The Effect of Capping layers on Anisotropy for Magnetic Tunnel Junctions

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Magnetic tunnel junctions with vanadium-based capping layers on top of the CoFeB free layer have been studied. The interest in the effect of capping on the free layer originated from reports that cap layers influence the crystallization of the CoFeB free layer through diffusion of the B into the cap, as well as induce a partial perpendicular magnetic anisotropy (PPMA or PPA) in the free layer. Different cap layers differently accelerate the diffusion of the B from the free layer. In this study, we have sputter-deposited V/Ru and V/Ta capping layers on CoFeB and subsequently characterized these films by magnetometry and ferromagnetic resonance (FMR). We have found that V/Ru and V/Ta capping of CoFeB induces partial perpendicular anisotropy (PPA) in CoFeB, as well as reduces the Gilbert damping parameter, confirming results reported by other researchers, as shown in Figures 1 (a) and (b), respectively. The origin of this PPA is believed to be caused by the interface anisotropy between the free layer and the capping layer. The effect of post-deposition annealing, CoFeB thickness, and doping of CoFeB with vanadium on the anisotropy and damping of these V/Ru and V/Ta capped samples has been studied for the free layers. Doping CoFeB with vanadium greatly reduces the $4\pi M_s$ and $4\pi M_{eff}$ values, resulting in an effective increase in the PPA, as well as the damping parameter. X-ray magnetic circular dichroism (XMCD) has also been performed on a series of V-doped films over a range of V concentrations. Figures 2 (a) and (b), respectively, show the magnetic properties and damping parameter for a) CoFeB free layers over a range of thicknesses doped with 20 vol% V and capped with V/Ru, and b) 4 nm thick CoFeB free layers doped with a range of V concentrations and capped with Ru. The partial perpendicular anisotropy is believed to be caused by an interfacial effect between the CoFeB and the capping layer.