Co-solvent Enhanced Zinc Oxysulfide Buffer Layers in Kesterite Copper Zinc Tin Selenide Solar Cells

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Supporting Information:

S1: Data from literature survey with 121 Eg values from peer reviewed journal articles compiled along with their corresponding ion concentrations. Additional information such as references and ligand type is also provided in SI file ZnS_CBD_Data.csv.

Figure S2: Auger electron spectroscopy map of Cu, Zn, Sn and Se. Slight variations in intensity are due to the rough polycrystalline film surface.
Figure S3: Zn LMM lineshape analysis showing distinct chemical environments for CZTSe and CBD-ZnOS.

Figure S4: CZTSe/CBD-ZnOS layer-by-layer XPS of O 1s showing removal and/or conversion of surface oxide and subsequent ZnOS growth. The film ends in largely ZnOS with some ZnO evidenced by the low BE tail.
Figure S5: Representative VB spectra for CZTSe/ZnOS heterojunction formed layer-by-layer.

Figure S6: Thickness dependence of $J_{sc}$ and $V_{oc}$ for devices made with water+DMSO CBD-ZnOS buffer layers. $V_{oc}$ and $J_{sc}$ for optimized CdS buffered devices is shown for comparison (dashed lines). The CdS buffered device reaches over 8% power conversion efficiency with $V_{oc}$ of 0.36 V and $J_{sc}$ of 34.5 mA/cm$^2$. $V_{oc}$ increases as the buffer nucleates and fills in to cover the absorber surface and matches the CdS performance. However, $J_{sc}$ falls quickly as the buffer thickness increases.