Effects of MgO sputtering power and thermal annealing on the perpendicular magnetic anisotropy of Pt/Co/MgO trilayer

Hyung Keun Gweon*, Sang Ho Lim and Seong-Rae Lee
Department of Materials Science and Engineering, Korea University, Seoul 136-713, Korea

Pt/Co/MgO is an imperative model system that requires more thorough understanding, since in-plane current induced magnetization switching[1,2], chiral magnetic order[3] and strong perpendicular magnetic anisotropy (PMA)[4] have been demonstrated from this very brief structure. The interface contributions, arising from either Pt/Co (bottom) or Co/MgO (top) interfaces, are known to be the critical source that bring about such anomalous phenomena. Among these phenomena, we particularly focused on tailoring PMA, especially on the perspective of oxdiation states and the degree of intermixing at the top Co/MgO interface. In order to manipulate the oxygen induced PMA from the top interface (Co/MgO), we have grown Pt/Co/MgO under two different MgO sputtering power, namely, 200 W and 50 W. When MgO sputtering power is relatively high (200 W), penetration of oxygen atoms into the Co layer prevails. While in the opposite case (50 W), the penetration is kept to a minimum. As a result, these two discrete samples exhibit disparate PMA properties, where each maximum value of effective anisotropy energy density (K_{eff}) from the two samples series (200 W, 50 W) show 1.64 × 10^7 erg/cm^3 and 1.98 × 10^7 erg/cm^3, respectively. Although it appeared that depositing oxide barrier with reduced MgO sputtering power can remarkably improve the PMA properties, thermal annealing treatment seems inevitable to further optimize the strength of PMA. This can be ascribed to the oxygen migration; the penetrated oxygen atoms, formed while the oxide barrier deposition, migrate back to the oxide barrier due to thermal-assisted diffusion. This eventually leads to interface smoothing and optimal oxidation at the interface, which are observed as improvements on PMA properties. Figure 1(a) and (b) clearly manifest these trends where K_{eff} values gradually ascend with rising annealing temperatures. The annealing treatments have been performed at 250°C and 300°C for 30 min at the

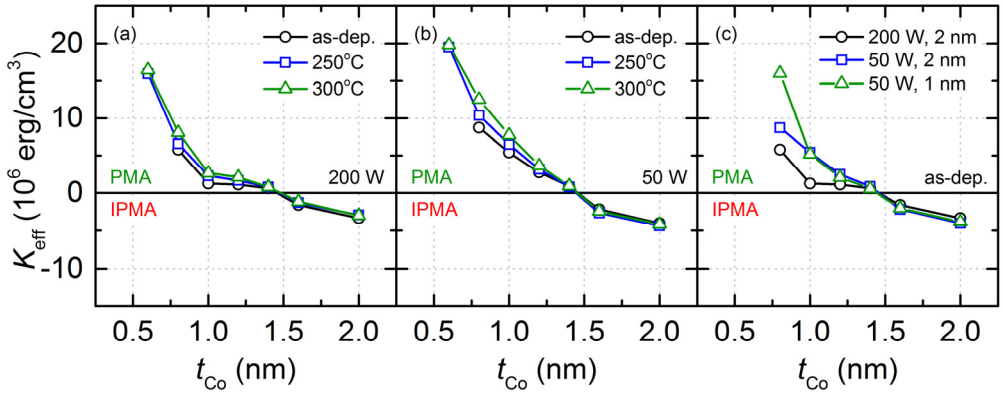

Fig. 1. K_{eff} values plotted as a function of t_{Co} for two different sputtering and annealing conditions: (a) MgO sputtering power of 200 W and (b) 50 W at different annealing temperatures. (c) Comparison between MgO sputtering power (200 W and 50 W) and t_{MgO} (1 nm and 2 nm) for as-deposited samples.

base pressure of under 10^{-6} Torr. Moreover, as it has been shown in Figure 1(c), we have also monitored increment of K_{eff} values when t_{MgO} are reduced to 1 nm. This is presumably due to an open structure of MgO layer, where oxygen atoms continuously penetrate the MgO barrier and oxidize the Co layer during the deposition. In other words, we can tentatively conclude that the degree of Co oxidation is proportional to t_{MgO}, and it can only be monitored specifically when $t_{Co} < 1$ nm.

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