Development of pinned electrode for magnetic tunnel junction with perpendicular magnetic anisotropy

P. D. Kulkarni[1,2], M. Krishnan[1], Harish C. Barshilia[1], P. Predeep[2] and P. Chowdury[1]*

[1] *Surface Engineering Division, CSIR-National Aerospace Laboratories, Bangalore, India*

[2] *Laboratory for Molecular Photonics and Electronics, Department of Physics, National Institute of Technology, Calicut, India*

*Email- pchowdhury@nal.res.in

ABSTRACT

The magnetic electrodes with perpendicular magnetic anisotropy (PMA) have gained a great deal of attention in magnetic information storage technology. The use of perpendicular magnetic tunnel junctions (p-MTJs) enhances the storage density due to the reduction in area required for a unit bit. Among two electrodes in a MTJ structure (ferromagnetic/insulator/ferromagnetic), one electrode should be fixed or pinned to a specific direction of magnetization in order to have a unidirectional magnetic anisotropy with higher exchange field[1]. This can be achieved by a phenomenon of exchange bias observed between the ferromagnetic (FM) and the anti-ferromagnetic (AFM) materials as a shift in a hysteresis loop when they are deposited in a presence of an external applied field [2].

We have fabricated the pinned electrode with structure of Pt(10 nm)/ [Pt(2 nm)/Co(0.4 nm)]$_3$/ Pt(t_{Pt} nm)/ FeMn(13 nm) /Ta (5 nm) on Si (100) substrate by using UHV sputtering system with base pressure ~ 5×10^{-9} torr. The magnetic properties were studied by vibrating sample measurements (VSM) at room temperature. Both on experimental and theoretical investigations revealed that PMA arises in ultrathin multilayer stacks of Co/Pt structure due to hybridization of Co *3d* - Pt *5d* orbital at the Co/Pt interfaces due to interfacial Neel's anisotropy. Deposition of FeMn layer on the top of Co layer reduces the effective PMA due to change in interfacial composition. However, the addition of ultrathin Pt layer in between Co and FeMn enhances the PMA due to following reasons. The exchange bias highly depends on the spin configuration at the FM-AFM interface. As Pt atoms have higher Stoner factor, the magnetic moment of Pt atoms in vicinity of Co atoms gets increased and Pt atoms become ferromagnetic with its easy axis along the perpendicular direction[3]. Thus the Pt-FeMn interface acts as FM-AFM interface. But with increasing t_{Pt} above a critical thickness, the induced ferromagnetic behaviour in Pt layer starts decreasing resulting weaker FM-AFM spin projection at the Pt-FeMn interface and, as a result, the exchange bias stars to vanish. Thus, as shown in fig 1, the exchange bias first increases with t_{Pt} to its maximum (~ 240 Oe) along with maximum coercive field (~ 180 Oe) upto a critical Pt spacer thickness of ~ 0.45 nm and then starts decreasing to reach almost zero value as t_{Pt} increases to 1.6 nm. This also suggests the Pt atoms gets magnetized to depth of ~ 1.0 nm adjacent to the Co/Pt interface and then gradually changes to paramagnetic behaviour.

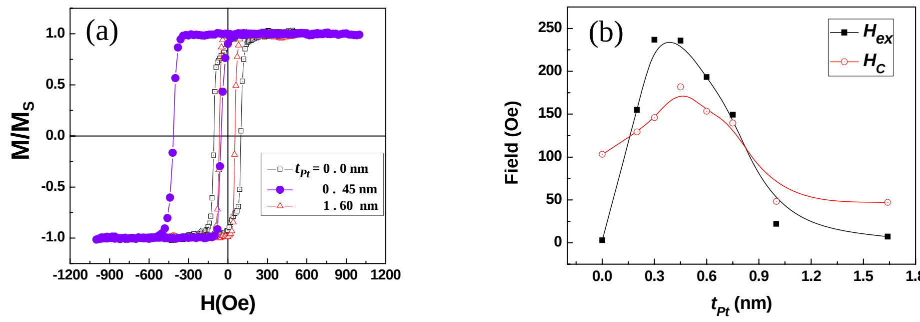

Fig.1: (a) The M(H) hysteresis curves with applied external field (H) perpendicular to film plane and (b) H_{ex} and H_C against t_{Pt}.

References:

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