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Characterizing the Back-Contact Interface for CdTe PV through HRSTEM, EELS, and XEDS

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CdTe PV devices show promise for higher energy and cost efficiency in the near future. Carrier recombination in the absorber has been improved, which now highlights the importance of back contact engineering to transport the photo-electrons to the electrode [1][2]. Atomic-resolution characterization of the back contact is a necessary to quantify defects at the interface that limit efficiency. STEM imaging techniques, as well chemical analysis with electron energy-loss spectroscopy (EELS) and energy-dispersive X-ray spectroscopy (XEDS) accurately informs problem solving approaches for new devices. New materials designed for carrier transport to the back contact will be characterized by their interfacial properties with CdTe and their elemental stability using in situ imaging and spectroscopy.

In this study, we will utilize the aberration-corrected cold-field emission JEOL ARM200CF features STEM resolution 0.78 Å for dark field imaging and XEDS with 0.13 nm spatial resolution and EELS. XEDS analysis is performed using the Oxford XMAX100TLE large solid-angle detector and the Gatan Continuum GIF spectrometer equipped on the JEOL ARM200CF. Combining EELS and XEDS provides information about the elemental distribution of a particular region in the poly-crystalline region of the absorber layer, as well as information regarding its bonding at the hetero-interfaces. Atomic-resolution high-angle annular dark-field (HAADF) imaging in a STEM is used characterize the atomic- and electronic structures of the defects at the interfaces between the CdTe absorber and the back contacts.

Figure 1 shows a low magnification image of a typical polycrystalline CdTe PV device and labeled are the front and back contact regions as well as the absorber bulk. The region indicated with the red box is typical of back contact interfaces. Figure 2 shows the results of an XEDS linescan across interfaces near the back contact of the device. The layer with the amorphous contrast on top of figure 2 is Pt deposited during FIB specimen preparation. Underneath the Pt is a Te-rich film buffer layer for the back contact, followed by the CdTe absorber. It depicts signal intensity at each linescan step correlated with selected elements using the XEDS detector. In this contribution, we will show our atomic-resolution characterization of the back-contact interfaces, and correlate the measured atomic and electronic structures with the devices transport properties. [3]

