CoFeB thickness dependence of electric-field effects on magnetic anisotropy and damping constant in Ta/CoFeB/MgO structures

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Magnetic anisotropy and damping constant α are important parameters characterizing spintronics materials and devices. They are expected to be related to each other through the spin-orbit interaction, and thus the correlation between them has been studied in various materials [1-3]. We investigated the correlation in Ta/CoFeB/MgO structures by modulating the anisotropy through the application of the electric field E [4,5], where clear modulation of α was observed for one device with the largest perpendicular magnetic anisotropy among studied devices [5]. In order to clarify the trend experimentally, we investigate here the electric-field effect on α in devices with thinner CoFeB and thus larger magnetic anisotropy than that in the previous study [5].

Stack structures, Ta/Ru/Ta/$Co_{0.2}Fe_{0.6}B_{0.2}$ (t = 1.30, 1.36 nm)/MgO (2 nm)/Al_2O_3(5 nm), are deposited on a Si (001)/SiO_2 substrate by rf magnetron sputtering, and are annealed at 300^{o}C for 1 h in vacuum under perpendicular magnetic field of 0.4 T. The stacks are processed into a 1-mm diameter circular mesa, and a 57-nm-thick Al_2O_3 insulator and a Cr (3)/Au (50) counter electrode were deposited to complete electric-field-effect devices. Positive voltage is defined as the Cr/Au layer positive with respect to the CoFeB layer.

The magnetic field angle θ_H dependence of ferromagnetic resonance spectra are measured as a function of E at room temperature. The magnetic anisotropy and α are determined from the analysis of the angle dependence of resonant field and linewidth, respectively. The effective perpendicular magnetic anisotropy energy constant K_1^{eff} and α decrease by the application of positive E for the two devices, and their modulation ratios increase with decreasing t. The present result along with the previous result indicates that the modulation of K_1^{eff} is observed for all the devices, whereas that of α is observed only in devices with a perpendicular easy axis ($K_1^{\mathrm{eff}} > 0$). The modulation ratio of α increases with increasing K_1^{eff} and thus decreasing t. These results suggest that the modulation of α is related to the interfacial effect and the direction of easy axis plays a role in the emergence of the electric field effect.

This work was supported in part by JSPS through FIRST program, R&D project for ICT Key Technology of MEXT, Grants-in-Aid for Scientific Research from JSPS (Nos. 26889007 and 23360002) as well as MEXT (No. 26103002), and ASPIMATT program from JST.

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