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Towards the Enhancement of Thermoelectric Properties by Controlling the Thermoelectrical Nature of Grain Boundaries in Polycrystalline Materials

Authors : Angel Fabian Mijangos, Jaime Alvarez Quintana

Abstract : Waste heat occurs in many areas of daily life because world's energy consumption is inefficient. In general, generating 1 watt of power requires about 3 watt of energy input and involves dumping into the environment the equivalent of about 2 watts of power in the form of heat. Therefore, an attractive and sustainable solution to the energy problem would be the development of highly efficient thermoelectric devices which could help to recover this waste heat. This work presents the influence on the thermoelectric properties of metallic, semiconducting, and dielectric nanoparticles added into the grain boundaries of polycrystalline antimony (Sb) and bismuth (Bi) matrixes in order to obtain p- and n-type thermoelectric materials, respectively, by hot pressing methods. Results show that thermoelectric properties are significantly affected by the electrical and thermal nature as well as concentration of nanoparticles. Nevertheless, by optimizing the amount of the nanoparticles on the grain boundaries, an oscillatory behavior in ZT as function of the concentration of the nanoscale constituents is present. This effect is due to energy filtering mechanism which module the quantity of charge transport in the system and affects thermoelectric properties. Accordingly, a ZTmax can be accomplished through the addition of the appropriate amount of nanoparticles into the grain boundaries region. In this case, till three orders of amelioration on ZT is reached in both systems compared with the reference sample of each one. This approach paves the way to pursuit high performance thermoelectric materials in a simple way and opens a new route towards the enhancement of the thermoelectric figure of merit.

Keywords : energy filtering, grain boundaries, thermoelectric, nanostructured materials
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