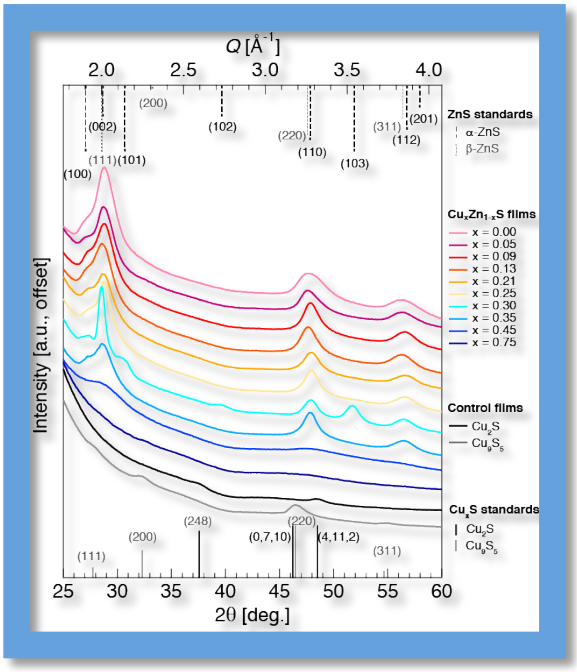
The Cu-Zn-S Phase Space: Unlocking the Mysteries of Promising p-type Transparent Conductors at SSRL

Rachel Woods-Robinson, Xiaojie Xu, Joel W. Ager
Lawrence Berkeley National Laboratory

P-type transparent conducting materials (TCMs) could be an important enabling material in next generation solar cell and optoelectronic technologies. In particular, p-type TCMs are in high demand as top electrodes and as interconnect layers in tandem structures. However, due to low conductivity compared to existing n-type TCMs, no p-type TCM to date has been used in a solar cell. Our group has explored the Cu-Zn-S phase space, and found some remarkably high performing p-type TCMs. Recently, we have used pulsed laser deposition (PLD), chemical bath deposition (CBD), atomic layer deposition (ALD), among other methods, to synthesize Cu-Zn-S films at low temperature, which is advantageous for many practical device applications.

To better understand the structure of our materials and the mechanisms behind high conductivity and transparency, we have conducted wide-angle x-ray scattering (WAXS) analysis on beam line 11-3 at SSRL. In this poster we compare the properties and microstructure of our PLD and CBD synthesized films, and pinpoint the regions in the Cu-Zn-S phase space we have accessed. Both films are heterostructured, but their paths to conductivity are vastly different. With PLD, Cu-doped ZnS conducting regions are embedded in non-conducting amorphous Cu_xS. In contrast, the CBD films consist of conducting CuS regions embedded in non-conducting ZnS. We also analyze the crystal size and the lattice constant shifts. Both structures have unique properties beneficial to different applications. Future work at SSRL will use x-ray absorption to study the bonding and phase ratios in greater detail in order to understand and optimize this class of p-type TCMs.

PLD-CuZnS



CBD-CuZnS