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Comparative nm-Resolution Electrical Potential and Resistance Mapping of Cu(In,Ga)Se_2, $Cu_2ZnSnSe_4$, and CdTe Thin Films CHUNSHENG JIANG, INGRID REPINS, LORELLE MANSFIELD, MIGUEL CONTRERAS, HELIO MOUTINHO, KANNAN RAMANATHAN, MOWAFAK ALJASSIM, National Renewable Energy Laboratory, NATIONAL RENEWABLE ENERGY LABORATORY TEAM — We report on a comparative study of three leading thin-film PV materials of Cu(In,Ga)Se_2 (CIGS), $Cu_2ZnSnSe_4$ (CZTS), and CdTe, by mapping the local electrical potential and resistance using atomic force microscopy (AFM)-based electrical techniques of scanning Kelvin probe force microscopy (SKPFM) and scanning spreading resistance microscopy (SSRM). The SKPFM potential mapping shows consistent results among the three films. The energy bands around the grain boundaries (GBs) bent downward and the GBs are positively charged. However, whether the carriers around the GBs are depleted or inverted could not be determined solely by the potential contrast between the GB and grain surface because surface band bending decreases this contrast. The SSRM resistance mapping shows different results between the films. A higher conduction channel was imaged along the GBs of CIGS and CZTS, indicating an inversion of carriers around the GBs. However, no characteristic resistance was imaged on the GBs of CdTe. This difference of local resistance on the GBs suggests a depletion of carriers in CdTe, in contrast to CIGS and CZTS. These nm-electrical mapping proposes an active GB of CdTe for minority carrier recombination, but inactive GBs of CIGS and CZTS.

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