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Magnetic and electrical transport properties of Mn_2CoAl Heusler alloy thin films

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Mn_2CoAl is an inverse Heusler compound whose prototype of the crystal structure is Hg_2CuTi (space group is $F\bar{4}3m$). According to experimental and theoretical investigations by Ouardi *et al*, Mn_2CoAl is a so called half-metallic spin gapless semiconductor which has a zero bandgap at the Fermi level for the majority spin channel, and there is a half-metallic band gap for the minority spin channel [1]. Although the investigation on the poly-crystalline bulk samples in ref. [1] is successful, it is still needed to fabricate single crystalline samples to understand the material. Thus, in this study, we fabricated epitaxially grown Mn_2CoAl Heusler alloy thin films and investigated magnetic and electrical transport properties.

Films were prepared by an ultra-high vacuum magnetron sputtering machine. A stacking structure of the samples was MgO(100) substrate/Mn_2CoAl (50 nm)/Al (3 nm). The Mn_2CoAl layer was deposited by co-sputtering technique using three metallic targets; Mn, Co, and Al. The stoichiometry of the film was confirmed by an electron probe micro analyzer (EPMA) and inductively coupled plasma optical emission spectroscopy technique. Substrate temperature (T_{sub}) was changed from room temperature (RT) to 700°C for the deposition of the Mn_2CoAl layer. Al layer was deposited at room temperature as a protection layer. The crystal structure, magnetic property, and transport properties were investigated by x-ray diffractometer (XRD), superconducting quantum interface device (SQUID), and van der Pauw technique, respectively.

Figure 1 (a) shows XRD $2\theta/\theta$-profiles of the samples depending on the substrate temperature. All samples were highly oriented to (001) direction. Results of (111)-and (220)-ϕ-scans are shown in figs. 1 (b) and (c) for the sample deposited at 500°C. (111) superlattice diffractions were clearly confirmed, which comes from X_a (inverse Heusler) structure or $L2_1$ (full Heusler) structure. Saturation magnetization of the sample (T_{sub} = 500°C) was about 200 emu/cm^3.

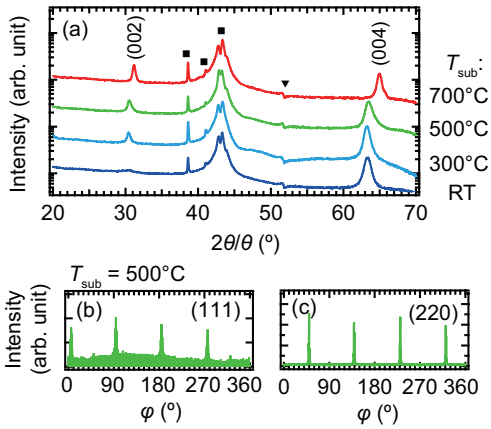

Figure 1: Profiles of (a) $2\theta/\theta$ scans for the Mn_2CoAl films.Temperatures besides the graph denote substrate temperature (T_{sub}). Squares (■) and a triangle (▼) marks the peaks from the MgO substrates and a background. (b) and (c) are ϕ-scans for (111) and (220) planes of the film deposited at 500°C.

Measurement temperature dependence of electrical resistivity was also investigated. All the samples, except for one deposited at 700°C, exhibited *positive* temperature dependence of the conductivity; the values of which were about 3000 S/cm and 2780 S/cm at RT and 10 K for the sample deposited at 500°C, respectively. The magnitude of the conductivity was the same order as that reported for the bulk sample [1]. Results of anomalous hall effect will be also discussed in the presentation.

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[1] S. Ouardi *et al.*, Phys. Rev. Lett. **110**, 100401 (2013).