Electric-field effect on domain structure in MgO/CoFeB/Ta

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We investigate the electric-field effects on the domain structures in MgO/CoFeB/Ta, whose magnetic parameters, such as magnetic anisotropy and damping constant, can be modulated by the application of an electric field [1,2].

We define a Ta (5 nm)/Ru (5 nm) bottom electrode deposited by sputtering on a Si/SiO_2 substrate, and form an Al_2O_3 (59 nm) insulator by atomic layer deposition. The fabrication of an electric-field-effect device is completed by the formation of a 1 mm-diameter MgO (2 nm)/$Co_{18.75}Fe_{56.25}B_{25}$ (1.5 nm)/Ta (3 nm)/Ru (1 nm) top electrode by dc/rf sputtering and liftoff. The device is annealed under perpendicular magnetic field of 1 T at 200°C for 1 h. Positive electric field corresponds to the situation with positively biased top electrode with respect to the bottom electrode. All the measurements are conducted at room temperature.

We observe domain structures at demagnetized state under several electric fields E by a magneto-optical Kerr effect microscope. The observed maze domain structures are analyzed by two-dimensional fast Fourier transform, which shows the domain patterns possess an isotropic characteristic period (domain width) as reported previously [3]. The domain width is determined to be 1.75 μm at E = 0, which increases to 2.00 μm at E = +0.11 V/nm, as shown in Fig. 1. Because the domain widths are expected to be determined by the magnetic and structural parameters of CoFeB, such as thickness, spontaneous magnetization, magnetic anisotropy, and exchange stiffness constant A_S, we measure also the electric-field dependence of the magnitudes of spontaneous magnetization and magnetic anisotropy [1,2]. The comparison of the obtained domain width and calculated ones [4] (circles and lines in Fig. 1) suggests that A_S of 10.4 pJ/m at E = 0 is modulated by plus/minus a few percent by the application of E = ±0.11 V/nm.

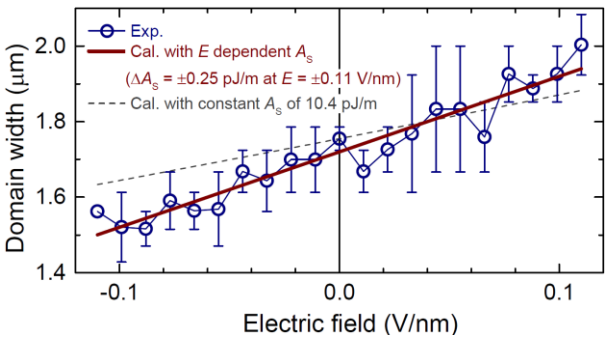

Fig. 1: Electric-field dependence of domain widths. Circles are obtained from experiments, and error bars are determined from five-region measurements. Calculated dependences are shown by solid line with electric-field dependent A_S as well as by dashed line with constant A_S.

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