Optimizing Sn Doping in Zn_4Sb_3 Thin Films: Insights into Processing and Electrical Performance

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Abstract

β-Zn_4Sb_3 is a promising thermoelectric material due to its environmental friendliness and suitability for mid-temperature applications which aligns with the development of renewable energy. However, maintaining its pure β-phase during fabrication remains a significant challenge, as phase instabilities often degrade its thermoelectric performance. Here, we demonstrate the successful optimization of β-Zn_4Sb_3 thin films through controlled Sn doping using ion beam-assisted deposition. By precisely regulating the Sn concentration at 0.97 %, the β-Zn_4Sb_3 phase is preserved, resulting in a maximum power factor of 1.4 mW m^{-1} K^{-2} at 573 K—a 60 % improvement over undoped films. Comprehensive analyses reveal that dilute Sn doping enhances carrier mobility and structural stability while avoiding detrimental phase transitions to ZnSb. These findings highlight the importance of precise doping and processing control in stabilizing the β-phase structure. This work provides a new pathway for fabricating high-quality thermoelectric thin films, offering

valuable insights into the development of scalable, efficient energy harvesting technologies.

Author keywords

Doping; Energy efficiency; Ion beam-assisted deposition; Renewable energy; Thermoelectric; Zn_4Sb_3

Indexed keywords

Engineering controlled terms

Clean energy; Energy harvesting; High temperature applications; Ion beam assisted deposition; Layered semiconductors; Renewable energy; Semiconductor doping; Tin alloys; Zinc alloys; Zinc Selenide; Zinc sulfide

Engineering uncontrolled terms

Electrical performance; Energy; Ion beam-assisted deposition; Processing performance; Renewable energies; Sn doping; Thermo-Electric materials; Thermoelectric; Thermoelectric material; Thin-films

EMTREE medical terms

article; controlled study; degradation; energy; human; male; pharmaceutics; phase transition; renewable energy; temperature

Engineering main heading

Thin films

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Abstract

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