C9

Unusual change of coercivity with temperature in the Co-Co_2TiSn two phase magnet

Taewan Kim* and Sung-Chul Shin
Department of Physics, KAIST

I. INTRODUCTION

In two-phase magnets when the two phases are in intimate contact it is possible to have exchange coupling at the phase boundary. The two-metallic phase magnetic are materials consisting of two metallic magnetic phases with a negative or positive exchange at the phase boundary. A new two-metallic-phase magnet Co-Co_2TiSn has a low-T_c and high-magnetization phase, Co_2TiSn, and a high-T_c and low-magnetization phase, hexagonal Co. The Co_2TiSn Heusler alloy phase precipitates out of the hexagonal Co matrix. This system showed an unusual coercivity change with temperature that may be due to the wall formation caused by exchange coupling at the phase boundary. The change in coercivity was modeled assuming the antiferromagnetic exchange coupling and wall formation at the phase boundary.

II. EXPERIMENTS

Ingots were prepared by arc melting in a commercial arc furnace with water-cooled hearth and tungsten electrode. The high-purity argon gas (99.999 %) flowed through the chamber continuously during arc melting. The analysis of microstructures was made with backscattered electron images on a SEM and x-ray diffraction. The compositional analysis of the phases was carried out using EDX. Magnetization loops and magnetization versus temperature curves were made using a vibrating sample magnetometer (VSM) with a temperature controlling system.

III. RESULTS and DISCUSSION

The magnetization and coercivity versus temperature for several compositions, are shown in Fig. 1 and 2, respectively. Figure 1 shows that the samples contain two phases: one with low T_c and high magnetization and the other with high Tc and low magnetization. The T_c magnetization of the low Curie temperature phase can be estimated by extrapolating from the break in the magnetizations (Fig. 1). All magnetization curves have the break point at almost the same temperature which is consistant with the Curie temperature, ~ 100 °C, of arc-melted one-phase Co_2TiSn Heusler alloy. Fig. 2 exhibits that the coercivity at Co_3TiSn, Co_4TiSn, Co_5TiSn samples as a function of temperature can be divided into a low- and high-coercivity region with about 100 °C in center as the case of magnetization versus temperature. The coercivity decreases with temperature where the magnetization of the low-Tc Co_2TiSn phase disappears. Arc-melted one-phase Co_2TiSn Heusler alloy shows a closed loop without coercivity or remanence. The unusual temperature dependence of the coercivity can be explained by exchange coupling at the phase boundary. The change of coercivity with temperature was modeled using the formation of a wall at the phase boundary in the low temperature region. Using the total magnetic free energy of the exchange coupled equilibrium system, the relation between the coercivity change with temperature and the wall energy at the phase boundary was obtained as follow;

$$\Delta H_c = (\gamma_{Co} - \gamma_F)/M_{s1}d_1$$

Where ΔH_c is the change of coercivity with temperature. d1 is the size of Co matrix which is the distance between precipitates. γ_{Co} is the domain wall energy of hexagonal Co and γ_F is the ferromagnetic wall energy under saturation field. Using the experimental data, the ferromagnetic wall energy γ_F was extracted from the above equation. The extracted wall energy at the phase boundary is ~13.2 erg/cm^2.

IV. CONCLUSIONS

A new Co-Co2TiSn composite magnet was formed at the composition of 60 – 78 at. % Co. This materials showed an unusual coercivity change with temperature. The relation between the change of coercivity with temperature and the wall energy at the phase boundary could be described by a model assuming the formation of a wall at the phase boundary.

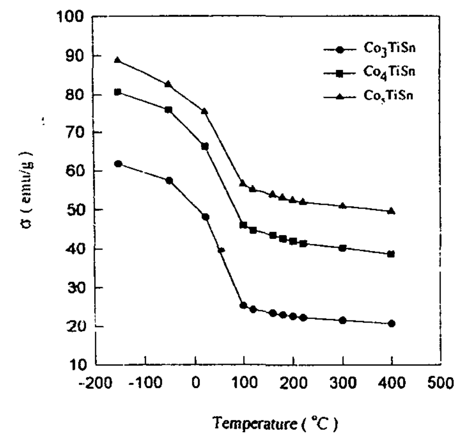

Fig. 1 Magnetization vs temperature curves

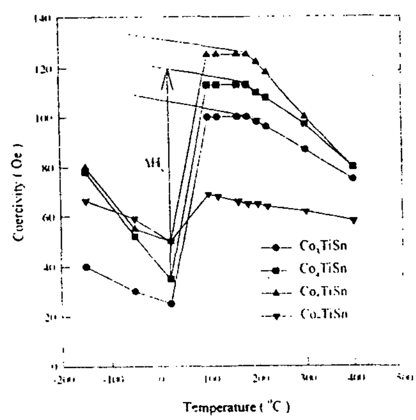

Fig. 2 Coercivity vs temperature curves