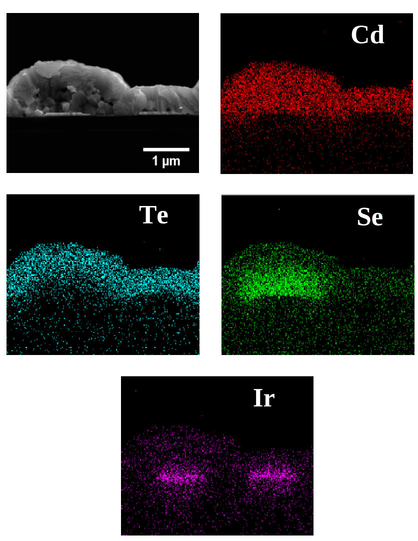

Fig. 1: A cross-section of a photovoltaic device with electrodeposited CdSe and CdTe showing a single pair of adjacent wires from the interdigitated positive and negative electrodes of the device with the composition distribution mapped by energy dispersive spectroscopy.[1]

Short circuit current density (J_{sc}) in current vs voltage measurements under simulated AM1.5 illumination are interpreted through modeling of carrier transport and recombination. With electrodeposited CdSe and pulsed laser deposited CdTe, J_{sc} exceeds 15 mA/cm^2 and efficiency 4% for electrode comb pitch of 2 to 3 μm without antireflection coating or backcontact field at the metal/CdTe contact; surface passivation increases V_{oc} by ~ 150 mV.

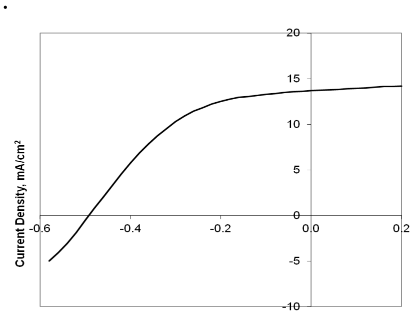

Fig. 2 Current-voltage response of a CdSe-CdTe backcontact device exhibiting 3.1% efficiency under simulated A.M. 1.5 illumination.

External Quantum Efficiencies exceeds 40% at energies above the CdTe absorption edge with current extraction decreasing only modestly even for illumination at 300 nm. This is consistent with removal of the CdS window layer found over the CdTe absorber in standard devices.

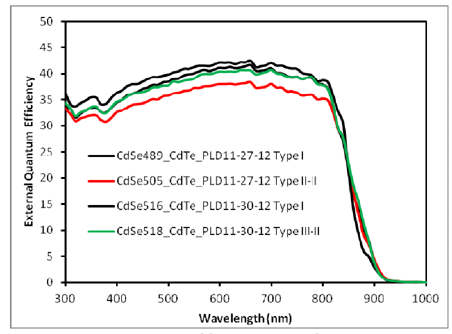

Fig. 3 External quantum efficiency of a CdSe-CdTe backcontact devices showing the fraction of light that generates current at the electrodes under zero bias.

Laser beam induced current measurements with submicrometer spatial resolution are detailed and used to understand device performance. Results are also compared to quantitative modeling, the model predictions capturing trends observed with variation of electrode comb dimensions as well as semiconductor type and quality.

Device performance exceeds the performance of CdS/CdTe pillar devices with far finer dimensions.

1. D.U. Kim, C.M. Hangarter, R. Debnath, J.Y. Ha, C. R. Beauchamp, M.D. Widstrom, J.E. Guyer, N. Nguyen, B.Y. Yoo, and D. Josell, Solar Energy Materials and Solar Cells **109**, 246 (2013).