P-9

THERMAL SATABILITY AND MAGNETORESISTANCE OF TOP SPIN VALVE WITH SYNTHETIC ANTIFERROMAGNET CoFe/Ru/CoFe/IrMn †

Sookmyung Women's University — J. Y. Hwang*, M. Y. Kim, K. I. Jun, and J. R. Rhee

Sangji University — S. S. Lee and D. G. Hwang

Chongju University — S. C. Yu

Chungbuk National University — S. H. Lee

1. INTRODUCTION

Recently the synthetic antiferromagnetic layer (SAF) has received much attention because it replaces the pinned layer of the conventional spin valve (CSV) sensors and its overall performance [1]. The spin valve (SV) with SAF has the from buffer/F/Cu/AP1/Ru/AP2/AF, where F is the soft ferromagnetic layer (typically NiFe with CoFe interfacial doping), AP1 and AP2 are two ferromagnetic layers (typically CoFe alloys) antiferromagnetically coupled through a thin Ru layer. The SAF can enhance a stronger pinning field of the pinned layer and increase the thermal and magnetic stability. It reduces the highly nonuniform demagnetizing field from the pinned layer and improves the bias point of the free layer [2]. In this work, we fabricated the top SAF/SV film of Ta/NiFe/CoFe/Cu/CoFe/Ru/CoFe/IrMn/Ta using dc magnetron sputtering. We have investigated the effect of Ru and CoFe thickness and cyclic thermal annealing treatments on magnetic and magnetoresistive properties.

2. EXPERIMENTAL

The Ta20/NiFe20/$Co_{75}Fe_{25}$20/Cu22/$Co_{75}Fe_{25}$25/Ru5/$Co_{75}Fe_{25}$22/$Ir_{22}Mn_{78}$40/Ta20 (angstroms) multilayer film were deposited by the dc magnetron sputtering on thermally oxidized Si (111) substrates at room temperature under a magnetic field of about 100 Oe. The background and argon pressure were below 5×10^{-8} Torr and 2 mTorr, respectively. The deposition rates of IrMn, CoFe, Ru, and NiFe layers were 0.5×1 Å/s. The samples were annealed during 1 hour under a magnetic field of 1050 Oe and a base pressure of 5×10^{-7} Torr at 60~300 ℃ to get exchange biasing. Each annealing at a designated temperature consisted of a 1 h ramp to the temperature, a 1 h soak at the temperature and a 1 h cool down to room temperature. The magnetization curves were measured by a vibrating sample magnetometer (VSM). The MR ratio was measured by a four-point method at room temperature.

3. RESULTS AND DISCUSSION

Figure 1 shows the GMR curves of the Ta20/NiFe20/CoFe20/Cu22/CoFe25/Ru5/CoFe22/IrMn40/Ta20 films annealed for a 1 h at 200 ℃. The insets are a minor MR curve and M-H loops. The magnetization of all ferromagnetic layers were aligned parallel at a saturation field (H_s) of 5.2 kOe. An effective exchange coupling field (H_{eex}), defined as the field at which the GMR amplitude is half of the maximum, was 1170 Oe. It is compared to H_{ex}= 220 Oe from a CSV film of Ta20/NiFe20/CoFe20/Cu24/CoFe25/IrMn40/Ta20. The large H_{eex} is attributed to the very thin effective pinned layer thickness, which is the difference of two strongly antiferromagnetically coupled CoFe layers Δt_{AP} ($H_{eex} \propto \Delta 1/t_{AP}$), where $\Delta t_{AP} = t_{AP1} - t_{AP2}$. Figure 2 shows the GMR and H_{eex} dependence as a function of pinned layer thickness, t_{AP1} and t_{AP2} with a fixed difference Δt_{AP} = 3 Å. The H_{eex} varies in approximately a $1/t_{AP2}$ fashion. This can be understood since H_{eex} reflects the H_s of

AF interlayer exchange coupling between AP1 and AP2, which is inversely related to CoFe layer thickness. Figure 3 shows the dependence of MR ratio and H_{eex} on the number of annealing cycles. The as-deposited SAF/SV film has H_{eex} of 1250 Oe and an MR ratio of 4.5%. After one annealing cycle, the MR ratio is increased to 6.9% but H_{eex} is decreased to 1170 Oe. After the second annealing cycle, both of the curves become relatively stable with same MR ratio and H_{eex} as the first annealing cycle. After further cycles, H_{eex} and MR ratio are almost constant. The H_{eex} is especially stabilized after the first annealing cycle, and it is thought that this SAF/SV reveals higher thermal stability. In conclusion, SAF/SV films with antiferromagnet CoFe/Ru/CoFe/IrMn were developed. In addition to the enhancement of GMR ratio, SAF/SV structures show a large effective exchange coupling field and a good thermal stability.

