Magnetic Couplings in MgO/CoFeB/Ta/CoFeB/MgO and CoPt/Co/Ta/CoFeB/MgO Structures

Chul-Hyun Moon[1,2]*, Byoung-Chul Min[1], Kyung-Jin Lee[1,2], and Kyung-Ho Shin[1]
[1]Korea Institute of Science and Technology (KIST), Seoul 136-791, South Korea
[2]Korea University, Seoul 136-701, South Korea

1. Introduction

We studied the magnetic couplings in a free-layer stack of MgO/ $Co_4Fe_4B_2$/ Ta/ $Co_4Fe_4B_2$/ MgO and a pinned-layer stack of Co_3Pt_1/ Co/ Ta/ $Co_4Fe_4B_2$/ MgO for perpendicular magnetic tunnel junctions (MTJs). The MgO/CoFeB/Ta stack is known to have a large perpendicular magnetic anisotropy (PMA) as well as high tunnel magnetoresistance (TMR) of over 120%[1]. It has been recently reported that a MgO/ CoFeB/ Ta/ CoFeB/ MgO structure with two CoFeB/MgO interfaces has a high thermal stability factor of 95 with a junction size of 70 nm[2]. The CoPt alloy is a decent choice of pinned layer material, since it has a high coercivity and a large PMA [3,4].

2. Experiment Method

The samples were deposited using both DC and RF magnetron sputtering on the oxidized Si(100) substrates. The magnetic properties were characterized by vibrating sample magnetometer (VSM), and the magnetotransport properties by four-point probe method.

3. Results and Discussion

A PMA was observed both in the free layer of MgO/ $Co_4Fe_4B_2$/ Ta/ $Co_4Fe_4B_2$/ MgO and in the pinned layer of Co_3Pt_1/ Co/ Ta/$Co_4Fe_4B_2$/ MgO after annealing the structures at 300 ℃. The Ta interlayer thickness affects the magnetic coupling between CoPt (or CoFeB) and CoFeB layers in the pinned (free) layer. The magnetic configuration of the two layers, parallel or anti-parallel states, can be controlled by changing the Ta thickness. For example, a 0.4-nm-thick Ta layer gives rise to ferromagnetic (F) coupling, whereas a 1.2-nm-thick Ta layer results in antiferromagnetic (AF) coupling. Especially, the AF-coupling in the pinned layer can be used to enhance the thermal stability of the free layer by reducing the stray field.

4. Conclusion

In summary, we show that the magnetic couplings in MgO/ $Co_4Fe_4B_2$/ Ta/ $Co_4Fe_4B_2$/ MgO and Co_3Pt_1/ Co/ Ta/ $Co_4Fe_4B_2$/ MgO depend strongly on the Ta interlayer thickness. The structures studied in this paper can be used for perpendicular magnetic tunnel junctions (p-MTJs) having a free-layer of MgO/ $Co_4Fe_4B_2$/ Ta/ $Co_4Fe_4B_2$/ MgO and a pinned-layer of Co_3Pt_1/ Co/ Ta/ $Co_4Fe_4B_2$/ MgO.

5. Reference

[1] S. Ikeda, K. Miura, H. Yamamoto, K. Mizunuma, H. D. Gan, M. Endo, S. Kanal, J. Haykawa, F. Matsukura and H. Ohno, Nature Materials 9, 721 (2010).

[2] H. Sato, M. Yamanouchi, S. Fukami, F. Matsukura and H. Ohno, Appl. Phys. Lett. 101, 022414 (2012).
[3] Iulica Zana, Giovanni Zangari and Mohamad Shamsuzzoha, J. Magn. Magn. Mater. 292, 266-280 (2005).
[4] G. M. Choi, B. C. Min and K. H. Shin, IEEE Trans. Magn. 48, 1130 (2012).