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EDITORIAL
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Editorial: Eco-Friendly Chalcogenide and Perovskite Based Materials for Solar Energy Conversion

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Editorial on the Research Topic

Eco-Friendly Chalcogenide and Perovskite Based Materials for Solar Energy Conversion

With rising threats associated with global climate change, a paradigm shift to renewable energy is indispensable for decarbonization and limiting the temperature rise below 1.5°C. Photovoltaic solar energy conversion constitutes a major proportion of the total energy conversion, and it is estimated that about 30 TW of energy will be required by 2050. To address this Tera-Watt energy challenge, different PV technologies beyond Silicon would play a key role. Thin-film photovoltaic-based materials such as chalcogenide (CIGSSe), kesterite (CZTSSe), and perovskite (ABX_3) have gained impetus owing to their high theoretical efficiency limits, low material cost, flexibility and energy-efficient device processing. In recent years, thin-film photovoltaics have witnessed rapid advancements in their efficiency and processability. However, key challenges still lie ahead, particularly the understanding of the complex defect physics and passivation strategies to improve the performance. This special issue focuses on two key technologies—1) chalcogenide and kesterite-based solar cells and 2) perovskite solar cells.

Low photovoltage is the major performance-limiting factor for CIGSe and CZTS based solar cells. Several underlying reasons have been identified, including losses due to—bulk defects, surface defects, phase segregation, absorber-buffer interface recombination. The presence of intrinsic defects, secondary phases, and disorder are very sensitive to the chemical composition. Cation substitution has emerged as a promising strategy towards phase stabilization and to alter the formation energy of deleterious defects and secondary phases. However, the atomic-scale insights in terms of bond lengths and lattice constants remain elusive. In an attempt to gain mechanistic understanding, Ritter et al. studied the effect of cation substitution in $(Ag,Cu)ZnSnSe_4$ and $Cu_2Zn(Sn,Ge)Se_4$ kesterite thin films *via* grazing angle X-ray diffraction (XRD) and low-temperature X-ray absorption spectroscopy (XAS).

Various approaches have been explored to improve device efficiency of organic-inorganic halide perovskite-based solar cells, which include—composition tuning, additive engineering, solvent engineering, bulk and surface passivation (3D-2D interfaces), grain size, and morphology engineering. It is clear that the control over crystallization kinetics and passivation is crucial to achieving high efficiency and stable perovskite devices. Kazemi et al. show the effect of annealing temperature and time on the device efficiency of solution-processed $CH_3NH_3PbI_3$ solar cells. Through controlled annealing parameters, a direct correlation between film crystallinity and performance is established, along with key insights on the perovskite decomposition.

Bouich et al. report the incorporation of tetrabutylammonium (TBA) in $MAPbI_3$ thin films. The partial inclusion of TBA cation improves the perovskite crystallinity, grain size, and morphology, resulting in improved moisture resistance.

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As highlighted by the authors of this special issue, chalcogenide and perovskite materials and devices demonstrate exceptional potential and cost-effectiveness. Despite rapid developments, fundamental challenges need to be addressed to realize the practical adoption of these materials for large-scale deployment. New materials and novel chemical formulations with promising properties are also on the horizon. We hope that the cation substitution and passivation strategies highlighted in this issue would be interesting for the readers in this exciting area of research.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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