III-8

Perpendicular Magnetic Anisotropy of CoFeB/Pd Multilayers

Jong Ho Jung* Seong-Rae Lee and Sang Ho Lim

Department of Materials Science and Engineering, Korea University, Seoul 136-713, Korea

Magnetic tunnel junctions (MTJs) with perpendicular magnetic anisotropy (PMA) have the important advantage of a smaller critical current density for current induced magnetization switching (CIMS) over MTJs with an in-plane anisotropy (in-plane MTJs). This is because the current-induced spin transfer torque (STT) in the in-plane MTJs must overcome the large additional 2πMs factor that arises from the demagnetizing field of a magnetic thin film [1]. Since the CoFeB/MgO/CoFeB MTJs were shown to have large values of TMR, and most of the results were observed to be in the in-plane geometry, it would be highly desirable for the perpendicular MTJs structure to contain a CoFeB layer. In this study, an effort is made in this direction by investigating CoFeB/Pd multilayer system.

All the layers were deposited using a magnetron sputtering system that had two separate chambers with differentbase pressures of 1×10^{-8} Torr and 2×10^{-9} Torr. The $M-H$ hysteresis loops, which are mainly used to characterize the PMA properties, were measured with a vibrating sample magnetometer at room temperature.

The effects of N were investigated and the results are shown in Figs. 1(a) and (b). The multilayer structure is shown in the inset of Fig. 1(a). The $m-H$ hysteresis loops measured under the perpendicular applied field, shown in Fig. 1(a), indicate that all the samples have a good PMA. It can be seen in Fig. 1(b) that the coercivity (H_c) remains nearly constant up to N=12 and is followed by a steep decrease at N=20. The results for the two critical fields, the saturation field (H_s) and the nucleation field (or switching field) (H_n), are also shown in the lower panel of Fig. 1(b), together with their definition in the inset. The value of H_s increases monotonically from 114 Oe to 1360 Oe, as N increases from 3 to 20. On the other hand, the value of H_n is nearly independent of N in the low N range (N=3~9). In this range, the value of H_n is negative. However, H_n is nearly zero (at N=12) or even positive at the larger N values. At the largest N value (N=20), for example, the value of H_n is quite high (+390 Oe), indicating that the irreversible switching starts to occur even though a large value of H_{ext} is applied in the same (positive) direction. The value of m decreases quite steeply at H_n and it approaches zero at the remanent state. This behavior, which has been observed in the past, is explained by the formation of multi-domains with the PMA at large N values and the motion of the domain walls [2]. This behavior is also confirmed by an MFM image for the N=20 sample measured at the remanent state, as shown in the inset of Fig. 1(a).

References

[1] S. Mangin et al., *Nat. Mater*. 5, 210 (2006).

[2] B. Kaplan et al., *J. Magn. Magn. Mater*. 128, 111 (1993).

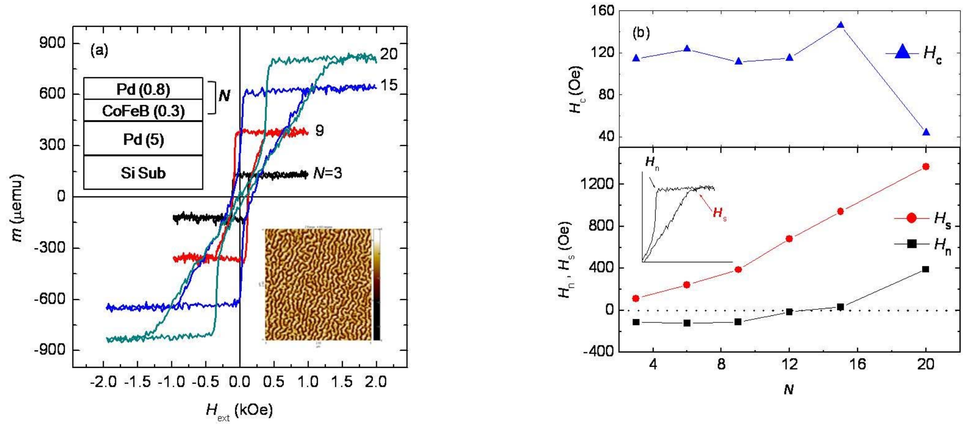

Figure 1. (a) The m-H hysteresis loops of the CoFeB/Pd multilayers with different N values (N=3~20). The insets show the investigated multilayer structure and an MFM image for the N=20 multilayer at the remanent state. (b) The three characteristic fields (the coercivity (H_c), the saturation field (H_s), and the nucleation field (H_n)) as a function of N. Shown in the inset is the definition of H_s and H_n.