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Perpendicular magnetic anisotropy in annealing-free La/CoFeB/MgO studied by X-ray magnetic circular dichroism

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Perpendicular magnetic anisotropy (PMA) is one of the most important issues for perpendicular magnetic tunnel junctions (p-MTJs). In p-MTJs, CoFeB based alloys have been intensively studied, many efforts elucidated the mechanism of the occurrence of PMA[1]. First principles calculations show that the hybridization of Fe-3d_{z^2} and O-2p_z states contributes to the interface PMA [2]. In the case of CoFeB/MgO, the easy magnetization axis is generally changed from in-plane to perpendicular-to-plane direction by post-annealing. However, interface PMA can also be obtained even for the annealing-free CoFeB/MgO heterostructures, if specific materials, e.g., low-electronegativity elements such as Zr, are used for buffer layer underneth CoFeB [3,4]. In this study, we investigated interface PMA in annealing-free La/CoFeB/MgO heterostructures, since La has typically low electronegativity. Here, one of the possible roles of low electronegativity is modification of interface electronic structure, and the other is a chemical role such as an oxygen absorber.

CoFeB (1nm)/MgO (2nm) bilayer structures with a 2-nm-thick La underlayer were prepared by rf sputtering on a W buffered thermally oxidized Si substrates. The whole stacking structures are Si/SiO_2-subs.//W-buffer(3nm)/La(2nm)/CoFeB (1nm)/MgO(2nm)/W-cap(1nm) which are grown at room temperature. We also prepared La(2nm) /CoFeB(1nm)/La(2nm) structure to investigate that which interfaces contribute to PMA.

Figure 1 shows the M-H curves measured by using a vibrating sample magnetometer for (a) La/CoFeB/MgO and (b) La/CoFeB/La. Blue and red lines indicate magnetization when magnetic field was applied to perpendicular and in-plane direction, respectively. Here, PMA was observed in La/CoFeB/MgO structure, but La/CoFeB/La showed isotropic M-H curve. These results indicate La/CoFeB interface does not have dominant influence for PMA.

In order to investigate the detailed mechanism of the interface PMA, we performed X-ray circular magnetic dichroism (XMCD) measurements. Figure 2 shows (a) X-ray absorption spectra (XAS) and (b) XMCD spectra of Fe-$L_{2,3}$ edges in the La/CoFeB/MgO structure. The normal component of the orbital magnetic moment in Fe is slightly larger than the in-plane one, and therefore it seems to be qualitatively the same as the results in XMCD study for Fe/MgO heterostructure [5]. From these results, the role of La buffer layer is likely considered to absorb boron or oxygen of CoFeB, and the improvement of CoFeB/MgO interface brings about interface PMA.

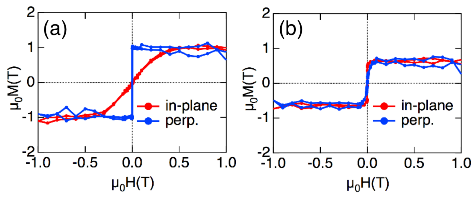

Fig. 1. M-H curves for (a) Si/SiO_2 sub.//W/La /CoFeB/MgO/W and (b) Si/SiO_2 sub.//W/La/ CoFeB/La/W.

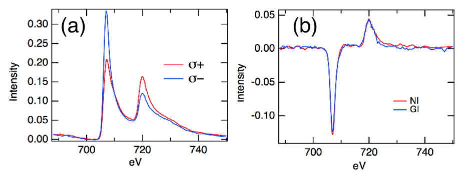

Fig. 2 (a) XAS and (b) XMCD spectra for Fe-$L_{2,3}$ edges in La/CoFeB/MgO heterostructures

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