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Effects of $CdCl_2$ treatment on the local electronic properties of polycrystalline CdTe measured with photoemission electron microscopy

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A critical step in manufacturing efficient thin-film polycrystalline CdTe photovoltaic devices involves a post-growth treatment using $CdCl_2$. Tough the role of $CdCl_2$ treatment in the uptake of efficiencies in CdTe devices has been a subject of intense study, it is not completely understood, and there is ample room for unique approaches. To examine the effect of CdCl2 treatment on the local electronic band alignment in CdTe films, we used a newly-developed spectroscopy technique based on photoemission electron microscopy (PEEM) coupled to deep ultraviolet (DUV) light. DUV-PEEM enables collection of spectrally-resolved electronic band information with nanoscale spatial resolution. With maps of the vacuum level and ionization energy, we observed electronic property variation amongst grains in CdTe in addition to variation between grain interiors and grain boundaries. Preparation of oxide-free CdTe surfaces enabled us to observe that reduced work function at grain boundaries, previously attributed to Cl segregation and doping at grain boundaries, is likely the result of an interaction between Cl and O. In addition, we found that grain boundary behavior in CdTe is more heterogeneous than prevailing GB models suggest. Attempts to integrate surface photovoltage measurement with PEEM also provided a direct measure of the directionality of surface band bending, a necessary consideration for interface passivation. These new insights regarding the local electronic properties of CdTe may provide a route to engineer grain boundary and interface properties for optimum device efficiency.