ESRF	**Experiment title:** **Fully epitaxial oxide-based magnetic tunnel junctions: a study of the spin polarization at the Fe_3O_4/Al_2O_3 interface**	**Experiment number**: HE1636
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Report:

Spin-polarized transport have received great interest since the discovery of giant magnetoresistance in Fe/Cr multilayers. Part of the research effort has been directed on magnetic tunnel junctions (MTJ) made by a sandwich of two magnetic conductive films separated by a non metallic insulator, which could become the core element of non volatile memories (MRAM) and magnetic sensors. The tunnel magnetoresistance (TMR = $\Delta R/R$) of such devices is strongly dependent on the spin polarisation of the magnetic films at the interfaces. The Jullière formula (TMR = $P_1P_2/(1- P_1P_2)$, where P_i is the polarisation at the *i* interface) predicts infinite TMR for 100% polarisation at the two interfaces of a MTJ. The dependence of the TMR on the polarisation explains the great investigation effort aimed to assess the real polarisation of materials, which was predicted to be half metallic (i.e. having P=100%).

Magnetite (Fe_3O_4) has been predicted half metallic at room temperature and has a high Curie temperature, which makes it an extremely promising candidate for industrial applications. However, the experimental spin polarization value is still a matter of debate: Dedkov et al. report -80 % [1] for Fe3O4 (111) grown by oxidation of W/Fe(110) and –60% for Mo/Fe(110); Huang et al. report -55 % [2] on MBE-grown Fe3O4(100); finally, Morton et al. also report -40% on both MBE and sputtergrown Fe3O4(100) samples but find their value consistent with the full polarisation after taking into account energy resolution of their experiment and surface imperfection of their sample.

Yet, all these measurements have been performed on Fe_3O_4 free surfaces, which are not relevant for technological applications, where the interface with the insulating spacer plays the relevant role. Indeed, it is well known that interface defects can dramatically modify the value and even the sign of spin polarization [3].

We performed Spin-resolved high energy X-ray photoemission (SRXPS) measurements on a Fe_3O_4(111) single crystalline film, covered by a 2 nm thick Al_2O_3(0001) barrier grown epitaxially on it. The Al_2O_3(0001)/Fe_3O_4(111) bilayer was carefull characterised for stoichiometry, crystalline quality and omogenity

of the barrier thickness by the usual techniques, as already explained in ref. [4], granting a very high quality of the sample. The known problem of low remanent magnetisation was addressed by comparing XMCD data taken in high field (6 T) and in the SRXPS setup (0.6 T pulsed magnetisation at 30° from the surface). The resulting remanent magnetisation was reliably determined in 55% of the one obtained under 6 T magnetising field [Figure 1].

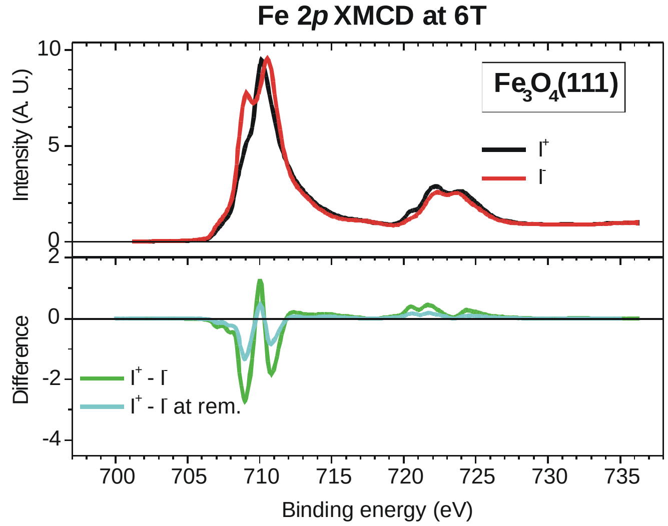

Figure 1. Top: X-ray Absorption spectra with right and left circular polarisation of the exciting beam taken under 6 T magnetic field. Bottom: XMCD (difference) spectrum compared with the one taken at remanence in the SRXPS experimental conditions, showing a reduction to 52% of the peak value.

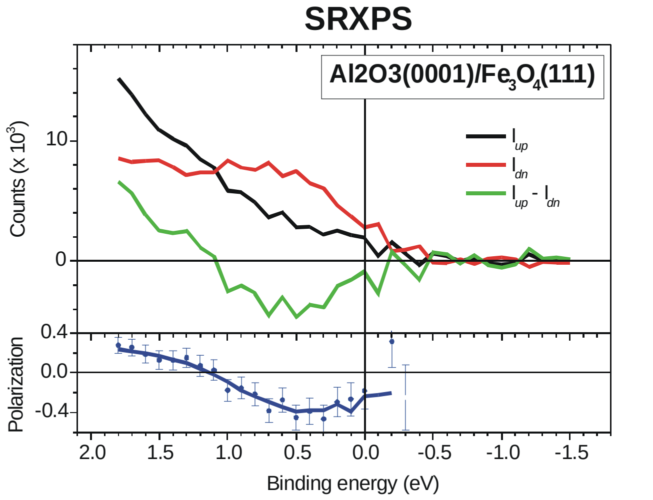

Figure 2. Top: SRXPS spectra and their difference, corrected for the spin analyser efficiency and the reduction of the remanent magnetisation with respect to the saturation (measured at 6 T). Bottom: Polarisation spectrum showing a negative value in the interval 30 ÷ 40 % at E_F.

The spin polarisation at E_F was then measured by SRXPS with 600 eV exciting photons, which allowed the long escape depth needed to look through the barrier. The high excitation energy is beneficial also because the emitted electron can be considered nearly a free particle and this strongly reduces final state effects on the experimental results. The Sherman function was determined by comparison with a CuO reference as S_{eff} = 0.14 and the resolution had to be limited to 0.7 eV due to the very low counting rate. Figure 2 presents the data already extrapolated for 100% magnetisation of the sample, showing a polarisation between 30 and 40 % at the barrier. The result sets a lower limit to the real polarisation due to the energy resolution, which is of the order of the predicted energy gap of 0.5 eV in the occupied majority electron band of Fe_3O_4(111) at E_F.

We also measured resonant magnetic XPS at the Fe L_3 edge that are in very good agreement whith the result published in ref. [5]

The results will be submitted soon for publication.

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