CoFeB thickness dependence of exchange stiffness constants in Ta/CoFeB/MgO determined from domain structures

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In our previous work, we reported magnetic domain structures of CoFeB/MgO and their electric-field modulation [1]. In this work, we investigate the CoFeB thickness t_{CoFeB} dependence of domain structures and determine the CoFeB thickness dependence of exchange stiffness constants A_S.

Stacks, Ta (2 nm)/ $Co_{40}Fe_{40}B_{20}$ (t_{CoFeB} = 1.18 – 1.30 nm)/ MgO (5 nm)/ Al_2O_3 (5 nm), are deposited by dc/rf magnetron sputtering on a thermally oxidized Si substrate. The samples are annealed at 350°C for 1 hour under a perpendicular magnetic field of 0.4 T in vacuum (10^{-6} Torr). The t_{CoFeB} is determined from the deposition rate of CoFeB.

The samples are demagnetized by applying an ac perpendicular magnetic field with exponentially decaying amplitude. The domain structures at demagnetized state are observed by magneto-optical polar-Kerr-effect microscope. Figure 1(a) shows a typical domain structure observed for the film with t_{CoFeB} = 1.18 nm. Clear maze pattern is observed for the films with 1.18 nm ≤ t_{CoFeB} ≤ 1.30 nm. Domain period D_p is determined from fast Fourier transform of observed images. The CoFeB thickness dependence of t_{CoFeB} in Fig. 1(b) indicates that D_p decreases with increasing t_{CoFeB}. A_S is determined from D_p utilizing an expression of $D_p = (A_S/K_{eff})^{0.5}\exp\{4\pi\mu_0(A_S/K_{eff})^{0.5}/M_S^2 t_{CoFeB}\}$ [2], where μ_0, K_{eff}, and M_S, are permeability of vacuum, effective magnetic anisotropy density, and spontaneous magnetization, respectively. The K_{eff} and M_S are determined from magnetization measurements. The values of A_S decrease from ~8 to ~4 pJ/m with decreasing t_{CoFeB}, from 1.3 to 1.18 nm, indicating the presence of the interfacial effect on A_S.

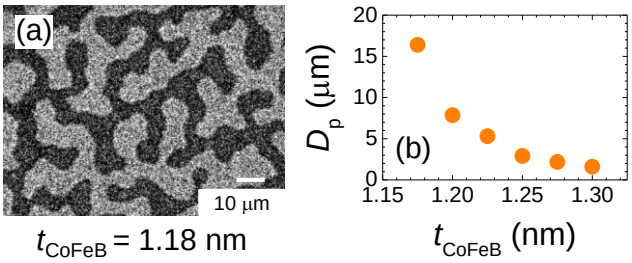

Fig. 1. (a) Magnetic domain structure for 1.18-nm-thick CoFeB. (b) CoFeB thickness t_{CoFeB} dependence of domain period D_p.

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