Type of presentation: Invited

MS-14-IN-2388 Structure-property relationships in thin-film solar cells on multiple scales by correlative electron microscopy

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Thin-film solar cells consist of a stack of polycrystalline layers with thicknesses of few 10 nm to several micrometers, which can be deposited on rigid glass as well as on flexible metal or polymer substrates. A typical p-n setup comprises the use of a p-type absorber layer, an n-type semiconductor layer to form the p-n junction, as well as two electrical contacts, of which one is formed by a transparent conductive oxide. Nowadays, highest power-conversion efficiencies of almost 21 % have been achieved using polycrystalline Cu(In,Ga)Se_2 thin films as absorber material [1,2]. The question remains of how such excellent photovoltaic performance is possible, in view of the large densities of extended structural defects present in the absorber layer.

In the recent years, we have addressed this question in various studies, combining different electron microscopy techniques on identical regions of interest on the specimen [3-10]. The present contribution intends to give an overview of this work, showing results from electron backscatter diffraction, electron-beam-induced current, and cathodoluminescence measurements in scanning electron microscopy on scales of up to few hundreds of micrometers, as well as by high-resolution imaging, electron energy-loss spectrometry, and inline electron holography in transmission electron microscopy in the subnanometer range. Challenges in specimen preparation and analysis will be covered, and an outlook on future activities will be presented.

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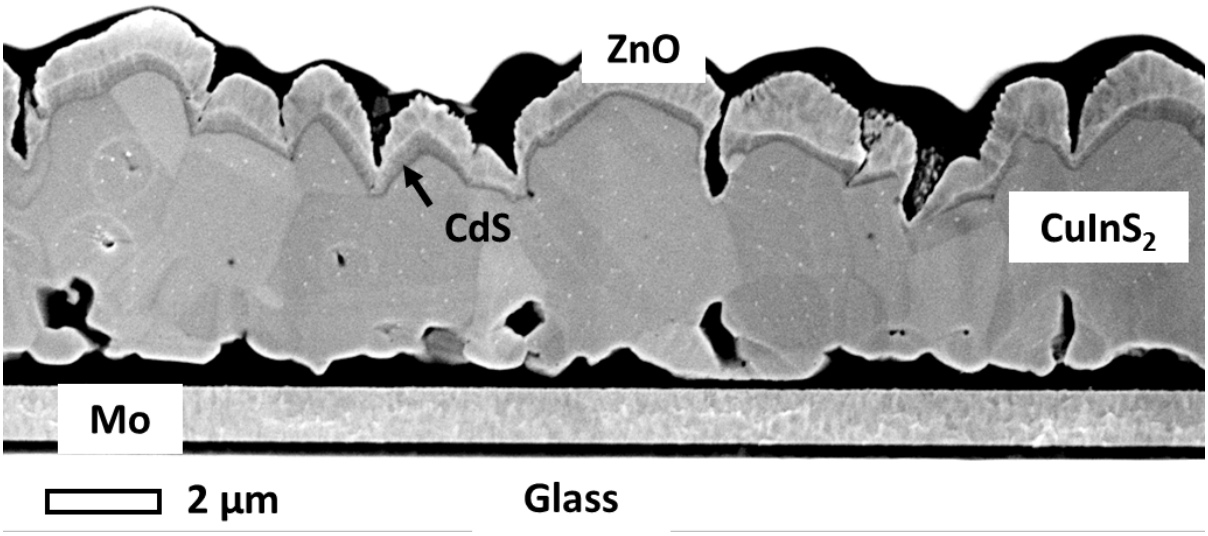

Fig. 1: Scanning electron micrograph of a glass/Mo/$CuInS_2$/CdS/ZnO solar-cell stack acquired in cross-section.

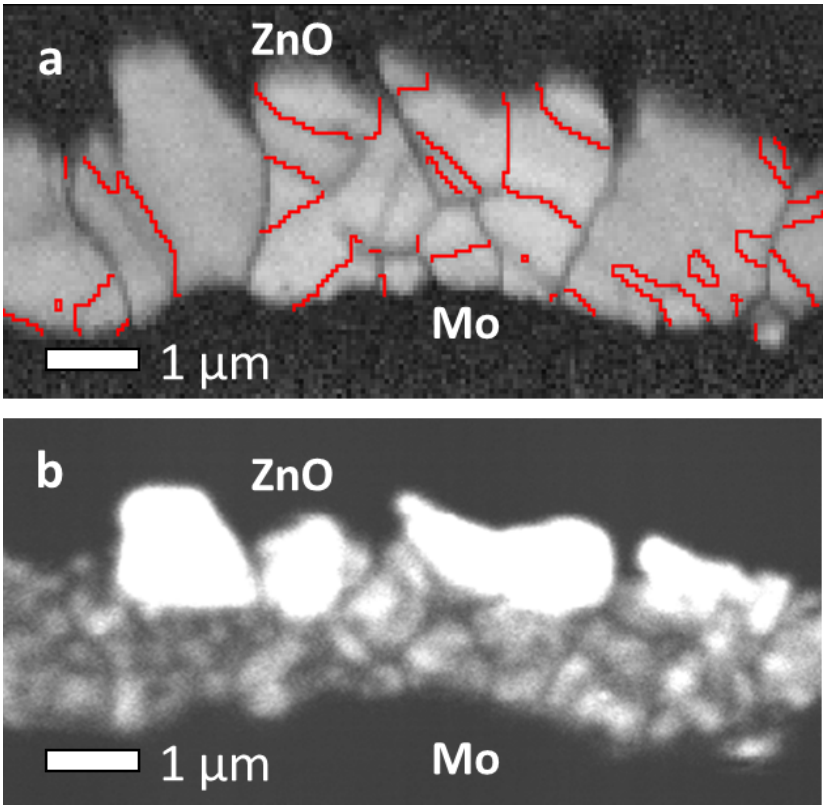

Fig. 2: a) EBSD pattern-quality map of a glass/Mo/$CuInS_2$/CdS/ZnO solar-cell stack with Σ3 grain boundaries highlighted by red lines. b) Monochromatic CL image at 820 nm from the same identical position as in a). The contrast in the CL image was increased substantially in order to make the details close to the Mo back contact visible. Adapted from Ref. [10]