

Emerging Chalcogenides for Sustainable Energy and Environmental Applications

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Abstract: Copper–zinc–tin–sulfide ($\text{Cu}_2\text{ZnSnS}_4$, CZTS) kesterites a promising earth-abundant and non-toxic absorber for next-generation thin-film photovoltaics. However, sulfur-based CZTS solar cells remain limited in performance, largely due to intrinsic defects and interfacial recombination losses. Impact of solvent chemistry and extrinsic doping and compositional engineering on the quality of solution-processed CZTS absorbers is revealed [2,3,4,5]. Cd-alloyed CZTS (CZCTS) improves the solar cells efficiencies promoting nearly defect -free due to a quasi-epitaxy between CZCTS and CdS. A synergistic compositional strategy combining silver (Ag) – cadmium (Cd) co-alloying with lithium (Li) doping is introduced to suppress cation disorder, passivate grain-boundary defects, and enhance carrier transport. As a result, champion devices with power conversion efficiency over 10% are obtained, placing it among the highest efficiencies reported for solution-processed, selenium-free CZTS solar cells.

Antimony chalcogenides (Sb_2X_3 , where $\text{X} = \text{S}, \text{Se}, \text{or } \text{S}_x\text{Se}_{1-x}$), as an earth-abundant light-absorbing material class with long-term stability for thin-film photovoltaics, is recognized as promising for emerging inorganic thin-film solar cells Among the Sb_2X_3 family, antimony sulfide (Sb_2S_3) is one of the most attractive materials for thin-film solar cells due to its favorable optoelectronic properties, including a high absorption coefficient ($\alpha > 10^5 \text{ cm}^{-1}$) and a direct bandgap of around 1.7 eV, while being a binary compound with a single stable phase and earth-abundant elemental composition However, to further develop Sb_2S_3 -based solar cells, which are yet less explored among Sb_2X_3 , precise control over film deposition parameters, morphology, crystallinity, and defect passivation to optimize charge transport and reduce recombination losses is required, several aspects being presented in this work [6,7].

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