Large MR ratio in epitaxial $Co_{50}Fe_{50}/Cu/Co_{50}Fe_{50}$ current-in-plane giant magnetoresistive devices

K.B. Fathoni[1,2], Y. Sakuraba[1], T. Sasaki[1], T. Nakatani[1], K. Hono[1]
[1]National Institute of Materials Science, Tsukuba 305-0047, Japan
[2]University of Tsukuba, Tsukuba 305-8577, Japan

Current in-plane giant magnetoresistance (CIP-GMR) is a classical magnetoresistive effect, which had been utilized as read heads for HDD. After tunnel magnetoresistance (TMR) became major interest in spintronics, the research on CIP-GMR has become obsolete. However, CIP-GMR is worth to be revisited for a highly sensitive magnetic field sensor because of its advantages such as small low frequency noise and small bias voltage dependence of MR ratio unlike TMR devices. A serious drawback of CIP-GMR is low MR ratio compared to TMR devices, at most 29% in the trilayer device by using the specular reflection technique [1]; thus the enhancement of MR ratio will expand the possibility of CIP-GMR for various sensor applications. Although the spin-dependent scattering at the ferromagnetic layer/non-magnetic spacer interface is essential in CIP-GMR, the relationship between magnetotransport properties and interfacial microstructure in epitaxially grown CIP-GMR have not been systematically studied so far. Therefore, in this study, we fabricated epitaxial and poly-crystalline CIP-GMR devices having different crystalline orientation and interfacial lattice matching to investigate their transport property and microstructure systematically.

A multilayer stack of $Co_{50}Fe_{50}$(6)/Ag(t) or Cu(t)/$Co_{50}Fe_{50}$(6)/IrMn(8)/Ta(3) (thickness in nm) was deposited onto MgO(001) single-crystalline substrate using ultrahigh magnetron sputtering system and then annealed at 250 °C under 3 kOe constant magnetic field to obtain the exchange bias by IrMn. The thicknesses (t) of the Cu and Ag spacers were varied from t = 0 – 5 nm. Figure 1 shows t dependence of MR ratio. As t decreases, MR ratio increases until two $Co_{50}Fe_{50}$ layers are coupled ferromagnetically. Interestingly, the device with Cu spacer having a large lattice mismatch with $Co_{50}Fe_{50}$ (lattice misfit ~ 10%) shows larger MR ratios up to 25% at room temperature compared to those with a Ag spacer with a smaller lattice mismatch with $Co_{50}Fe_{50}$ (lattice misfit ~ 2%). Figure 2 shows temperature dependences of MR ratio and ΔR of the CIP-GMR devices with Cu and Ag spacers. As temperature decreases, the MR ratio of both samples increases. On the other hand, ΔR increases with decreasing temperature in the device with a Cu spacer while ΔR decreases in the sample with a Ag spacer. If we assume the same spin-dependent bulk scattering in $Co_{50}Fe_{50}$ between two samples, this result suggests a spin-dependent scattering at the $Co_{50}Fe_{50}$/Cu interface enlarges with decreasing temperature.

Reference

1) M. Seigler, IEEE Trans. Magn., **43** (2007) 651.

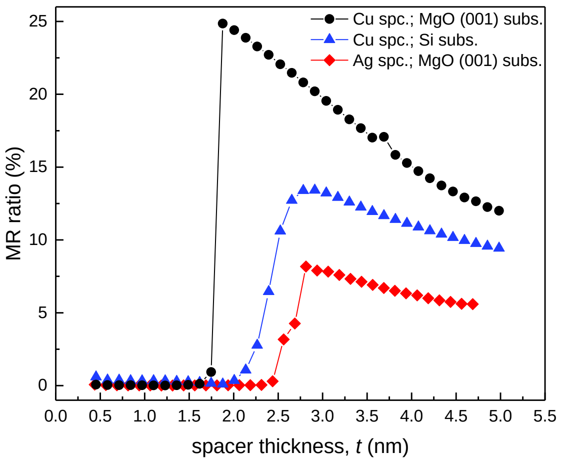

Figure 1. Spacer thickness (t) dependence of MR ratio.

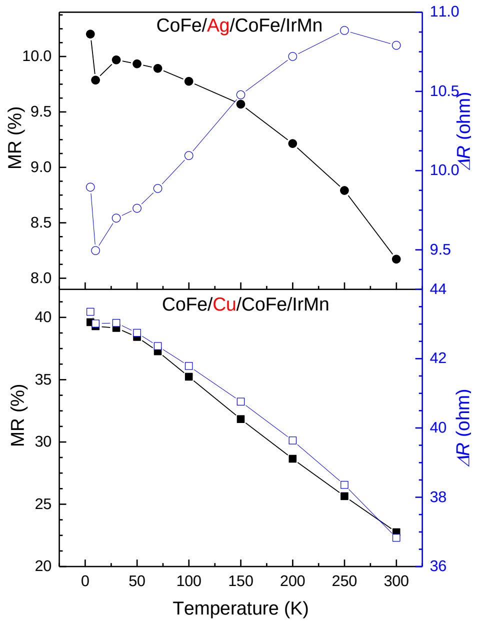

Figure 2. Temperature dependences of MR ratio and ΔR with Ag and Cu spacers.