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An investigation on the relationship between open circuit voltage and grain size for CZTSSe thin film solar cells fabricated by selenization of sputtered precursors

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ABSTRACT

The low open circuit voltage (V_{oc}) of $Cu_2ZnSn(S,Se)_4$ (CZTSSe) thin film solar cells limits their efficiency. CZTSSe absorbers were fabricated by sputtering Cu_2ZnSnS_4 (CZTS) target and subsequent selenization treatment and then incorporated into solar cells. The influence of selenization temperature on the growth of the CZTSSe grains and device performance was examined. The absorber films were composed of a CZTSSe phase with high Se/(Se+S) ratios. As the selenization temperature was increased from 460 °C to 500 °C, the grains grew from the top to the bottom of the CZTSSe absorbers, and the average V_{oc} of the CZTSSe solar cells increased from 284 mV to 371 mV. The band gaps (E_g), derived from external quantum efficiency (EQE) data, were approximately 1.11 eV. Activation energies (E_a) was extracted from temperature-dependent current density-voltage (*J-V*) measurements and used to evaluate the interface recombination level. The E_a increased from 0.82 eV to 0.89 eV as the selenization temperature was increased, which approached the E_g of CZTSSe. This was likely caused by reduced interface recombination because the grain boundaries decreased as the grains grew larger. An approximately linear relationship between the grain size and V_{oc} was observed. The increase of grain size was achieved by optimizing the selenization temperature, which reduced