Large perpendicular magnetic anisotropy in Fe/$MgAl_2O_4$ heterostructures

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$MgAl_2O_4$ is considered a promising alternative barrier material to MgO for magnetic tunnel junctions (MTJs) due to its tunable lattice constant[1)]. The interface-induced perpendicular magnetic anisotropy (PMA) at an $MgAl_2O_4$ interface is a crucial property for applications of perpendicularly magnetized MTJs (p-MTJs). Based on a recent theoretical calculation,[2)] the areal PMA energy density of ~1.3 mJ/m^2 was predicted at an Fe/$MgAl_2O_4$(001) interface, which is nearly comparable to that at an Fe/MgO(001) interface (~1.5–1.7 mJ/m^2). However, a much smaller PMA energy density ~0.4 MJ/m^3,[3)] comparing with ~1.4 MJ/m^3 in Fe/MgO,[4)] has been experimentally reported in Fe/$MgAl_2O_4$(001) where the $MgAl_2O_4$ layers were prepared by post-oxidization of an Mg-Al metallic layer. Therefore, further improvement in the PMA energy of ultrathin-Fe/$MgAl_2O_4$(001) interfaces is expected if a sharp interface is obtained by suppressing atomic intermixing and over-oxidation through process optimization. In this study, we report achievement of large PMA at an Fe/$MgAl_2O_4$ by introducing electron-beam deposition of $MgAl_2O_4$.[5)]

Stacks of Cr buffer(30)/Fe(0.7)/$MgAl_2O_4$(t_{MAO} = 2 or 3 nm) (unit in nm) multilayers were epitaxially grown on an monocrystalline MgO(001) substrate by electron-beam evaporation. The Cr and Fe were post-annealed at 800°C and 250°C, respectively. The $MgAl_2O_4$, were post-annealed at various temperatures between 350°C and 500°C to modify the interface conditions. Magnetic properties were investigated using a vibrating sample magnetometer(VSM) and VSM incorporated with superconducting quantum interference device (SQUID). The ultrafast magnetization dynamics property was measured by the time-resolved magneto-optical Kerr effect (TR-MOKE) method.

Figure 1 shows the *M-H* curve of an optimized Fe (0.7 nm)/$MgAl_2O_4$(t_{MAO} = 2 or 3 nm) interface with a large PMA energy up to ~1.0 MJ/m^3, comparable to the reported value for an Fe (0.7 nm)/MgO[4)] (~1.4 MJ/m^3). We also found that the PMA energy and saturation magnetization (M_s) were not very sensitive to measurement temperature, where from 100K to 300K, K_i drops from ~2.0 mJ/m^2 to ~1.7 mJ/m^2. The effective damping constant was also evaluated to be ~0.02 by TR-MOKE under high magnetic fields. This study demonstrated robust interface PMA in ultrathin-Fe/$MgAl_2O_4$, which is useful for p-MTJ applications.

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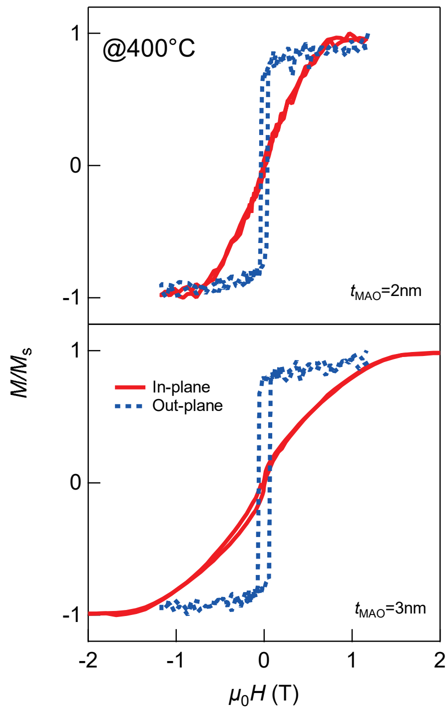

Figure 1 M-H curves for samples annealed at 400°C with t_{MAO} = 2 and 3 nm.

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