Magnetization and transport properties in Heusler-type Fe_2TiSn compound

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Abstract

Magnetic and transport properties of Heusler-type $Fe_{3-x}Ti_xSn$ (x = 0.9, 0.95, 1.0, 1.05 and 1.1) compounds have been investigated with DC magnetization, thermoelectric power and resistance measurements. The electrical resistivity of $Fe_{3-x}Ti_xSn$ compounds with x = 1, 1.05 and 1.1 exhibit metallic behavior. On the other hand, $Fe_{2.05}Ti_{0.95}Sn$ compound (x = 0.95) exhibits semiconductor-like behavior above the Curie temperature. These results suggest that the $Fe_{2.05}Ti_{0.95}Sn$ compound should be a semimetal with a pseudogap in the density of states at the Fermi level.

Key words: Heusler compound, electrical resistivity, thermoelectric power, magnetization

1. Introduction

The recently reported electronic properties of Heusler-type Fe_2VAl compound are unusual, for example a semiconducting behavior of electrical resistivity, the negative giant magnetoresistance and an enhancement of low-temperature specific-heat [1-3]. However, the origin of these behaviors is not clear so far. The Fe_2TiSn compound also belongs to the group of Heusler-type alloys. It is reported that Fe_2TiSn compound exhibits the behavior which is different from typical metallic about electrical resistivity and low-temperature specific-heat [4]. Therefore, it is interesting to investigate the electronic structure of Fe_2TiSn. In the present study, $Fe_{3-x}Ti_xSn$ (x = 0.9-1.1) prepared by arc melting and annealing. Electrical resistivity, magnetic susceptibility, and Seebeck coefficient were measured and discussed as a function of Ti concentration.

2. Experimental

$Fe_{3-x}Ti_xSn$ compounds were prepared by melting in arc furnace under Ar atmosphere. After melting, the ingots were annealed at 1153K for 50 h in order to homogenize, and the quenched in water. The crystal structure of all prepared samples was identified single phase of Heusler-type structure by XRD patterns. The electrical resistivity was measured by a standard dc four-terminal method in the temperature range 5 to 300K. Magnetization measurements in the temperature range 5 to 300K in magnetic fields up to 2T were made using a superconducting quantum interference device magnetometer (SQUID). Thermo-electromotive force E was measured by applying the temperature difference $\triangle T$ of about 2.5K and Seebeck coefficient was calculated from $\alpha = E / \triangle T$.

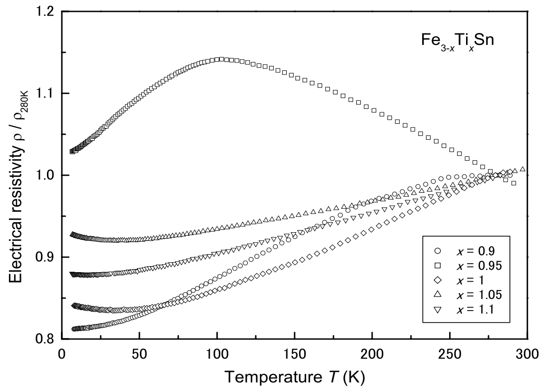

Fig. 1. Temperature dependence of electrical resistivity ρ/ρ_{280K} in $Fe_{3-x}Ti_xSn$.

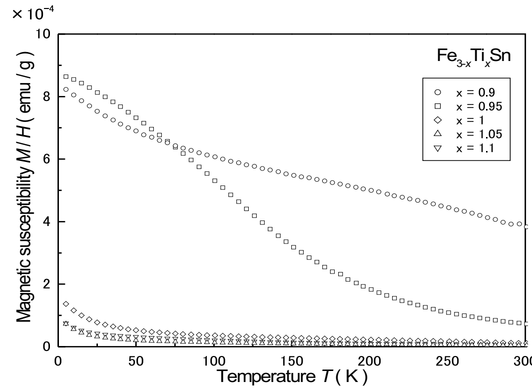

Fig. 2. Temperature dependence of magnetic susceptibility M/H in $Fe_{3-x}Ti_xSn$.

3. Results and discussion

Fig.1 shows the temperature dependence of the electrical resistivity in $Fe_{3-x}Ti_xSn$ (x = 0.9- 1.1) alloys. The electrical resistivities of the samples with x = 1, 1.05 and 1.1 exhibit metallic behavior above 30K. However, the enhancement of resistivity below 30K was observed. This tendency is also reported at $Fe_{1.95}V_{1.05}Al$ alloy [2] and it may be considered to be what is depended on Fe cluster. The sample with x = 0.95 exhibits semiconductor-like behavior and maximum around 100K. In x = 0.9, the metallic behavior of resistivity was observed again, but the shape of the resistivity curve is obviously different from that of the Ti-rich samples.

@Fig.2 shows the temperature dependence of the magnetic susceptibility in $Fe_{3-x}Ti_xSn$ alloys. The magnetic susceptibility curve of the samples with x = 1, 1.05 and 1.1 exhibited essentially the Curie-Weiss type temperature dependence. Therefore the magnetic state of these samples was paramagnetic. In x = 0.95 and 0.9, the large enhancement of the susceptibility was observed in comparison with Ti-rich samples. From the results of the magnetization as a function of magnetic field, we confirmed the ferromagnetic transition around 100K for the sample with x = 0.95 and above 300K for that with x = 0.9, respectively. The ferromagnetic transition temperature of the sample with x = 0.95 corresponded to the resistivity maximum temperature. Therefore, it may be considered that the drop of resistivity below 100K in x = 0.95 and the metallic behavior of resistivity in x = 0.9 were duo to the ferromagnetic state.

Fig.3 shows the temperature dependence of Seebeck coefficient in $Fe_{3-x}Ti_xSn$ alloys. All samples were obtained the positive Seebeck coefficient in the whole measured temperature region. The temperature dependence of Seebeck coefficient of the sample with x = 0.95 was noticeably small compared with other samples. This result suggests that the $Fe_{2.05}Ti_{0.95}Sn$ compound should be a semimetal with a pseudogap in the density of states at the Fermi level.

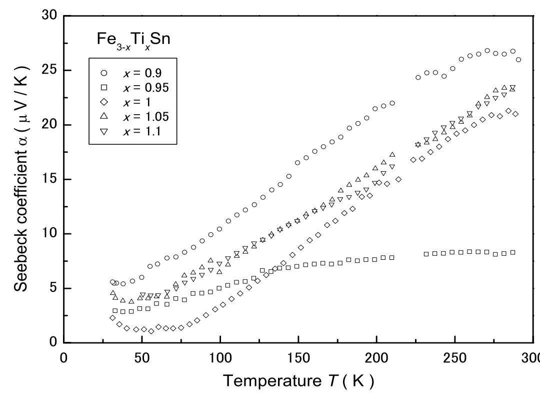

Fig. 3. Temperature dependence of Seebeck coefficient α in $Fe_{3-x}Ti_xSn$.

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