Magnetic-field-angle dependence of coercivity in a nanoscale CoFeB-MgO magnetic tunnel junction with perpendicular easy axis at various temperatures

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Understanding the magnetization reversal mode in nanomagnets with perpendicular easy axis is critical to correctly measure their thermal stability factor, and thus assess the data retention capability of nanomagnet-based memory/storage applications. Measuring the dependence of coercivity on the angle of the applied magnetic field allows the magnetization reversal mode to be determined [1, 2]. In this study, we study magnetic-field-angle θ_H dependence of coercivity in a nanoscale CoFeB/MgO magnetic tunnel junction (MTJ) with perpendicular easy axis at various temperatures T.

A stack structure of the MTJ is, from substrate side, Ta(5)/Pt(5)/[Co(0.34)/Pt(0.4)]$_6$/Co(0.34)/Ru(0.44)/[Co(0.34)/Pt(0.4)]$_2$/Co(0.34)/Ta(0.3)/$Co_{18.75}Fe_{56.25}B_{25}$(1)/MgO/$Co_{18.75}Fe_{56.25}B_{25}$(1.5)/Ta(5)/Ru(5) deposited by dc/rf magnetron sputtering. The numbers in parentheses are layer thickness in nm. The influence of stray field from the reference layer on magnetization reversal is minimized by processing the MTJs into a “step” structure in which the reference layers are many times wider than the recording layer, which is defined by ion milling as a circular dot of diameter of 21 nm. We measure resistance versus magnetic field curves at various θ_H from film normal direction and temperatures. We determine coercivity H_C from parallel to antiparallel (P to AP) and antiparallel to parallel (AP to P) states at the field where the large resistance change is observed.

Figure 1 shows the relationship between in-plane component of H_C ($H_C\sin\theta_H$) and out-of-plane component of H_C ($H_C\cos\theta_H$). One can observe that as T reduces, the experimental results become closer to astroid curve describing the coherent reversal of a single-domain nanomagnet at zero temperature. We obtain good fit to our data by including thermal fluctuation effect in the single-domain reversal model, indicating that the reversal of 21 nm diameter step MTJ is dominated by the single-domain reversal like process.

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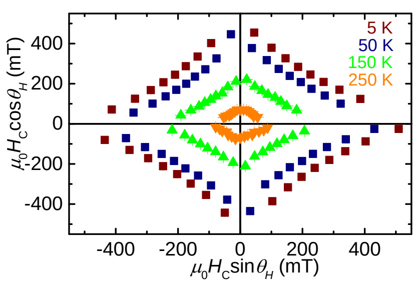

Figure 1 Relationship between out-of-plane component and in-plane component of coercivity for the magnetic tunnel junction with diameter of 21 nm.

[1] R. Dittrich *et al*., J. Appl. Phys. **97**, 10J705 (2005).

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