Luminescent, structural and chemical properties of defects in MBE- and CSS-grown CdTe films for solar cell applications

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CdTe solar cells are the leading thin film solar cell technology. However, despite their near ideal bandgap, the cell efficiency is far less than the theoretical limit, and considerably less than efficiencies reported in other systems with similar bandgaps, such as GaAs. The purpose of this study is to investigate the loss mechanisms in commercial CdTe cells by comparing them with model systems. We combined scanning electron microscopy (SEM)-based cryogenic cathodoluminescence (CL) spectrum imaging and electron backscatter diffraction (EBSD) in order to map the spatial distribution of various atomic-level defects in CdTe films as a function of deposition and film processing. Two different deposition techniques were used. Lattice-matched, epitaxial CdTe films were deposited on single crystal as well as polycrystalline CdTe substrates by molecular beam epitaxy (MBE). For comparison purposes, polycrystalline CdTe films were deposited using our standard close-spaced sublimation (CSS) method on glass-based substrates. Correlations between the CSL relationship, defect structure, and radiative recombination intensity at grain boundaries and intra-grain regions are then made and discussed in the context of film deposition conditions and post-deposition processing history. Further, the effect of the $CdCl_2$ passivating treatment was investigated. The distribution of Cl on grain boundaries and intra-grain dislocations was studied by time of flight SIMS (TOF-SIMS) imaging and high resolution STEM-EELS. These results were correlated with the recombination behavior of these defects as revealed by CL.