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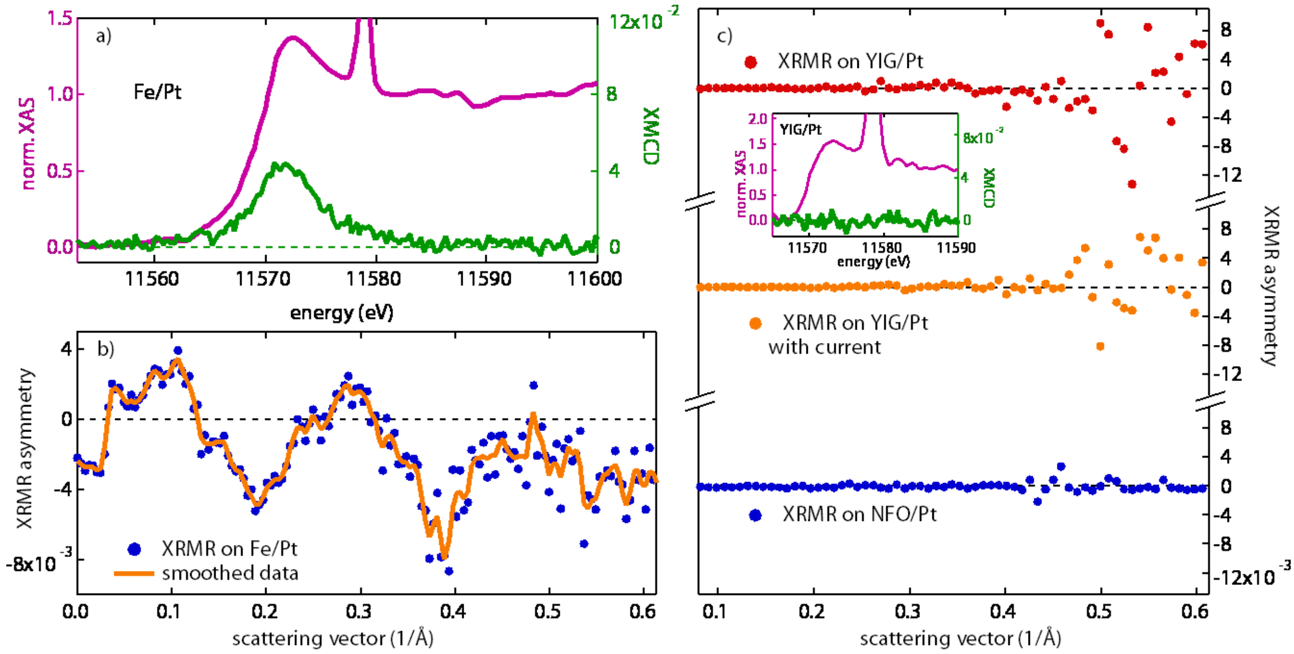
Report:

In spintronics, novel spin-dependent effects originate from the interplay between charge and spin currents and rely on the spin-Hall effect (SHE). Different groups reported an unexpected magnetoresistance (MR) in YIG($Y_3Fe_5O_{12}$)/Pt hybrids, dependent on the magnetization of the ferrimagnetic insulator YIG [1-3]. Since the paramagnetic metal Pt is solely carrying the electric current, its close proximity to YIG must be responsible for the observed MR. Two conflictive models explain this observation. One proposes the occurrence of a "conventional" anisotropic MR in Pt based on a proximity spin polarization [3], well known for metallic hybrids like Fe/Pt or Ni/Pt [4]. The second relies on the spin-Hall MR (SMR) effect, resulting from the reflection or absorption of spin currents at the interface [1,2]. The fundamental difference between both models is the occurrence of an interface proximity spin polarization or of the SHE in Pt. In our previous investigation of the YIG/Pt system at ID12 (HE-3784), we found no evidence for an X-ray magnetic circular dichroism (XMCD) at the Pt L_3 edge for thicknesses of the Pt layer down to 3 nm [5]. To further clarify this issue, we here comparatively measure the XMCD and the X-ray resonant magnetic reflectivity (XRMR) [6] in YIG/Pt(3.2 nm), NFO($NiFe_2O_4$)/Pt(3 nm), and Fe/Pt(3.2 nm) (reference sample) hybrids with or without applying a dc electrical current. Both methods provide element-selective information on the magnetic properties of Pt alone, in which the XRMR signal is independent of the thickness of the Pt layer [7]. All XMCD/XRMR measurements are performed in the newly developed reflectometer at ID12.



To check our method(s) and setup, we first investigate a Fe/Pt reference sample at the Pt L_3 edge. In the X-ray absorption spectrum (XAS), it displays a normalized whiteline intensity of 1.30 (Fig.(a)), consistent with non-oxidized, metallic Pt [8]. The normalized XMCD measured at a switching magnetic field of ±0.4 T reaches 4%, evidencing a magnetic proximity effect in Pt in agreement with earlier reports [4,5]. In XRMR, we observe an asymmetry of the data for ±0.4 T as expected (Fig.(b)) that fits well to a spin polarized layer in Pt close to the interface to Fe [7]. In proximity to the ferrimagnetic insulators YIG and NFO, however, we do not detect any XRMR asymmetry in Pt within the resolution of the experiment (Fig.(c)). We do not observe any significant deviation from zero up to a scattering vector of 0.4 $Å^{-1}$, neither when applying a switching magnetic field of ±0.4 T to probe a static spin polarization in Pt (red and blue) nor a switching electrical current of ±0.1 mA to probe a dynamic spin polarization in Pt as a result of the SHE (orange). The observation comes along with a zero XMCD signal for all samples, although they show an XAS whiteline intensity close to metallic Pt, as exemplarily displayed for YIG/Pt in the inset of Fig.(c). For scattering vectors larger than 0.5 $Å^{-1}$, the low photon intensity leads to an increased relative noise level that prevents an unambiguous analysis of the XRMR (difference) data.

In conclusion and in contrast to Pt on Fe, we find no significance for an induced magnetic moment in Pt on YIG or in Pt on NFO. At the Pt L_3 edge, both the XMCD (sensitive to the complete Pt layer thickness) and the XRMR (sensitive only to the interface) are zero within experimental error. We cannot confirm a magnetic proximity effect [3] in paramagnetic Pt on ferrimagnetic insulators. The unexpectedly observed MR effect in YIG/Pt and NFO/Pt should therefore be interpreted in the framework of the SMR model [1,2].

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