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Magnetic anisotropy in Ta/CoFeB/MgO investigated by x-ray magnetic circular dichroism and first-principles calculation

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A Ta/CoFeB/MgO junction with a thin ferromagnetic layer shows perpendicular magnetic anisotropy due to interface magnetic anisotropy, which enables us to fabricate high-performance magnetic tunnel junction. In this report, we investigate the origin of the interface anisotropy by x-ray magnetic circular dichroism.

A stack structure, Ta /Ru /Ta /$Co_{0.4}Fe_{0.4}B_{0.2}$ (t_{CoFeB} = 0.85 or 2.0) /MgO (1)/Ta (1) (numbers in parentheses are nominal thicknesses in nanometers), is deposited by rf magnetron sputtering on a thermally oxidized Si substrate at room temperature, and annealed at 350°C in vacuum (10^{-6} Torr) under perpendicular magnetic field (0.4 T) for 1 hour. From magnetization measurements by vibrating sample magnetometer, the interface magnetic anisotropy is determined to be 1 mJ/m^2. The x-ray absorption spectra (XAS) at Fe and Co $L_{2,3}$-edges are collected in total-electron-yield mode.

Figure shows typical XAS of Fe and Co $L_{2,3}$-edges for the sample with t_{CoFeB} = 0.85 nm with 1 T perpendicular magnetic field, which is enough to saturate magnetization. μ_+ and μ_- are the absorption coefficients in antiparallel and parallel magnetic fields to photon incident direction, respectively. By integrating spectrum obtained for different magnetization angles, we determine the orbital magnetic moments and their anisotropy from x-ray sum rules [1]. The orbital moment in Fe is more anisotropic than that in Co, and the anisotropy is larger in film with t_{CoFeB} = 0.85 nm than that in 2.0 nm. Because the anisotropy of the orbital magnetic moment is proportional to the magnetic anisotropy [2], the results indicate that Fe atoms in CoFeB at the interface with MgO mainly contribute to the interface anisotropy.

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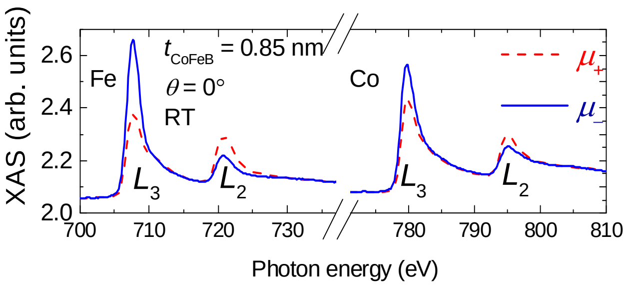

Figure: X-ray absorption spectra (XAS) of Fe and Co $L_{2,3}$-edges for sample with t = 0.85 nm at normal incident angle.

References

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