The Effect of Hot Extrusion on the Structure and Thermoelectric Properties of Bi_2Te_3 Material

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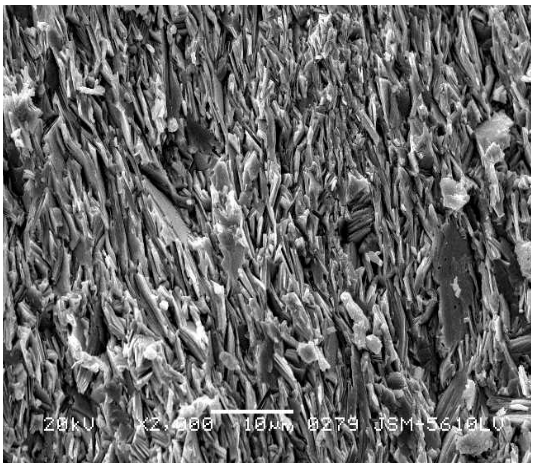
Extended Abstract

The Bi_2Te_3 compound is well known to have excellent thermoelectric properties at around room temperature, and is used in thermoelectric cooling device. Many approaches are followed to elaborate the alloys and to fabricate the thermoelements. As often mentioned previously, the thermoelectric performance and the mechanical properties of these alloys depend strongly on the crystal orientation for single crystal or crystalline texture for polycrystalline materials. Bismuth telluride material was fabricated using hot extrusion in this paper.

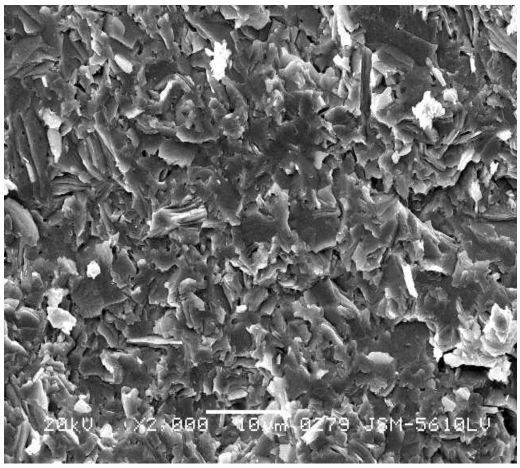
Stoichiometric amounts of the starting materials, high purity Bi, Te, Sb and Se of 5N purity were mixed and loaded in quartz tubes, evacuated and sealed off, subsequently melted at 1023K for 6 hours and then were cooled to room temperature in water. The polycrystalline ingots were crushed into small powders and were selected through oscillating sieve of 100 mesh, billets were produced by cold pressing and were hot-extruded at a temperature between 400 and 500 ℃.

The microstructure of the specimen was measure by SEM and X-ray diffraction. The effect of the texture on the thermoelectric properties has been highlighted by electrical measurements and mechanical testing along directions parallel and perpendicular to the extrusion direction. The Seebeck coefficient was determined by using a computer control testing system up to 673K. A standard four-probe method with a DC power supply of 50mA was employed to measure the electrical conductivity. Thermal conductivity was determined by using a common Harman methods. Three-points bending tests were carried out on specimens of $5\times5\times40$ mm^3 to obtain the mechanical strength in different directions.

Fig. 1 shows the scanning electron micrograph of the $(Bi_{0.2}Sb_{0.8})_2Te_3$ samples extruded at 450℃. in parallel sections and perpendicular sections to the extrusion



(a)



(b)

Fig. 1 SEM micrograph of $(Bi_{0.2}Sb_{0.8})_2Te_3$ extruded at 500℃ in parallel (a) and perpendicular (b) sections to the extrusion direction

direction. The orientation preferentially in extrusion direction is observed in the samples. Fig. 2 shows the XRD patterns of extrusion $(Bi_{0.2}Sb_{0.8})_2Te_3$ products. It was confirmed that the hot extrusion process changed the crystal orientational distribution.

Table 1 shows the performance comparisons including Seebeck coefficient, electrical resistivity, thermal conductivity, figure of merit and bending strength of samples extruded in different temperature. As extrusion temperature increases, the thermoelectric performance becomes better but when close to the melting point of alloys, a large deformation appear and both the thermoelectric and mechanical properties become worse.

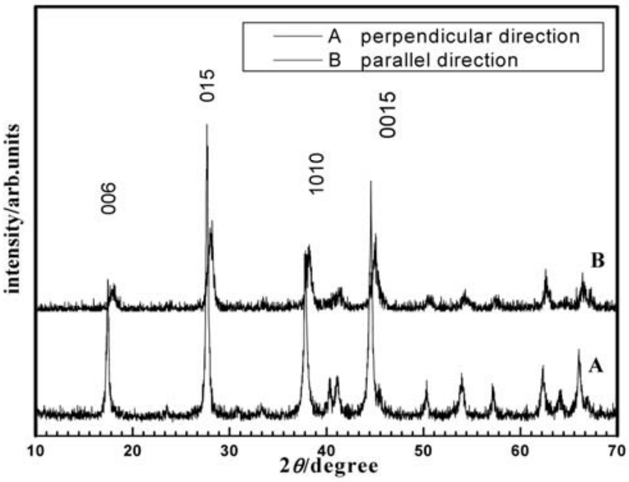


Fig. 2. XRD patterns of $(Bi_{0.2}Sb_{0.8})_2Te_3$ sintering samples. A: perpendicular section. B: parallel section to the extrusion direction

Table 1. Performance of $(Bi_{0.2}Sb_{0.8})_2Te_3$ Extruded at Different Temperature

Extrusion Temperature (℃)		Seebeck coefficient (μV/K)	Electrical Resistivity (mΩcm)	Thermal conductivity (watt/m.K)	Figure of merit ($\times10^{-3}$/K)	Bending strength (MPa)
450	parallel	196	0.91	1.29	3.27	54
	perpendicular	191	1.65	1.10	2.01	49
500	parallel	185	0.68	1.37	3.67	76
	perpendicular	189	0.92	1.23	3.16	67
600	parallel	282	15.58	0.45	1.13	33
	perpendicular	287	15.32	0.47	1.14	39