Improving Thermoelectric Properties of Bi2Te3 Thin Films By Manganese Co-Sputtering

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Abstract Bi2Te3 remains a benchmark n-type thermoelectric (TE) material for low-temperature energy conversion, but its small band gap can reduce efficiency because of thermally generated parasitic carriers. Elemental doping has been explored to improve TE performance, although systematic studies on manganese (Mn)-doped Bi2Te3 thin films remain limited. In this study, a radiofrequency magnetron co-sputtering workflow was used to fabricate Mn-doped Bi2Te3 thin films by varying Mn target power while maintaining constant Bi2Te3 deposition conditions. Structural, microstructural, compositional, and TE transport properties were evaluated using X-ray diffraction, field-emission scanning electron microscopy, energy-dispersive X-ray spectroscopy, and temperature-dependent transport measurements. X-ray diffraction confirmed retention of the rhombohedral Bi2Te3 phase with a preferred (015) orientation, while peak shifts toward higher 2 theta values were consistent with Mn-related lattice contraction. All films exhibited negative Seebeck coefficients, confirming n-type conduction. Increasing Mn doping enhanced the magnitude of the Seebeck coefficient but also increased electrical resistivity, demonstrating a transport tradeoff. The film deposited at 5 W Mn power achieved the highest power factor of 529.33 µW m-1 K-2 at 523 K because of its low resistivity combined with adequate thermopower. These results demonstrate that moderate Mn incorporation can improve the power-factor-related performance of Bi2Te3 thin films within the measured temperature range.

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