Remanence analysis of sub-micron MTJ cells with CoFe/NiFe free layers

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Formation of single domain state in MTJ free layer plays an important role in MRAM cell switching, because multi domain state or vortex formation in magnetization reversal process can increase switching anomaly [1]. Characteristic analysis of non-uniform switching process can provide information on the formation of single domain, vortex, or multi-domain. This work proposes the analysis method for the non-uniform switching process using the magneto-transport measurement. In order to observe the switching process of sub-micron MTJ cell and dependence of the switching characteristics on the Ms and thickness of the free layer, we investigate switching characteristics of patterned sub-micron MTJ arrays. MTJ is composed of synthetic anti-ferromagnetic(SAF)/Al-O/CoFe/NiFe with the different thickness of CoFe and NiFe. The MTJs are patterned into $0.4 \times 0.8\ \mu m^2$. To separate the single domain state, vortex, or multi-domain, we measured R-H curve on the field and remanence with the angle of applied field. Although non-uniform switching process is observed with the R-H curve, it is difficult to trace to its origin such as magnetic pinning, vortex, or multi domain. Using the remanence measurement, the existence of intermediate states was verified, which can provide the information of switching process. From the remanence measurement, it can be seen that single domain can have the non-uniform switching process by magnetic pinning, which is recovered to two stable states. On the other hand, the non-uniform switching process originated by vortex or multi domain remain at intermediate states.(Fig. 1.)

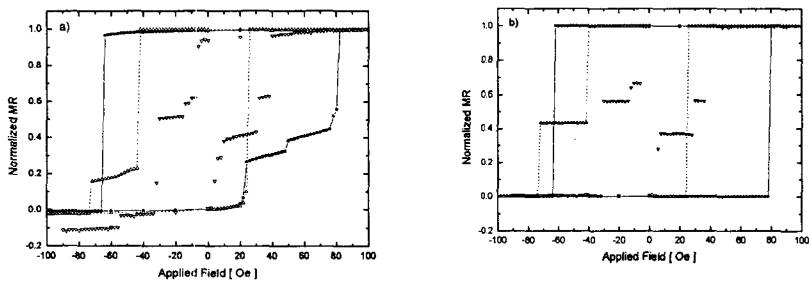

Fig.1. a) R-H on Field. b) Remanence Curve. The intermediate states show the formation of vortex or multi domain.

[1] Jing Shi, S. Tehrani, and M. R. Scheinfein. Appl. Phys. Lett. 76. 2588 (2000).