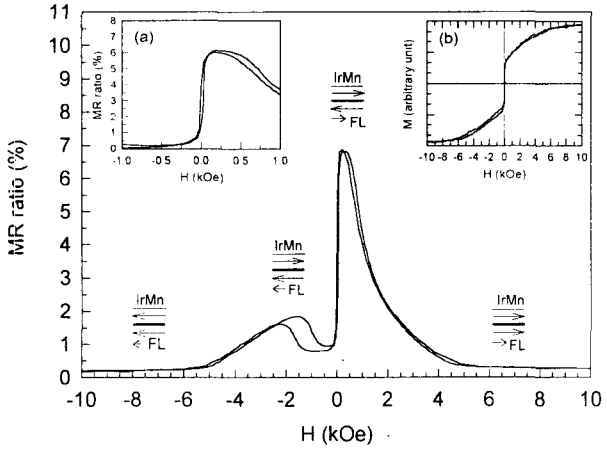

Fig. 1. The GMR curves of SAF/SV film annealed for a 1 h at 200 ℃. The insets are a minor MR curve (a) and a M-H loops (b).

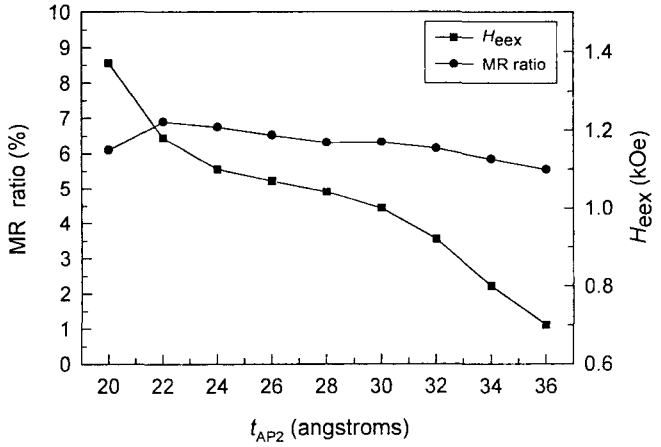

Fig. 2. The MR ratio and H_{eex} versus pinned layer thickness t_{AP2}, where $\Delta t_{AP} = t_{AP1} - t_{AP2} = 3$ Å.

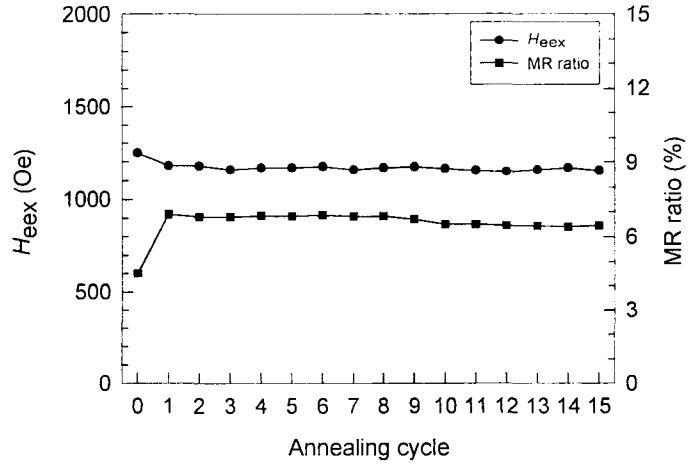

Fig. 3. The dependence of MR ratio and H_{eex} on the number of annealing cycles.

4. REFERENCES

[1] J. G. Zhu, IEEE Trans. Magn. **35**, 6807 (1999).
[2] J. L. Leal and M. H. Kryder, J. Appl. Phys., **83**, 3720 (1998).

† This work was supported by the Ministry of Science and Technology under the grant number M10022010001-01G050600110.