Electrical Current Applied Hot Pressing Processing of Bi_2Te_3-Bi_2Se_3 Thermoelectrics

S.C.Choi*, D.G.Baik and C.W.Hwang

Department of Materials Science and Engineering,
Ajou University, Suwon, Korea

Abstract

Bimuth telluride type thermoelectrics are prepared by AC current applied hot pressing method. It is possible to minimize the defects arising from the vaporization of Te, because of the very short processing time. The optimum conditions for the hot pressing of 95mol%Bi_2Te_3-5mol%Bi_2Se_3 themoelectrics are sintered at 400°C, for 2 min. with 1500 kgf/cm^2 from the particle size of 125 to 250 μm rang of powder. the resulted Z value (figure of merit) was $2.2\times10^{-3}deg^{-1}$.

1.Introduction

The thermoelctric material is a substance which converts the electrical energy into the thermal energy and vice versa. The fild of application are cooling and powder generation. They are based respectively on the Peltier and Seebeck effects.

Among thermoelectric materials, the Bi-Te system are the most widely used, specially for cooling, because it has the best figure of merit at room temperature rage. but these materials, when processed by the usual melt-grown method, have demerit of having cleavage planes by which mechanical damage occurs frequently and therefore significant waste results. To overcome this problem, the pullverized and hot pressing method of the materil processing has been studied.

The purpose of the presnt study is to find the optimum processing condition for n-type Bi_2Te_3-Bi_2Se_3 material through the AC applied hot

pressing method, which is suitable processing for industrial application.

2. Experimental Procedure

For the starting materilas, pure Bi, Te and Se of 99.999% were weighed out in a composition of 95mol% Bi_2Te_3-5mol%Bi_2Se_3, doped with CuBr(n-type) and encapsulated into a Pyrex glass tube with 10^{-4} torr vacuum . They were melted and shaken up in a rocking funace for 3 hours at about 650℃, and cooled in the funace to be formed into the starting ingot.

The ingot was crushed into powder size range of 74 - 595μm. 3% PVA aquerous solution was added to the powder as binder and pressed in a steel mold.

AC-applied hot pressing was done in nitrogen atmospere. The temperature and the pressure were fixed at 400℃ and 1500kgf/cm^2 for all particle sizes, while the sintering time was successively 1, 2, 3 and 4 minutes for each of the above powder size range respectively.

3. Results

The variation of density as a function of the sintering time are also shown in Fig.1 The density of the sample from larger particle size are increased more rapidly with sintering time than from the smaller ones and the density was finally saturated 7.1-7.2 g/cm^3 range. The obtainded final densities of sample were about 98% of the theoretical ones. In Fig. 2, The two of midium particle size show a maxium Z value at a relatively early stage, whereas sample from the smallist and largest particle size remain at about the same level throughout the sintering time range.

The thermoelectric properties of 95 mol% Bi_2Te_3 -5mol%Bi_2Se_3 thermoelectrics are shown in Table 1. The resulted Z value was 2. $2x10^{-3}deg^{-1}$ for hot pressed sample at 400℃, 2 min. The AC applied hot pressing method can be considered to be an industrially cost effective processing of Bi-Te thermoelectric system.

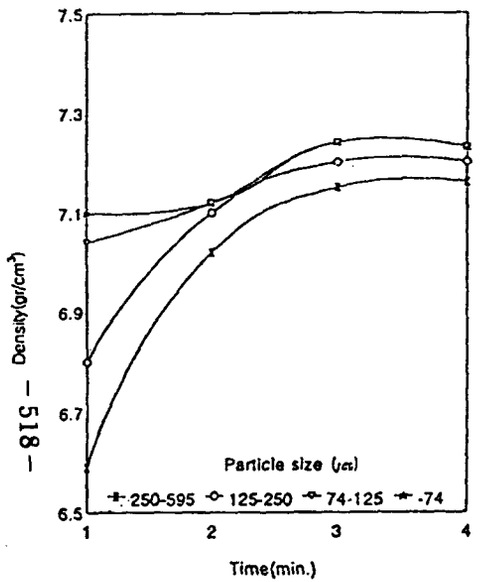

Fig. 1 Variation of density of hot pressed 95%Bi_2Te_3-5%Bi_2Se_3 with time and particle size.

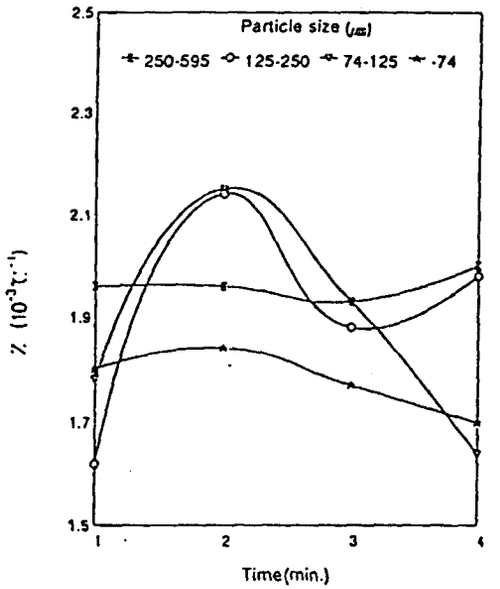

Fig. 2 Variation of figure of merit of hot pressed 95%Bi_2Te_3-5%Bi_2Se_3 with time and particle size.

Table 1 Thermoelectric properties of 95%Bi_2Te_3-5%Bi_2SE_3

	α (μV/℃)	σ (1/Ωcm)	K(W/m℃)	Z($\times 10^{-3}$℃)
Ingot*	-230	300	-1.3	1.22
AC applied sintering	-140	850	1.53	2.2

*, 650℃, 5hr.