A Study on the Effects of Gadolinium dopping on the Coercivity of Permalloy Film

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Permalloy($Ni_{81}Fe_{19}$) is an important material for the switching layer in a magnetic random access memory (MRAM) due to the low coercive field and high squareness. As the magnetic cell size decreases to micrometer order, however, the coercive field increases to higher than 50 Oe, which is hardly achievable with current memory design scheme. [1,2] Aiming at reducing the coercive field, we studied effects of gadolinium (Gd) doping to Permalloy. Films of trilayer (Permalloy/Gd/Permalloy) were made in an e-beam evaporator and annealed at 300℃ from 30secs to 5minutes for homogenisation. Nominal concentration of Gd varied between 1 ~ 7 at%. Lift-off technique produced patterned films with array of micrometer size rectangular cells. The films were characterized using auger electron spectroscopy (AES), inductively coupled plasma (ICP) emission spectroscopy, x-ray diffractometry (XRD) and transmission electron microscopy (TEM). Magnetic properties were measured using alternating gradient magnetometry (AGM).

The result tells that Gd-doping reduces the coercive field of Permalloy. It is explainable as follow: Gd diffuses along grain boundary faster than through grains at 300℃. The grain boundary becomes rich in Gd as confirmed by XRD and TEM. The strong ferromagnetic Gd at the grain boundary strengthens the magnetic interaction between grains. This prevents the formation of magnetic vortices, enhances simultaneous switching of grains and reduces the coercive field.

References

[1] R. L. Anderson, A. Gangulee, and L. T. Romankiw, J.Electron.Mater., vol.2, no. 2, p. 161, 1973.
[2] S. Tehrani, B. Engel, M. Slaughter, M. Durlam, and J. Calder, IEEE trans. Magn., vol.36, no.5, 2000.