The effect of Gd marker on the effective work function of Fe in contact with Al_2O_3/Si

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Inserting a tunnel barrier has been a key to achieving spin injection from ferromagnetic (FM) metals into GaAs. However, spin injection into Si has remained elusive because Schottky barrier formation leads to a huge conductivity mismatch of the FM tunnel contact and Si, which cannot be solved by the well-known method of adjusting the tunnel barrier thickness. A radically different approach for spin-tunnelling resistance control is the insertion of low-work-function ferromagnets at the FM/tunnel barrier interface [1]. Among those ferromagnets are rear-earth metals, particularly Gd. It has been shown [1] that in this way the resistance–area (RA) product of FM/Al_2O_3/Si contacts can be tuned over eight orders of magnitude, while simultaneously maintaining a reasonable tunnel spin polarization. However, the exact effective work function of the "marker" ferromagnets in contact with the tunnel isolator has not been measured so far. In this work, we systematically investigate the effect of the Gd marker interlayer thickness on the EWF of Fe in contact with the tunnel isolator (Al_2O_3).

Fe(6 nm)/Gd(0.2-2 nm)/Al_2O_3(10 nm)/Si structures with a Gd marker layer of variable thickness were prepared by the combination of atomic layer deposition and pulsed laser deposition techniques. HAXPES analysis at 4.5 keV provides the depth sensitivity to probe the entire stack down to the Si substrate. The band alignment at the Gd/Al_2O_3 interface is cleary visible in the Al 2s peak shift and depends on the Gd thickness (see inset).

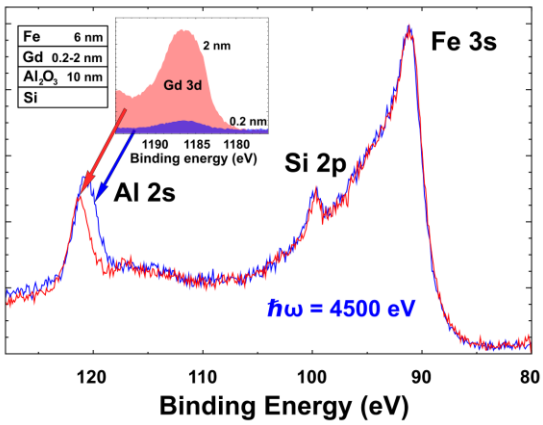

Figure 1: HAXPES data measured on Fe/Gd/Al_2O_3/Si heterostructures at BW2: the band alignment at the Fe/Al_2O_3 interface is clearly affected by the thickness of Gd marker layer.

References

[1] Byoung-Chul Min, Kazunari Motohashi, Cock Lodder And Ron Jansen, Nature Mat. 5 817 (2006).