MgO-CoFeB Interface Perpendicular Anisotropy for Spintronic Devices

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MgO (100)-CoFeB bcc(100) is a preferred system for making magnetic tunnel junction (MTJ), a spintronic device, because it offers a large tunnel magnetoresistance (TMR) of > 100% required for nonvolatile memory cells through symmetry filtering of wavefunctions. Integration of MTJs with CMOS in the back-end enables not only non-volatile, high density, and fast stand-alone and/or embedded RAMs, but also a possibility of nonvolatile logic-in-memory CMOS VLSIs [1]. To this end, MTJs utilizing current-induced magnetization switching have been developed; first with in-plane easy axis using MgO-CoFeB and then with perpendicular easy axis. The shift from in-plane to perpendicular is a natural one because high crystalline anisotropy in perpendicular materials is advantageous for reducing cell size. In addition, current-induced switching is inherently more efficient with perpendicular easy axis. However, satisfying both high tunnel magnetoresistance (TMR) over 100% and low switching current was a formidable task, because of the mismatch between MgO (100) - CoFe(B) bcc (100) structure needed to obtain high TMR and the crystal structure of perpendicular materials. We have experimentally shown that a strong perpendicular interface anisotropy exists at the MgO-CoFeB interface [2, 3], so strong ($K_i = 1.3$ mJ/m^2) that it can overcome the demagnetization and make the easy axis perpendicular. First principle calculation by Nakamura *et al.* shows that the perpendicular anisotropy is due to the oxygen-iron bond that reduces contribution of in-plane crystalline anisotropy [4]. Using this perpendicular easy axis, we have shown a 40 nmϕ perpendicular MgO-CoFeB MTJ with high TMR (>100 %) and low switching current of 49 μA [3]. In addition to MTJs, we have investigated current-induced domain wall motion in perpendicular MgO-CoFeB films [5], where perpendicular anisotropy is required for reducing critical current density for domain wall motion. We also report on the current induced effective fields in ultrathin perpendicular CoFeB films with MgO cap [6].

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