Controllable SnS-Vapor-Assisted Selenization to Enhance Carrier Transport in Kesterite Solar Cell with Power Conversion Efficiency Exceeding 15%

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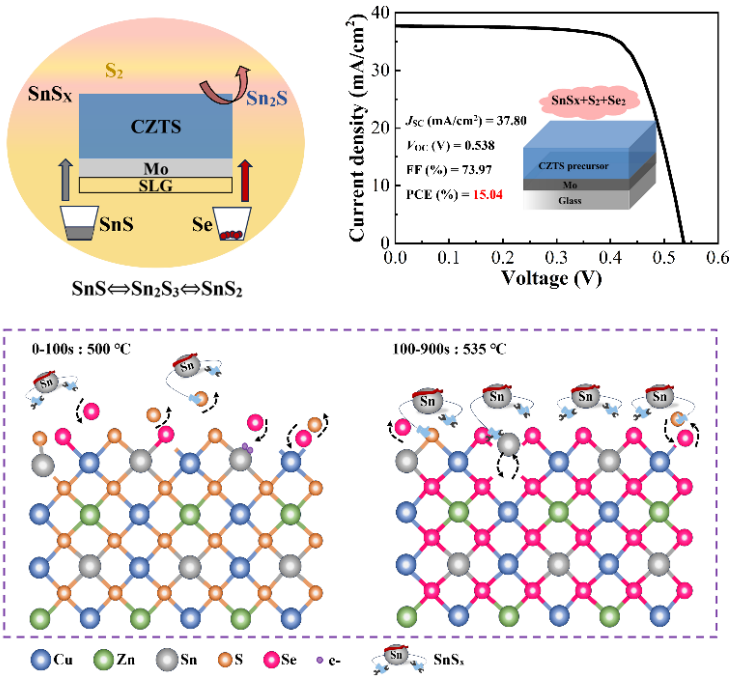
Abstract

Charge loss within the polycrystalline $Cu_2ZnSn(S,Se)_4$ (CZTSSe) absorbers remains a critical factor limiting the performance of this emerging thin-film solar cell. Herein, we introduce a SnS-vapor-assisted selenization strategy to mitigate defects and suppress charge loss in CZTSSe films by tuning the annealing temperature and the incorporation of SnS. Notably, SnS does not participate in grain growth but serves to suppress the volatilization of Sn from the film surface. In addition, the thermodynamic equilibrium between SnS and SnS_2 facilitates the regulation of sulfur partial pressure via S transport mediation during annealing. An initial high-temperature annealing step promotes Se-for-S substitution, effectively suppressing S enrichment and its adverse effects on grain nucleation and growth kinetics. Subsequently, a lower-temperature annealing step sustains S partial pressure through thermodynamic equilibrium of SnS, enabling defect passivation and interface bandgap tuning. These collective effects have importantly facilitated carrier transport within the device, leading to a conspicuous augmentation in the performance of kesterite solar cells. Specifically, a power conversion efficiency exceeding 15% has been attained, which represents one of the highest reported values for assisted selenization-fabricated CZTSSe solar cells.



Reference

1. A. Liang, Y. Jian, Y. Zhao, S. Chen, J. Zhao, Z. Zheng, J. Luo, H. Ma, X. Zhang, Z. Su, G. Liang, Adv. Energy Mater. 2024, 15, 2403950.