Influence of preparation conditions on PtMn pinned AAF structures with ultra-thin Ru spacer

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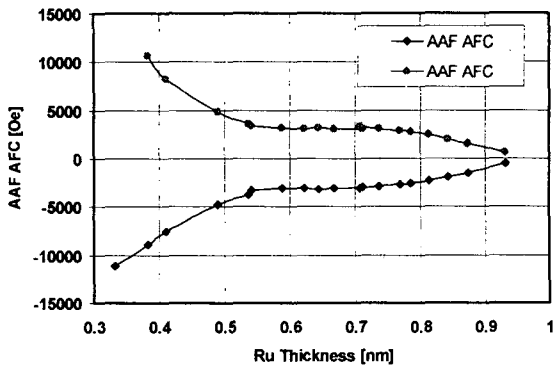
For technical application of the giant or tunnel magneto resistance (GMR or TMR) effect in MRAMs or sensors it is state of the art to use a so-called artificial anti-ferromagnet (AAF) [1] pinned by a PtMn layer as reference film. A complete xMR (x=G or T) consists of the bottom electrode including the AAF and the top electrode with the free layer, typically Seed/PtMn(t_{PG})/CoFe(t_{P1})/Ru(t_{Ru})/CoFe(t_{P2})/Spacer-/Free/Cap. To ensure the intended anti-ferromagnetic coupling in the CoFe/Ru/CoFe - AAF the thickness of the Ru has to be adjusted properly. The behaviour of the complete layer stack including the free layer can be phenomenologically explained taking into account coupling energies between the different layers as well as the anisotropy energy and the Zeemann energy [2]. We could demonstrate by a GMR multiplayer, controlling the Ru thickness in steps of ≈ 0.02 nm, that in the as-deposited state a strong AF-coupling can be observed down to t_{Ru} = 0.33 nm(see fig). Though we prepared a symmetric AAF (setpoint $t_{P1} = t_{P2}$ = 3 nm) the hysteresis loops clearly show that $t_{P1} < t_{P2}$. This indicates the existence of a "dead" layer at the interface between PtMn and the pinned CoFe. Since the symmetry of the AAF as well as the coupling strength within the AAF essentially determine the behaviour of the total xMR stack, we investigated furthermore the effect of the annealing step, required to establish the magnetic pinning by the PtMn film. The structural changes originated by the annealing result in an additional interface roughness between the PtMn but also at all interfaces on top of the PtMn. We discuss the related effect on the coupling within the AAF and on the switching behaviour of the free layer.



References

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