

Synthesis of Bi_2Te_3 Thermoelectric Material by Mechanical Grinding Process

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Bismuth telluride, Bi_2Te_3 , is commonly used in thermoelectric refrigeration applications due to its excellent thermoelectric properties near room temperature. In this study, the powder metallurgical fabrication of Bi_2Te_3 thermoelectric materials using mechanical grinding process has been studied with specific interest to control the microstructure and increase the figure of merit.

The Bi_2Te_3 powder has an average particle size of $200\mu\text{m}$ prepared by the combination of the casting and mechanical milling process. This Bi_2Te_3 powder was mechanically grinded using tumbler ball mill. And to study the effect of addition of ultrafine particle on the thermoelectric properties, ZrO_2 particle with an average particle size of 10nm added during mechanical grinding. Also, pure Bi_2Te_3 powder mechanical grinded for 24 hours was mixed with $\text{Bi}_2\text{Te}_3/2\text{vol.}\%\text{ZrO}_2$ powder mechanical grinded for 100 hours for the various mixing ratios. These mechanically grinded powders and mixed powders hot pressed at 500°C for 1 hour under argon atmosphere. The thermoelectric properties of the sintered body were investigated by measuring Seebeck coefficient, specific electric resistivity and thermal conductivity.

The figure of merit of sintered bodies of mechanical grinded pure Bi_2Te_3 powder decreased with increasing grinding time, mainly due to the increase of the electrical resistivity with grinding time. It has been known that microstructure refinement by the simple mechanical grinding process was not effective to improve the thermoelectric properties of Bi_2Te_3 thermoelectric material. Bi_2Te_3 sintered bodies with addition of ZrO_2 particle from 1vol.% to 4vol.% showed higher figure of merit than that without addition of ZrO_2 particle. Especially, figure of merit of Bi_2Te_3 sintered body with addition of 1vol.% ZrO_2 increased about 1.5 times compared to the value of the specimen without addition of ZrO_2 . Addition of ultrafine second particle to Bi_2Te_3 by mechanical grinding process seemed to be useful method to increase figure of merit.

With an increase in the weight fraction of the $\text{Bi}_2\text{Te}_3/2\text{vol.}\%\text{ZrO}_2$ powder from 0 to 40wt.%, the figure of merit of the mixed Bi_2Te_3 sintered body increases and thereafter decreases above 40wt.%. Mixing of two kinds of Bi_2Te_3 powders which have different thermal and electric properties with each other seemed to be useful method to increase the figure of merit of Bi_2Te_3 sintered body.