SPATIAL DISTRIBUTION ON THERMOELECTRIC PROPERTIES FOR $Bi_{1.8}Sb_{0.2}Te_{3.0}$ COMPOUND

Ngo Thu Huong

Department of Physics, College of Science, VNU

G. Nakamoto, M. Kurisu

School of Materials Science, JAIST

Abstract: The single crystal of $Bi_{1.8}Sb_{0.2}Te_{3.0}$ compound was prepared by the Gradient Freeze method. The Seebeck coefficient, electrical resistivity, Hall effect and EPMA have investigated on the position of the ingot. We have found that all the pieces showed p-type conduction except three pieces out of 44 pieces. Almost all the part have low ρ. The results show that the sample at the center part is homogeneous.

1. Introduction

Bismuth telluride based thermoelectric materials are candidates for good thermoelectric materials that operate near room temperature. Many effort have been devoted to improve the thermoelectric performance as the mechanical strength of the materials [1, 2]. In this report we present the influence of spatial distribution on the thermoelectric properties for $Bi_{1.8}Sb_{0.2}Te_3$ sample.

2. Experiment

The $Bi_{1.8}Sb_{0.2}Te_3$ single crystals were grown by the Gradient Freeze method. The starting metal elements of Bi, Sb and Te with the purity of 99.9999 % were used. The single crystals were grown by a Bridgman method with the temperature gradient of 40 K/cm at the growth speed of 1.25 mm/hr.

The ingot size is 8 mm in diametter and 30 mm in the length. The ingot was cut into 44 long bars along the growth direction. The cross section of each bar is about 1 × 1 mm^2. The spatial distribution of thermoelectric properties was examined by the Seebeck coefficient (α), electrical resistivity (ρ), EPMA and Hall effect measurements. The α (T) was measured in the temperature range from 4.2 K to 300K. The ρ (T) measurement was done by a conventional DC four-probe method. The R_H (T) was measured in the magnetic field up to 0.8 T in the temperature range from 77 K to 300K.

3. Results and discussion

Figure 1 shows the temperature dependence of the Seebeck coefficient α for the rectangular samples cut from the ingot. Most part of the ingot show p-type conduction with the thermopower of about 250 μVK^{-1} at room temperature. Several pieces show n-type conduction. This difference behavior may be due to that there is a small region in the ingot Te rich phase is composed [3].

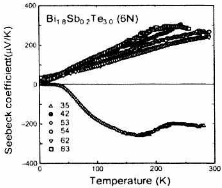

Fig.1. Temperature dependence of the Seebeck coefficient α of various pieces for $Bi_{1.8}Sb_{0.2}Te_3$ sample.

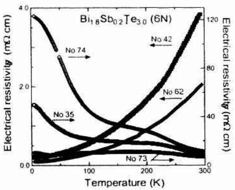

Fig.2. Temperature dependence of the electrical resistivity ρ of various pieces for $Bi_{1.8}Sb_{0.2}Te_3$ sample.

The electrical resistivity as a function of temperature for various pieces of $Bi_{1.8}Sb_{0.2}Te_3$ is show in Fig. 2. The samples No. 35 and No. 74 exhibit semiconducting behaviors, whereas other parts show metalic conduction. The different conduction may explain by the carrier concentration dependent conduction along the growth direction.

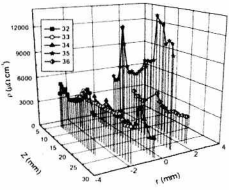

Fig.3a. Position dependence of the electrical resistivity for samples No. 32 to No. 36.

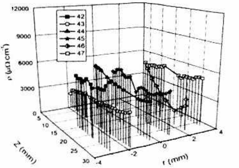

Fig.3b. Position dependence of the electrical resistivity for samples No. 42 to No. 47.

The spatial distribution of electrical resistivity of the ingot at room temperature was carried out for all the pieces. Figures 3a and 3b show the position dependence of ρ for the samples from No.32 to No.47. We note that almost piecies independent on the position except the sample No. 35 that shows the semiconducting behavior, implying that the ingot has homogeneous transport properties.

Hall effect measurements were performed on the cleavage samples. Figure 4 shows the carrier concentration n as a function of temperature for some piecies. It is found that the carrier concentration n is very high and temperature dependent.

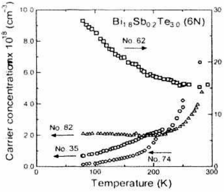

Fig.4. Temperature dependence of the carrier concentration n of $Bi_{1.8}Sb_{0.2}Te_3$ sample.

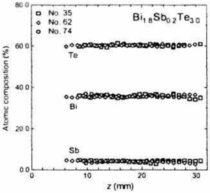

Fig.5. Atomic Bi, Sb and Te composition profiles of $Bi_{1.8}Sb_{0.2}Te_3$ sample.

The atomic Bi, Sb, Te composition profiles for three samples No. 35, 62 and 74 of $Bi_{1.8}Sb_{0.2}Te_3$ is shown in Fig. 5. The variation of atomic compositions along the crystal growth is nearly constant. All the three samples have the same composition profile. This result indicates that our crystal possesses the composition of $Bi_{1.8}Sb_{0.2}Te_3$ throughout the ingot. We have also examined the distribution along the growth direction for metallic piece of sample No. 62 and semiconducting sample No. 74 at the center parts. We can conclude that that the sample at the center part is homogeneous. At the bottom and top parts, some deviations from starting composition are found.

4. Conclusion

The p-type single crystal $Bi_{1.8}Sb_{0.2}Te_3$ was prepared by the Gradient Freeze method. The spartial distribution of thermoelectric properties was examined in detail. The sample is homegeneous at the center part of the ingot with low electrical resistivity.

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