CU10

Thermal Stability of Exchange-coupled Trilayer

J. M. Lee, C. W. Han, J. H. Namkoong, K. S. Kim, and S. H. Lim*
Department of Material Science and Engineering, Korea University, Seongbuk-gu, Seoul 136-713, Korea
*Corresponding author: S. H. Lim, e-mail: sangholim@korea.ac.kr

As areal density of the magnetic random access memory (MRAM) increases, the thermally assisted magnetization switching becomes one of hot issues because it determines the stability of stored information. A key question concerns the physical nature of the involved energy barrier (ΔE) over which thermally assisted switching occurs. For the Stoner-Wohlfarth (SW) particles ΔE can be determined using Sharrock's equation $H_c(t) = H_0\{1-[(k_B T/E_0)\ln(t/\tau_0 \ln 2)]^n\}$ [1]. For the exchange-coupled trilayer, however, it is not easy to determine the energy barrier due to the complexity of the structure. In this work we did the calculation of ΔE for the exchange-coupled trilayer using modified Worledge model [2], and the result was compared to the SW model. The exchange-coupled trilayer was composed of two ferromagnetic layers separated by spacer. An elliptical film having lateral dimensions of 120 nm × 60 nm was considered. The total thickness of the two magnetic layers ($t_1 + t_2$) was fixed at 4 nm; however, the thickness of each magnetic layer was varied over a wide range. The magnetic parameters were used: a saturation magnetization (M_s) of 820 emu/cc, an exchange stiffness constant (A_{ex}) of 1 × 10^{-6} erg/cm, and an interlayer exchange coupling (J) of -0.05 erg/cm^2. Figure 1 shows ΔE as a function of the applied field (H) at several values of Δt. At small field region, H < 70 Oe, the value of ΔE shows a strong dependence on Δt; ΔE increases as Δt increases. At large field region, H < 70 Oe, however, there is no big difference in the value of ΔE with Δt. The dependence of ΔE on H was compared to the SW model as shown in the inset. The solid lines show the fit to the data at Δt = 0.4 and 1.0 nm based on SW model. The energy barrier shows a quite different dependence on H with the SW model at Δt = 0.4 nm, however, but shows a good agreement with the SW model at Δt = 1.0 nm.

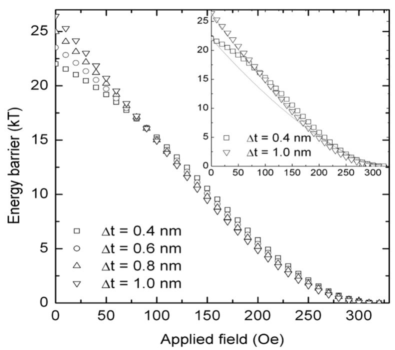

Fig. 1. Energy barrier as a function of applied field.

This work was supported by the Korea Science and Engineering Foundation (KOSEF) through the National Research Laboratory Program funded by the Korean Ministry of Science and Technology (Project No. M10600000198-06J0000-19810).

REFERENCES

[1] M. P. Sharrock and J. T. McKinney, IEEE Trans. MAG., **17**, 3020 (1981).
[2] D.C. Worledge, Appl. Phys. Lett., **84**, 2847 (2004).

CU11

Improvements of MgO Crystallization and Magnetoresistance in Bottom Type NiFeSiB/CoFeB/MgO/CoFeB Magnetic Tunnel Junctions

D. K. Kim[1], J. U. Cho[1], T. X. Wang[1], S. Isogami[2], M. Tsunoda[2], M. Takahashi[2], and Y. K. Kim[1]*
[1]Department of Materials Science and Engineering, Korea University, Seoul 136-713, Korea
[2]Department of Electronic Engineering, Tohoku University, Sendai 980-8579, Japan
*Corresponding author: Author7 Kim, e-mail: ykim97@korea.ac.kr

A bottom-type magnetic tunnel junction (MTJ) has an advantage over one a top-type for device fabrication (e.g. etching) because a thick bottom buffer layer is located below a tunnel barrier. However, the thick bottom layer may give a rougher interface for the tunnel barrier. The poor barrier quality would result in lower TMR, especially for the MTJ with structure-sensitive MgO tunnel barrier. Therefore, it is an important issue how to improve the interface morphology of bottom layer under the barrier.

In our experiment, a hybrid magnetic free layer comprising NiFeSiB and CoFeB is utilized for improving the properties of MgO-MTJs. The TMR ratio of the bottom-type MTJs are smaller than that of top-type one. Then, we employed the same hybrid layer and compared with the similar MTJs with CoFeB pinned layers as shown in Fig. 1. As expected, the TMR ratio was increased after the thin NiFeSiB insertion. The microstructure of the underlying amorphous CoFeB layer is important to obtain (001) oriented MgO layer. But the microstructure of CoFeB layer is affected by a crystallinity of seed layer [1]. The amorphous NiFeSiB layer insertion can act as a prevention layer of CoFeB crystallization to improve the amorphous structure. In addition, the hybrid structure can lower the saturation magnetization (Ms) because the Ms of NiFeSiB (878 emu/cm^3) is lower compared to that of the CoFeB (1170 emu/cm^3).

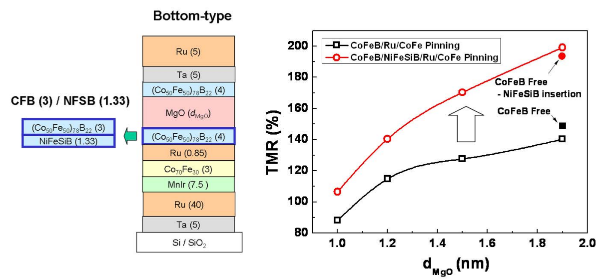

Fig. 1. (a) The scheme of insertion of NiFeSiB layer to bottom type MTJ and (b) improvement of TMR ratio by insertion of NiFeSiB layer with various MgO barrier thickness.

REFERENCES

[1] Y. Ashizawa, H. Ohyama, K. Sunaga, Y. Watanabe, M. Tsunoda, and M. Takahashi, J. Magn. Soc. Jpn., 3, 411 (2007).