Impact of keV He ion bombardment on the magnetic proximity effect in Pt/Fe bilayers investigated by x-ray resonant magnetic reflectivity

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The static magnetic proximity effect (MPE) describes the occurrence of spin polarization at the interface of nominally paramagnetic materials caused by its adjacency to a ferromagnetic material. Low-sputter yield keV-He^+ ion bombardment (IB) of thin-film interfaces offers the opportunity to modify the interface properties of thin-film systems, including the roughness σ, while the sample itself should remain essentially intact. In case of magnetic systems, the interfacial magnetic properties can be altered by IB without destroying the thin films, e.g., as shown for exchange-bias systems [1]. Therefore, the MPE is expected to be influenced by IB as well. This targeted manipulation of magnetic interface properties could play an important role when adjusting device properties for spin current applications that include the detection of spin currents via the inverse spin Hall effect in Pt [2].

Samples of Pt 4.5 nm/Fe 10 nm//MgO(001) were fabricated by sputter deposition and pre-characterized (lab-x-ray reflectivity (XRR)) in Bielefeld. The subsequent IB has been performed in Kassel with 10 keV He^+ ions, for which the applied IB dose has been systematically varied from 10^{15} to 10^{17} ions/cm^2 in several steps. To analyse the strength of the MPE in Pt, x-ray resonant magnetic reflectivity (XRMR) [3,4] measurements were performed at the Pt L_3 absorption edge (11.567 keV) at DESY beamline P09 in Hamburg.

The fits of the XRR measurements provide a significant difference for the roughness σ of the Pt-Fe interface due to IB while substrate and surface roughnesses as well as layer thicknesses remained nearly unchanged. After fitting the magnetooptic profiles, extracted from the XRMR measurements, the $\Delta\beta$ depth profiles can be converted into the induced Pt moments per spin-polarized Pt atom by an ab initio calculated conversation factor [5]. The resulting maximum Pt moment at the interface for the samples with moderate IB is higher than without IB, likely because of the increasing intermixing of Pt and Fe atoms at the Pt-Fe interface.

References:

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