Optimizing electrical and thermal transport properties of n-type Bi_2Te_3-based materials for room-temperature theremoelectric application

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Bi_2Te_3 has been the most efficient system for near-room temperature thermoelectric (TE) applications. Because TE modules consist of numerous pairs of p- and n-type TE legs, it is important to improve both types of materials with high TE performance. Compared to the reported TE performances of p-type Bi_2Te_3-based materials, the progress of n-type counterparts has been retarded because of limited dopants and substituents for suppessing their thermal transport with minimizing the deterioration of electrical transport properties.

Here, we report high performance n-type Bi_2Te_3-based system via introducing K_2Se_x (x = 1 – 6). We demonstrate that the incorporation of K_2Se_x effectively induces multi-scale microstructures in Bi_2Te_3 matrix, resulting in the increased phonon scattering. As a result, the best performing member of these systems shows the significantly reduced lattice thermal conductivity (κ_{lat}) down to ~ 0.57 $W \cdot m^{-1} \cdot K^{-1}$ and remarkably high peak TE figure of merit (ZT) of ~ 1.12 at 397 K and average ZT over unity in the wide range of temperature from 300 K to 500 K.