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In-plane anisotropy in a CoFeB-MgO magnetic tunnel junction detected by magnetoresistance

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We reported that the ferromagnetic resonant frequency f_r depends on the in-plane magnetic field angle ϕ_H in a nanoscale CoFeB-MgO magnetic tunnel junction (MTJ) with perpendicular magnetic easy axis [1]. In this work, we measure the ϕ_H dependence of the junction resistance R in the same MTJ.

A circular MTJ with 100 nm diameter is fabricated in a coplanar waveguide from a stack structure, Ta(5)/Pt(5)/ $[Co(0.4)/Pt(0.4)]_6$ /Co(0.4)/Ru(0.42)/ $[Co(0.4)/Pt(0.4)]_2$ /Co(0.4)/Ta(0.3)/$Co_{18.75}Fe_{56.25}B_{25}$(1)/ MgO(1.3)/$Co_{18.75}Fe_{56.25}B_{25}$(1.8)/Ta(5)/Ru(5) (numbers in parentheses are nominal thickness in nanometers). The two CoFeB layers have perpendicular magnetic easy axis, and the top (bottom) layer is the free (reference) layer. The magnetization configuration at zero magnetic field is set to antiparallel configuration. We measure R by sweeping the amplitude of an in-plane magnetic field H_{in} as a function of ϕ_H, where ϕ_H is measured from the direction along the coplanar waveguide.

Figure shows a typical R-H_{in} curve at $\phi_H = 0^o$. The change of R reflects the change of the relative angle θ between the magnetizations in the two CoFeB layers through the tunnel magnetoresistance effect. We determine the H_{in} dependence of magnetization angle θ_F in the free layer from the relationship between R and θ, by assuming the fixed magnetization direction in the reference layer at the normal of the device surface under relatively low $\mu_0 H_{in} < 200$ mT (μ_0: permeability of vacuum). The H_{in} dependence of θ_F is fitted by using the minimum condition of magnetostatic energy, from which we determine the effective perpendicular magnetic anisotropy field H_{K1}^{eff} in the free layer including demagnetizing field. The ϕ_H dependence of H_{K1}^{eff} possesses two-fold symmetry, showing that the dependence is related to the unintentionally introduced shape anisotropy in the MTJ. The ϕ_H dependence of H_{K1}^{eff} is consistent with the ϕ_H dependence of f_r determined from homodyne detected ferromagnetic resonance for the same device [1].

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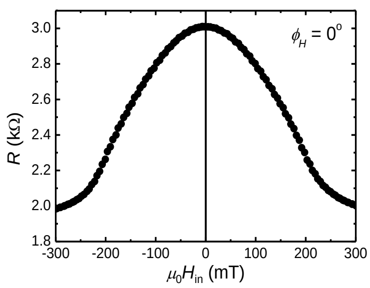

Figure: Junction resistance R under in-plane magnetic field H_{in} at $\phi_H = 0^o$.

References

[1] E. Hirayama *et al.*, The 61st Japan Society of Applied Physics Spring Meeting, 19p-E7-2 (2014).