

# Magnetic properties of $L1_0$ - $Mn_{50}Ga_{50-x}Al_x$ epitaxially grown thin films

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The  $L1_0$ - $MnGa$  and  $-MnAl$  alloy thin films have received much attention because of their high magnetic anisotropy of the order of  $10^7 \text{ erg/cm}^3$  at room temperature, for potential applications such as rare-earth free permanent magnets.<sup>1), 2), 3)</sup> The present work aims to study the magnetic anisotropy mechanism of  $L1_0$ - $Mn_{50}(GaAl)_{50}$  films in conjunction with structure.<sup>4)</sup>

Thin films of  $Mn_{50}Ga_{50-x}Al_x$  were grown onto  $MgO(001)$  substrates by DC magnetron sputtering using  $Mn_{50}Ga_{50-x}Al_x$  ( $x = 0 \sim 20$ ) alloy targets. During deposition, the substrates were heated at around  $600^\circ\text{C}$ . The film thicknesses for all the samples were about 60 nm. The crystal structures of the films were characterized by XRD ( $\text{Cu K}\alpha$ ) and TEM. Measurements of magnetic properties were carried out by VSM and torque magnetometer in fields up to 90 kOe over temperatures ranging from 20 to 300K.

Figure 1 shows the XRD patterns of the films. All the samples possess the c-axis orientation along the film normal and exhibit a (001) super lattice peak of the ordered  $L1_0$  structure. The order parameter  $S$  were estimated based on the intensity ratio of  $I_{(001)}/I_{(002)}$  to be about  $0.9^4)$ ,  $0.8$ ,  $0.6$ ,  $0.4$  for  $x = 0, 5, 10$  and  $20$ . Figure 2 shows the temperature dependence of saturation magnetization  $M_s$  and uniaxial magnetic anisotropy  $K_u$  over a temperature range of 20 to 300 K. It is seen that the  $K_u$  decreases rapidly with  $T$  than the  $M_s$  does. The exponent  $n$  in the correlation of  $K_u \propto M_s^n$  is found to decrease with  $x$  from around 2.5 for  $x=0$  to about 2 for  $x=20$ , as shown in the inserted figure in Figure 3. These results suggest the significant deviation from the single ion-model for the magnetic anisotropy mechanism.<sup>4)</sup>

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## References

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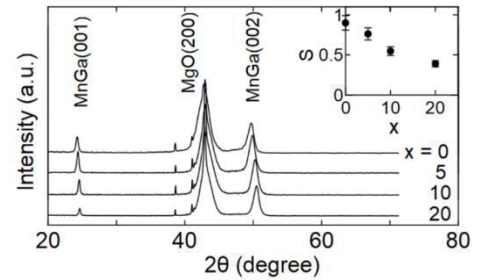


Fig.1 XRD patterns of  $Mn(GaAl)$  films. The data for  $x=0$  is after ref.<sup>4)</sup>

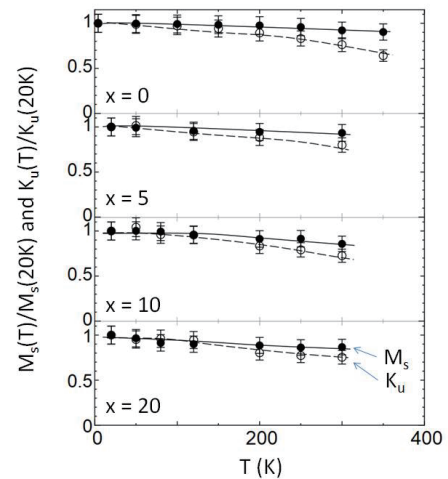


Fig.2 Temperature dependence of  $M_s$  and  $K_u$  for  $x=5, 10, 20$ . The data for  $x=0$  is after ref.<sup>4)</sup>

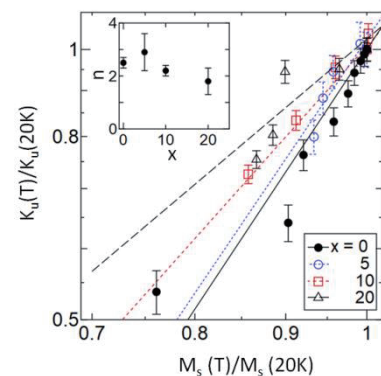


Fig.3 The correlation between  $K_u$  and  $M_s$  together with the  $n$  values (inset). The data for  $x=0$  is after ref.<sup>4)</sup>