CPP-GMR pseudo spin-valves using ferromagnetic Heusler layer $Co_2Fe(Ga_{0.5}Ge_{0.5})$ and nonmagnetic Heusler spacer Cu_2CrAl

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The current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) devices utilizing Co-based full Heusler alloys in the past few years have drawn much attention due to their potential application in the read sensors of ultrahigh density hard disk drives. Recent studies by Li *et al* and Sakuraba *et al* have demonstrated large MR ratio of over 50% and resistance change-area (ΔRA) product of ~12 mΩ μm^2 by depositing epitaxial CPP-GMR film stacks on MgO (001) single-crystalline substrates. In these works, Ag was adopted as the spacer layer. On the other hand, other spacer materials have been proposed theoretically and experimentally. Nikolaev *et al* realized the all-Heusler CPP-GMR devices with ferromagnetic Co_2MnGe (CMG) and nonmagnetic Rh_2CuSn (RCS) Heusler films. Desirable band matching for the majority spins of CMG and RCS was proved by band calculations and finally the ΔRA of 4 mΩ μm^2 was achieved. Another work by Ko *et al* demonstrated the possible usage of Heusler spacer Cu_2CrAl (CCA) for the CPP-GMR devices, yet no experimental work was done. In this work we investigated the CPP-GMR properties of pseudo spin-valves using ferromagnetic Heusler layer $Co_2Fe(Ga_{0.5}Ge_{0.5})$ (CFGG) and nonmagnetic Heusler spacer CCA.

Thin film of Cr(10)/Ag(100)/CFGG(15)/CCA(20)/Ag(5)/Ru(8) was sputter-deposited on MgO(001) substrates and annealed from 300°C to 400°C. The CCA films with different compositions were investigated by using different sputtering targets. The structural properties were examined by XRD, HAADF-STEM and EDS mapping. For the CPP-GMR properties, film stack of Cr(10)/Ag(100)/CFGG(5)/CCA(t_N)/CFGG(5)/Ag(5)/Ru(8) was deposited and annealed at 300°C before the microfabrication. Four-probe measurement was performed for transport properties.

For CCA thin films with the composition of $Cu_2Cr_{0.72}Al$, as shown in Figure 1, CCA (002) peak that indicates B2 ordering appears when annealed above 300°C. Better $L2_1$ ordering is observed when performing the Phi scan for the films. CPP-GMR devices with 10 nm CFGG and 5 nm CCA demonstrated MR ratio of 4-5%. On the other hand, when increasing the Cr content in the Cu_2Cr_XAl films from x=0.72 to x=1, the MR ratio decreases dramatically, and this indicates that excess Cr is detrimental to improve the MR output. Finally, in Figure 2 we summarized the MR ratio as a function of the CCA thickness (t_N varies from 2.8-5.0 nm), possible interlayer exchange coupling in the elliptical CPP-GMR devices may explain the MR oscillation.

Reference
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3) Nikolaev *et al.*, Appl. Phys. Lett. **94** (2009) 222501　　4) Ko *et al.*, Appl. Phys. Lett. **95** (2009) 202502

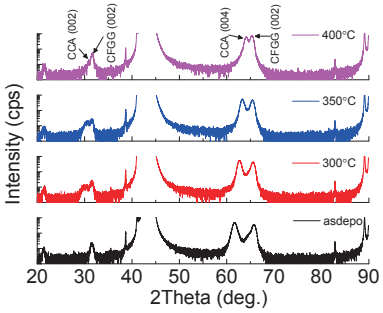

Figure 1 XRD profiles for film stack of MgO//Cr10/Ag100/CFGG15/CCA20/Ag5/Ru8. (units in nm)

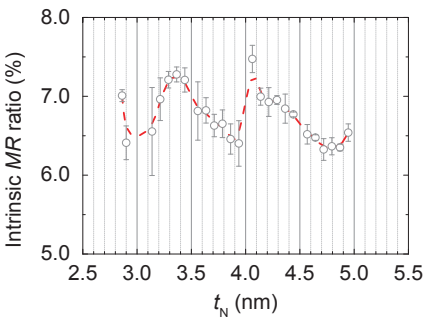

Figure 2 *MR* ratio as a function of CCA spacer thickness.