P-type thermoelectric properties of stoichiometric full-Heusler alloy Fe_2TiSn sintered samples

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Abstract

Full Heusler alloy Fe_2TiSn is predicted to show high S at 200℃ or lower from first principles calculation by Yabuchi[1]. On the other hand, the thermal conductivity κ is about 7 times higher than that of the Bi – Te practically used as a thermoelectric material, so reducing κ is an important issue. In this research, focusing on the advantage of powder metallurgy method which is easy to process into target shape and can produce dense specimen with less segregation, we focused on the sintered body specimen from mechanically homogenized powder while adjusting the milling time was prepared. In particular, it aims at controlling further grain refinement, promoting phonon scattering at grain boundaries, reducing κ of Fe_2TiSn sintered body, and further improving thermoelectric characteristics.

I. Experimental investigation

Samples were prepared by weighing Fe, Ti, Sn of 99.9% purity with a stoichiometric composition ratio of 2: 1: 1 and using an arc melting furnace. Six types of powder were prepared in air and in an Ar atmosphere at 1080 rpm using a stainless ball (φ 5 mm) while changing the milling time to 1, 3, 12 h. After press molding, the sintered body was calcined at 450℃ for 2 h under a vacuum of 4 Pa, vacuum sealed in a quartz tube, and subjected to homogenization annealing at 800℃ for 48 h. From the XRD, crystal structure parameters were identified, composition analysis of ingots and sintered bodies from EPMA, SEM observation of powders and sintered bodies, microstructural changes and crystal grain size analysis of sintered bodies were carried out. Thermoelectric properties were evaluated by the change of dimensionless figure of merit ZT by $S \cdot \rho$ measurement by ResiTest 8300 and κ measurement by PEM-2.

II. Results and Conclusion

From the SEM observation, the grain size of the sintered body progressed by increasing milling time, the average grain size was 0.86 μm in the sample of 1h, and 0.69 μm in the sample of 12h, and dispersion of particle size also decreased. In addition, as shown in Fig.1, as compared with the sample cut out from the ingot, κ was clearly reduced in the sintered body, but no change in κ due to the atmosphere during milling was observed. In particular, in the sintered body subjected to milling at 12h, 45% reduction in κ is realized at around room temperature as compared with the ingot sample. In the lecture, as a result of EPMA, we will also discuss the measurement results of S and ρ and the change of ZT.

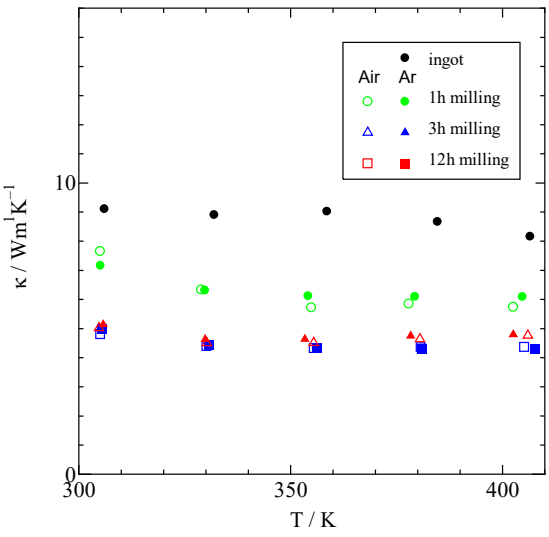

Fig.1 Temperature dependence of thermal conductivity κ.

Reference

1) S.Yabuuchi, M.Okamoto, A.Nishide, Y.Kurosaki, J.Hayakawa, Appl. Phys. Expr., **6**, 025504 (2013).