Syntheses and Thermoelectric Properties of Bulk Nanocomposites

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Nanostructuring is a new approach toward high performance bulk thermoelectric materials. Here we report our recent works on the preparation of bulk nanocomposites by solvo- or hydrothermal syntheses followed by hot-pressing (HP) or spark plasma sintering (SPS). The effects of nanosized microstructures on the thermoelectric properties were discussed.

Ternary $(Bi,Sb)_2Te_3$ nanocomposites were produced by HP from the mixture of two binary nanopowders. It was found that the nanocomposites have laminated structures of Bi_2Te_3 and Sb_2Te_3 nano-layers with the thickness varying alternately between 5 and 50 nm. The transport measurements indicate that the nanoscale laminated structure improves the thermoelectric performance. A high ZT near 1.5 was obtained for the $BiSbTe_3$ nanocomposite. $CoSb_3$ based skutterudite nanocomposites were prepared by SPS from the solvothermally synthesized nanopowders and melted/ground micro-powders. Microstructure analysis shows that the bulk materials are composed of coarse grains and fine grains with the sizes in the order of 100 nm. The highest ZT reaches 0.9 for both the nanocomposites of $Yb_{0.15}Co_4Sb_{12}$ containing 5% and 10% $CoSb_3$ nanopowders.

The results indicate that an ideal nanocomposite should consist of two semiconducting phases and at least one nano-phase with the construction size less than about 50 nm. The nanostructures could make it possible to vary the Seebeck coefficient, electric and thermal conductivity of the nanocomposite quasi-independently, give rise to quantum confinement effects and improve the thermoelectric performances of the sample efficiently. It remains also a large space for further enhancing ZT, by controlling the nanopowder morphology during synthesis, hindering grain growth during sintering and optimizing the doping concentration of the materials.

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