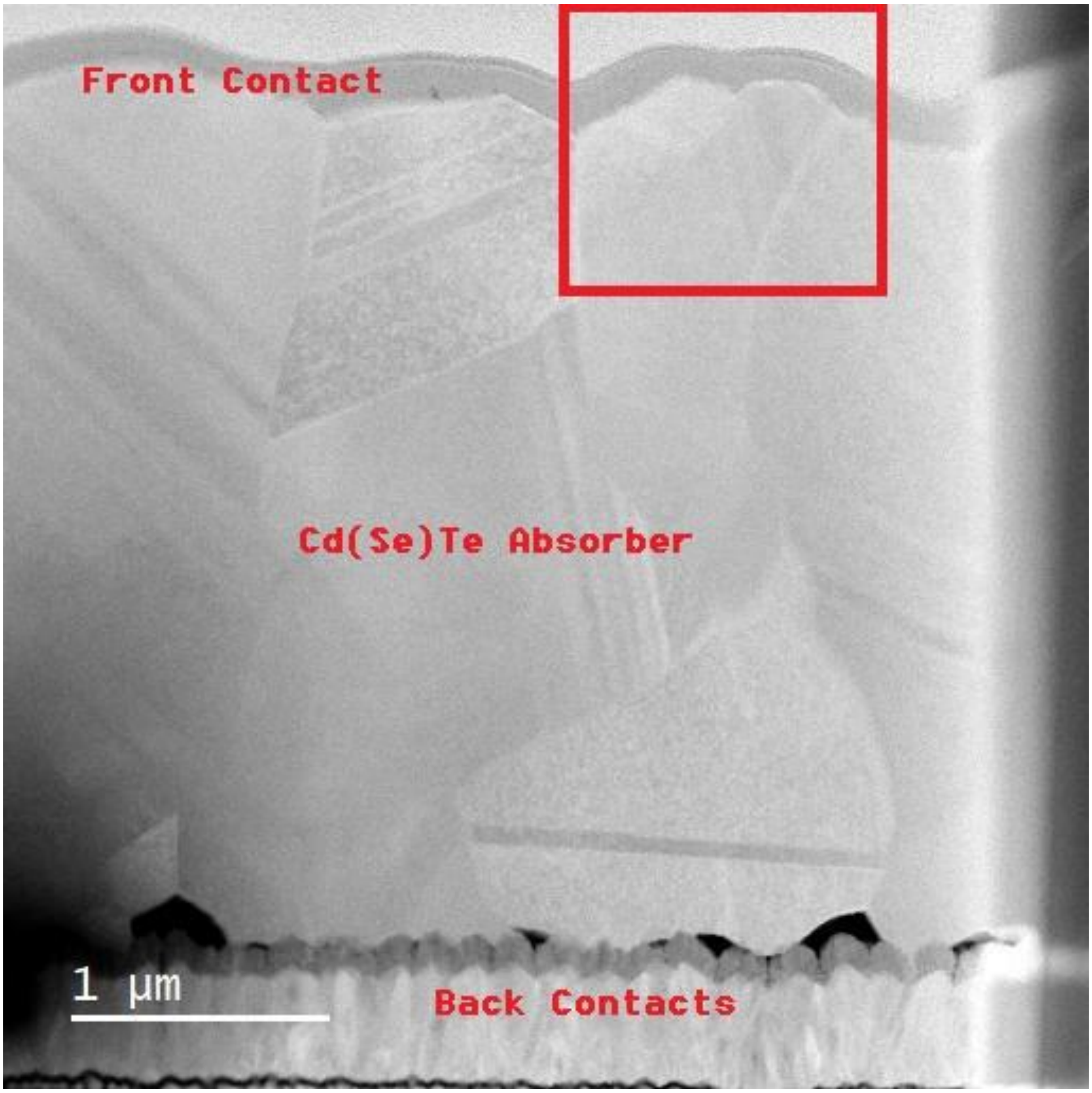

Figure 1. Low Magnification of CdTe device

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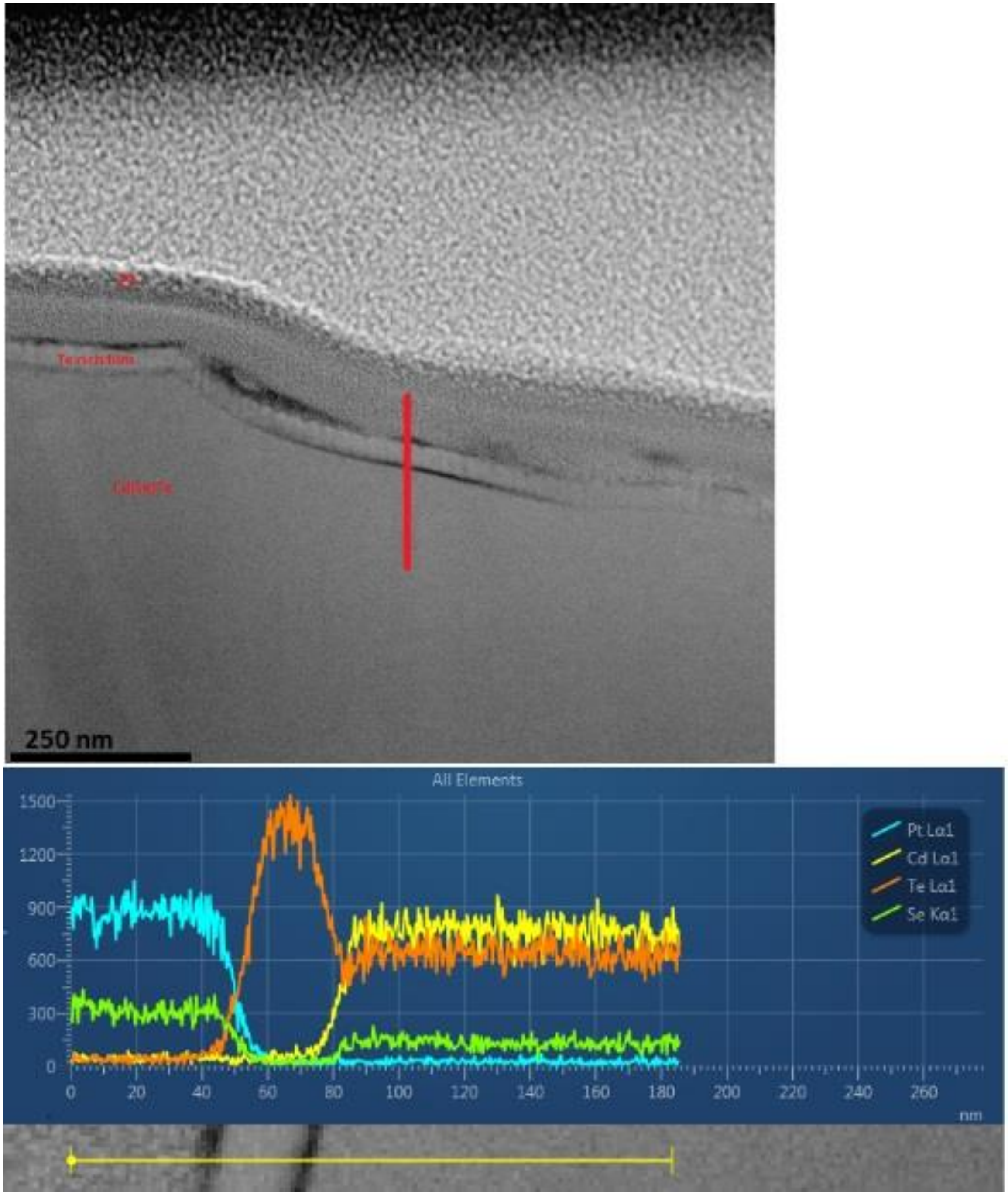

Figure 2. XEDS linescan

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