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# Effects of Different Morphologies of $Bi_2Te_3$ Nanopowders on Thermoelectric Properties

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Thermoelectric $Bi_2Te_3$ alloy nanopowders with different morphologies were synthesized by hydrothermal processes with different surfactants. The nanopowders were hot-pressed into pellets, and their thermoelectric properties were investigated. The results show that the morphologies of the nanopowders have remarkable effects on the thermoelectric properties of the hot-pressed bulk pellets. A suitable microstructure of the bulk pellet prepared from flower-like nanosheets was found, having a lower electrical resistivity, larger Seebeck coefficient, and lower thermal conductivity, resulting in a high figure of merit $ZT \approx 1.16$. The effects of the nanopowders with different morphologies on the microstructure and thermoelectric properties of hot-pressed bulk pellets are discussed.

**Key words:** Thermoelectric materials, $Bi_2Te_3$ nanopowders, thermoelectric properties

## INTRODUCTION

Thermoelectric materials have potential applications in many fields.[1,2] The efficiency of a thermoelectric material is determined by the dimensionless figure of merit $ZT = S^2\sigma/\kappa T$, where $T$ is the absolute temperature, and $S$, $\sigma$, and $\kappa$ are the Seebeck coefficient, electrical conductivity, and thermal conductivity of the material, respectively. High $ZT$ value corresponds to high efficiency, so a promising thermoelectric material should have large Seebeck coefficient, high electrical conductivity, and low thermal conductivity.[3] However, since these transport characteristics are correlated with each other, it is not an easy task to improve $S$, $\sigma$, and $\kappa$ simultaneously. In recent years, use of band engineering (usually through elemental doping) and nanostructure engineering (to reduce the size of the samples or grains in a bulk pellet to the nanoscale) to enhance the $ZT$ value of thermoelectric materials has become a focus.[4–6] The efficiency of nanostructure engineering to reduce the thermal conductivity and increase the Seebeck coefficient has been demonstrated.[7,8]

$Bi_2Te_3$ is an important commercialized thermoelectric alloy, usually prepared by the melt casting method. It was suggested that use of $Bi_2Te_3$ nanopowders to prepare $Bi_2Te_3$ bulk pellets would improve their $ZT$ values. In recent years, a lot of effort has been invested in this direction. Biswas et al.[9] synthesized $Bi_2Te_3$ nanowires by galvanostatic electrodeposition. Yu et al.[10] prepared very fine $Bi_2Te_3$ powders using mechanical alloying. Zhao and coworkers[11–15] synthesized $Bi_2Te_3$ nanopowders with different morphologies by a chemical method. However, it is very difficult to retain such nanostructure when pelletizing nanopowders at elevated temperature due to obvious growth of crystals. Use of a lower pelletizing temperature also results in lower bulk density and lower electrical conductivity, which are harmful to the thermoelectric properties of the bulk pellets. Although the morphologies of nanopowders may be lost when pelletizing at elevated temperature, it is still possible that the starting morphologies of the nanopowders will have some effects on the final bulk pellets.

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