Free-layer size dependence of magnetic anisotropy in nanoscale CoFeB/MgO magnetic tunnel junctions

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Thermal stability, which is one of the important properties characterizing MTJ, is proportion to effective magnetic anisotropy field of the free layer in nanoscale magnetic tunnel junction (MTJ). Homodyne-detected ferromagnetic resonance (FMR) is a powerful tool for evaluating magnetic properties such as magnetic anisotropy and damping constant in nanoscale MTJ. In this study, we investigate the free-layer size D dependence of the effective magnetic anisotropy field H_K^{eff} down to D ~ 15 nm.

The stack structure of the MTJs is, from substrate side, Ta(5)/PtMn(20)/Co (2.6)/Ru(0.9)/CoFeB(2.4)/MgO(1.1)/$Co_{18.75}Fe_{56.25}B_{25}$(1.8)/Ta(5)/Ru(5) deposited by dc/rf magnetron sputtering. Numbers in parentheses are nominal thicknesses in nm. The top CoFeB layer is a free layer with a perpendicular magnetic easy axis. The stack is processed into circular MTJs on a coplanar waveguide by electron beam lithography, reactive ion etching, and Ar ion milling down to top of PtMn layer.

We measure the homodyne-detected FMR spectra by sweeping the perpendicular magnetic field H_{perp} at several rf frequencies f_{rf}. By fitting a superposition of Lorentz and anti-Lorentz functions to the spectra, the dependence of resonance field $\mu_0 H_{\mathrm{R}}$ on f_{rf} is obtained. From an intercept of a liner fit to the dependence, H_K^{eff} is determined. H_K^{eff} does not monotonically increase with decreasing D and decreases at D of less than 20 nm, suggesting that $H_{\mathrm{K}}^{\mathrm{eff}}$ varies at the vicinity of the device edge. We find that the free-layer size dependence of $\mu_0 H_K^{\mathrm{eff}}$ can be reproduced by considering the variation of $\mu_0 H_K^{\mathrm{eff}}$ at vicinity of device edge [1].

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