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Texturing of $(Bi_{0.2}Sb_{0.8})_2Te_3$ Nanopowders by Open Die Pressing

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Open die pressing (ODP) at 370°C to 420°C has been employed as a straightforward forming process for sintering and texturing *p*-type $(Bi_{0.2}Sb_{0.8})_2Te_3$ nanopowders. x-Ray diffraction pattern analysis showed that ODP samples were strongly textured, with the basal (00*l*) planes of the hexagonal crystal cell oriented parallel to the pressing plates. The degree of texturing, evaluated as the orientation factor, *f*, by the Lotgering method, increased with decreasing final thickness of the samples. It was about f = 45% for 10-mm-thick samples and reached 70% for 2-mm-thick samples. Thermoelectric properties of ODP specimens were measured by the Harman method in the range from 20°C to 170°C. The dimensionless figure of merit, *ZT*, for 10-mm-thick samples was around 1 from room temperature up to 100°C.

Key words: Bi_2Te_3-based nanopowders, texturing, open die pressing, thermoelectrics

INTRODUCTION

Bi_2Te_3-based chalcogenides are known as the best thermoelectric materials for the temperature range of 20°C to 250°C.

Recently, a considerable enhancement of *ZT*, over a wide temperature range, has been achieved in *p*-type $Bi_xSb_{2-x}Te_3$, by reducing the crystalline grain size to the nanometer scale.[1,2] A further increase of the figure of merit in Bi_2Te_3-based chalcogenides can be expected by properly texturing the consolidated nanopowders. In fact, a 22% improvement of *ZT* at about 125°C has been reported in *n*-type $Bi_2Te_{2.7}Se_{0.3}$ by reorienting the basal (00*l*) planes of the hexagonal crystal cell.[3] Such reorientation was achieved by re-pressing consolidated hot-pressed samples.

In this paper we show that open die pressing (ODP) at 370°C to 420°C of Bi_2Te_3-based nanopowders, encapsulated in a metallic sleeve, allows for considerable improvement of the degree of texturing, together with simultaneous powder consolidation.

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Only results concerning *p*-type alloy are described herein, whereas results obtained on *n*-type nanopowders will be presented elsewhere (work in progress).

EXPERIMENTAL PROCEDURES

Nanopowders of $(Bi_{0.2}Sb_{0.8})_2Te_3$ alloy were prepared from shots of Bi, Sb, and Te elements (99.995% purity) by mechanical alloying. Attrition milling was performed in Ar atmosphere for 10 h. The average size of the nanograins was estimated as 20 nm to 25 nm, both by x-ray peak diffraction broadening and by direct observation by high-resolution transmission electron microscopy (HRTEM).[4]

Operating in an Ar-filled glovebox, nanopowders were encapsulated in cylindrical metallic sleeves. Preliminary tests were performed using Al 2011 commercial alloy, replaced in the following experiments with annealed Fe tubes (commercial purity), which is cheaper and more effective for the process. The inner surface of the metallic sleeve was covered by a film of BN to prevent sticking of the chalcogenide core. The sleeves were closed at both ends by Al alloy plugs, with a small hole for Ar leakage during pressing.