

Perpendicular exchange coupling of chemically ordered PtFe/PtMn bilayer on Pt(001) single-crystal

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The exchange interaction between antiferromagnetic (AFM) and ferromagnetic (FM) layers has been extensively investigated, especially for the pinning effect of the AFM layer on the FM one, which lead to a shift of the centre of the hysteresis loop away from zero applied magnetic field [1]. PtMn alloy in the tetragonal chemically ordered phase is one of the best AFM materials for technological applications. At room temperature (RT), however, the exchange bias in PtMn/FM bilayers is strongly reduced below 20 to 30 nm and vanishes when the PtMn layer is thinner than 8 to 10 nm. Despite numerous recent experimental studies, the origin of such a critical thickness is not properly understood. Current explanations relate it to AFM thermal stability, grain size distribution, finite scaling of the Néel Temperature or chemical disorder [2-6]. With only few exceptions, all these studies were performed on films grown by sputtering and with different degrees of texture and chemical order. High quality epitaxial ultra-thin films of few monolayers, provide ideal systems to get insights into such a complex correlation between structure and magnetic properties.

Grazing incidence X-ray diffraction (GIXRD) was carried out to follow the growth of ultra-thin PtMn(Fe) layers on Pt(001) at the UHV workstation of the French CRG BM32 beamline at ESRF. The films were grown by alternate electron-beam deposition of Mn(Fe) and Pt and studied *in situ* by GIXRD. At room temperature, Pt grows by island formation and the resulting ultra-thin PtMn layer is disordered and rough. Subsequent annealing (500°C) smooths the surface but gives rise to a (twinned) chemically ordered phase with the tetragonal c-axis mainly in the plane of the surface. On the other hand, on a substrate at 300°C, Pt grows layer-by-layer, while Mn has negligible diffusion into bulk. As consequence, an ultra-thin layer with the tetragonal c-axis perpendicular to the surface is formed. Subsequently, a tetragonally distorted PtFe layer with c-axis perpendicular to the surface was grown on that PtMn layer, yielding a well-suited system for perpendicular exchange coupling.

Magnetic properties were studied *ex situ* by polar magneto-optic Kerr effect (MOKE). After field cooling, increased coercivity and exchange bias shift of the hysteresis loops were observed. X-ray magnetic circular dichroism (XMCD) at the Mn and Fe L₂₃-edges was performed at the ID08 beamline at ESRF. The results show a perpendicular AFM coupling between Fe and Mn magnetic moments. They also point to a large amount of uncompensated Mn spins at interface, the majority of them being rotatable. A rough estimation indicates that only a small fraction (less than 3%) of these Mn spins is pinned.

References

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