

Ag ドープによるホイスラー合金ハーフメタルの $L2_1$ 規則改善効果

Improvement of $L2_1$ -ordering in half-metallic Heusler compounds by Ag-doping

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Cobalt-based Co_2YZ ($Y = \text{Mn, Fe, and Z} = \text{Si, Ge, Al etc.}$) compounds have attracted much attention in the recent spintronics because of their half-metallic nature. Drastic improvement of MR properties with increasing the degree of $L2_1$ -ordering was clearly confirmed in recent studies for CPP-GMR devices using $\text{Co}_2\text{Fe}_{0.4}\text{Mn}_{0.6}\text{Si}$ [1] and $\text{Co}_2\text{FeGe}_{0.5}\text{Ga}_{0.5}$ [2]. However, the annealing at high temperature around 600°C is often required to get enough high degree of $L2_1$ -ordering, which is a serial problem for practical usages such as next generation magnetic read sensor for HDD. In this study we have investigated the effect of doping of Ag on the enhancement of chemical ordering in Heusler compound Co_2MnSi (CMS) since Ag has no and small solubility with Co, Si and Mn, respectively.

CMS-Ag thin films were grown on (001) oriented MgO single crystalline substrates using ultra-high vacuum magnetron sputtering system. CMS-Ag (50 nm) epitaxial thin films with Ag concentration 0 to 4.5 atomic % were prepared on Cr(10 nm)/Ag (100 nm) buffer layer at both room temperature (RT), as well as substrate heating, T_s (= 250°C , and 300°C) by co-deposition technique using CMS and Ag targets. The RT deposited CMS-Ag thin films then post annealed at various

T_{ann} from 300°C to 600°C . Figure 1 shows the XRD measurement results of the ratio of superlattice $I(111)$ and fundamental $I(400)$ peak intensities of corresponding $L2_1$ ordering in CMS as a function of T_{ann} , and T_s . A clear

enhancement of $L2_1$ ordering with T_{ann}/T_s has been observed in all the samples for Ag concentration 0 to 4.5 atomic %. Moreover, the degree of $L2_1$ ordering increases monotonically with Ag concentration in accordance with T_{ann}/T_s . High resolution tunnel electron microscopy images (HRTEM) also confirmed (not shown) that Ag atoms mainly go out of the thin film and segregates on the CMS surface after working as a catalyst during heat treatment. Therefore, Ag doping could be a potential method for the enhancement of the $L2_1$ chemical ordering consequently the improvement of transport properties in Heusler compound based spintronic devices. [1] Sakuraba, *et al.*, J. Magn. Soc. Jpn. 38, 45 (2014), [2] Li et al, Appl. Phys. Lett. 103,042405 (2013)

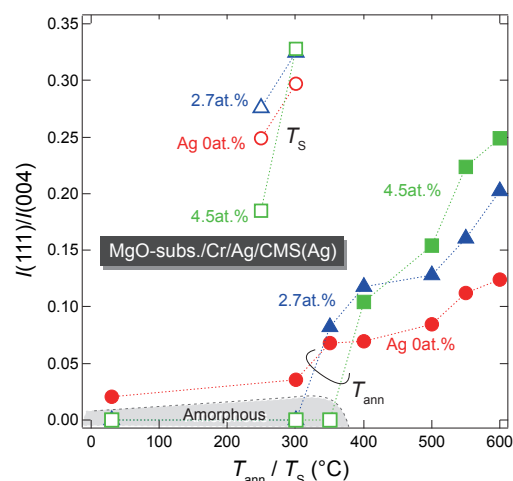


Fig. 1: The ratio of the superlattice $I(111)$ and fundamental $I(400)$ peak intensities of $L2_1$ ordering in CMS is plotted as a function of T_{ann} and T_s .