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Bottom 형 Ir-Mn 스핀밸브 박막의 열적안정성과 높은 교환결합력*

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Thermal Stability and High Exchange Coupling Field of Bottom Type IrMn-Pinned Spin Valve*

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Ⅰ. INTRODUCTION

Various antiferromagnetic (AFM) materials have been investigated in order to obtain higher thermal stability [1]-[2] and reliability of the pinned layer for use in spin valve (SV) giant magnetoresistance (GMR) heads in high density magnetic recording [1], [3]-[4]. That IrMn (80Å) exchange coupled to CoFe is suitable for narrow gap head structure have been reported [3], [5], because IrMn shows a high exchange coupling field (H_{ex}) at small layer thickness than other ordered AFM films, such as NiMn [1], [6] and PtMn.

We have found that AFM $Ir_{22}Mn_{78}$ alloy films exchange coupled to $Co_{75}Fe_{25}$ films showed a large H_{ex} of 1180 Oe and succeeded in developing CoFe spin valves with IrMn.

In this paper, we report the fabrication of an SV by dc magnetron sputtering, with the following structure: Ta/NiFe/IrMn/CoFe/Cu/CoFe/NiFe/Ta with 22 at% Ir IrMn alloy films as the pinning layer. We have investigated the effect of cyclic annealing treatments on the magnetic, magnetoresistive, and structural properties of the device.

Ⅱ. EXPERIMENTAL

The GMR/SV films having structure of Ta45/NiFe20/$Ir_{22}Mn_{78}$100/$Co_{75}Fe_{25}$12/Cu30/$Co_{75}Fe_{25}$20/NiFe30/Ta45 (all thicknesses in angstroms) were deposited by the dc magnetron on thermally oxidized Si(111) substrates at room temperature under a magnetic field of about 100 Oe. The base pressure of the system was below 5×10^{-8} Torr and the argon (99.9995%) gas pressure 2 mTorr. The crystal structures were investigated by 2theta scan of x-ray diffractometory (XRD) (CuK α line).

In order to induce large H_{ex} between the IrMn layer and the pinned CoFe layer, a series of annealing cycles were applied under a static magnetic field of 1050 Oe in a pressure of 1×10^{-6} Torr. Each annealing cycle consisted of a 1hour ramp to 250 ℃, a 1hour soak at 250 ℃ and a 1 hour cool down to room temperature. The MR ratio was measured by a four-point method at room temperature, where the magnetic field was applied to the direction of H_{ex} caused unidirectional anisotropy between a pinning layer and a pinned layer. The magnetization curves were measured by a vibrating sample magnetometer (VSM). Scanning probe microscopy was used to measure the surface roughness.

Ⅲ. RESULTS AND DISCUSSION

Magnetic hysteresis loop measured parallel to the easy axis of the SV structure is shown after annealing (two cycles) in Fig. 1(a), and major and minor MR curves are shown after annealing in Fig. 1(b). In Fig. 1 (a), there is an obvious shift in the lower half of the hysteresis loop. The values of H_{ex} and H_c of the pinned layer are found to be 1180 Oe and 150 Oe, respectively. A corresponding result is obtained from the major MR curve of Fig. 1(b). The H_{ex} at room temperature of the annealed SV film at 250 ℃ for 2 hours was about twice higher than that of the as-deposited one. From the minor MR curve (inset graph) of the Fig. 1(b), it is found that the interlayer coupling field between the free layer and the pinned layer is about 10 Oe, and the coercive field of the free layer is 5 Oe. In addition, we note that the pinned layer, which is critical for the operation of an SV head, shows stable MR properties. There is no change in behavior caused by applied fields up to about 600 Oe. Figure 2 shows the dependence of H_{ex}, H_c, and MR ratio of the SV on the number of annealing cycle. The as-deposited sample shows H_{ex} of 680 Oe and MR ratio of 2.7%. After one annealing cycle, the *H*ex and MR ratio are increase to about 1180 Oe and 4.3%, respectively. After the second annealing cycle, the MR ratio decreases to 3.6%, and the curves become relatively stable with H_{ex} and H_c values of 1180 Oe and 150 Oe, respectively. The decrease in MR ratio may be due to interdiffusion of the layers, increasing the shunting current in the IrMn layer causing loss of spin information. After further cycles, H_{ex}, MR ratio and H_c are almost constant. The H_{ex} is especially stabilized after the second annealing cycle and it is thought that this SV reveals higher thermal stability.

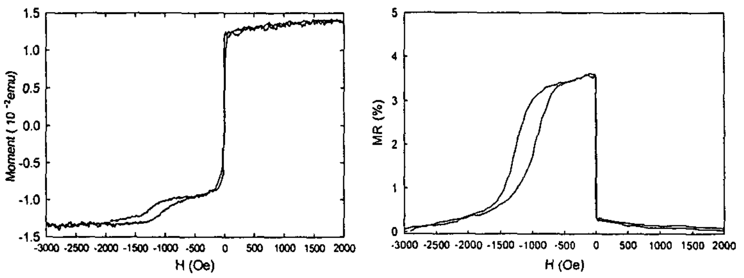

Fig. 1. (a) Magnetization curves of after second thermal annealing for the IrMn pinned SV film. (b) is major MR curve of the SV after second thermal annealing. The inset graph of the (b) shows minor MR curve.

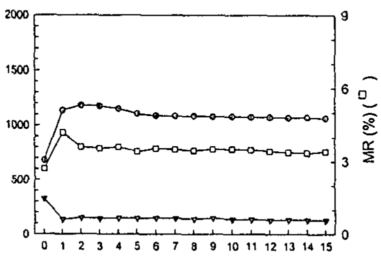

Fig. 2. Annealing cycle dependence of H_{ex}, H_c and MR ratio for the IrMn pinned SV film.

Ⅳ. CONCLUSIONS

An SV film structure, Si/Ta45/NiFe20/$Ir_{22}Mn_{78}$100/$Co_{75}Fe_{25}$12/Cu30/$Co_{75}Fe_{25}$20/NiFe30/Ta45 (all thicknesses in angstroms) fabricated by dc magnetron sputtering and annealed at 250 ℃ for 2 h in a field of 1050 Oe, shows MR ratio 3.6%, H_{ex} of 1180 Oe, and H_c of 150 Oe. This SV structure withstands thermal treatments up to 250 ℃ or higher. The pinning field of the SV stays constant up to 140 ℃ and then decreases to zero at the blocking temperature of 270 ℃. The H_c of the pinned layer remains constant at 150 Oe up to 270 ℃. These results suggest that one can enhance the MR ratios of SV by optimizing the thickness of pinned and free layer for the application of GMR/SV sensor with high thermal stabilities.

Ⅴ. REFERENCES

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