25/03/2008

Report on HE2515 experiment on ID08

The Fe/GaMnAs interface was predicted to give antiparallel magnetic coupling between the Fe and the Mn ions located in the proximity of the interface. Previous XMCD experiment performed on APE beamline at ELETTRA proved that the Fe induces a net magnetic moment on the Mn ions, antiparallel to the Fe ones. The strenght of the magnetic coupling depends on the Fe thickness and temperature, and extends up to 330K, well above the Curie temperature of GaMnAs (60 K). The results were obtained on polycrystal Fe films: the GaMnAs crystals were prepared ex-situ and subsequently decapped and cleaned by Ar^+-ions sputtering in-situ, prior to the Fe deposition. The resulting interfaces were thus quite rough.
The HE2512 experiment on ID08 was devoted to the study of the epitaxial Fe/GaMnAs layer, with sharp and ordered interfaces, in a wide range of temperature (8-300 K) and magnetic field (0-5 T).

The Mn XMCD spectrum can be decomposed in two energy shifted components, corresponding to Mn aligned parallel (P) and antiparallel (A) to the Fe magnetization and external magnetic field.

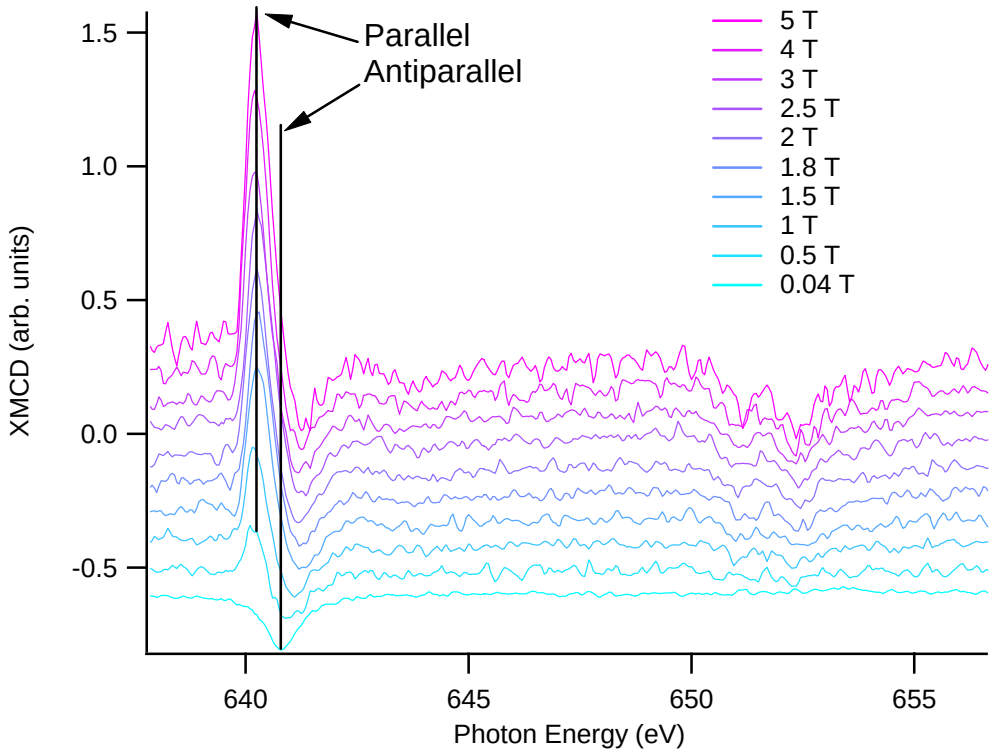

Fig.1 Mn XMCD evolution with respect to magnetic field, at T=150K and 23 ML of Fe. At low applied field the paramagnetic contribution of bulk Mn is absent and is well visible the antiparallel component of interfacial Mn ions.

This is clearly visible in fig. 1, showing the evolution of Mn XMCD lineshape for increasing external magnetic field. The (P) component can be attributed to the bulk GaMnAs, far from the interface. The lineshape corresponds to the pure GaMnAs and the peak of L_3 XMCD peak has the same energy as the L_3 XAS peak, as reported in literature. The (A) component has opposite sign and is shifted +0.5 eV with respect to the (P) one. We acquired an hystereses cycle at T=150K, measuring full XMCD spectra at the Mn and Fe $L_{2,3}$ edges for each magnetic field. We then extracted the relative intensity of (P) and (A) Mn contributions and drew the hystereses of Fe, Mn (P) and Mn (A). The Mn (P) has paramagnetic behaviour, because the measuring temperature is higher than the GaMnAs Curie temperature, that is 60K. The Mn (A) follows the Fe hysteresis shape, with reversed sign, with some differences at intermediate and high (H>2 T) magnetic field, as is visible on figure 2.

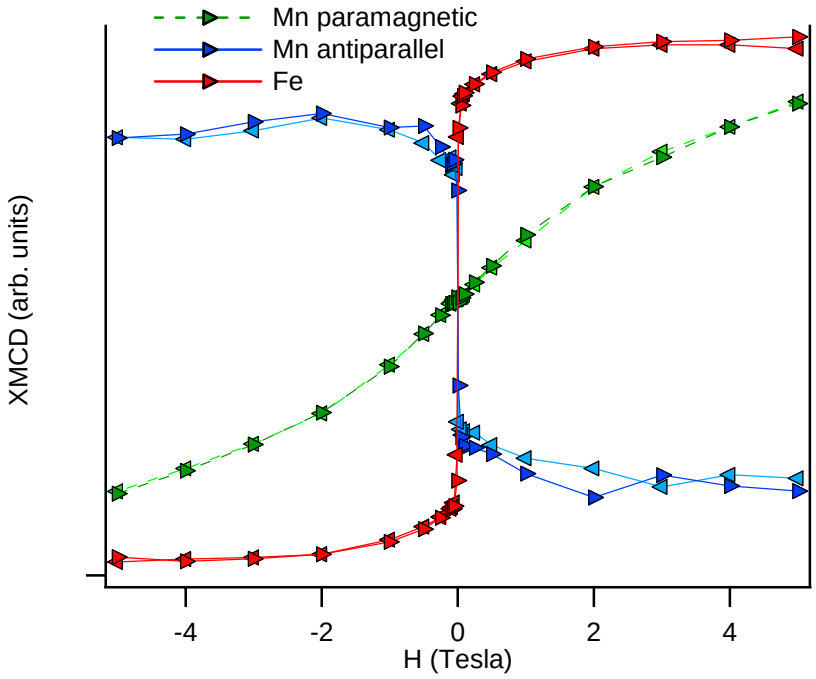

Fig.2 Hysteresis cycles of Fe, Mn parallel (P) and Mn antiparallel (A) components. The (A) Mn magnetic moments keep antiparallel orientation with respect to the Fe ones, but at high field a partial reorentation of Mn magnetization along the direction of the field is visible.

At high field the Mn/Fe XMCD ratio is slightly reduced, probably for a partial reorentation of Mn (A) magnetization along the applied mangnetic field direction. The complete analysis of experimental data will give us the full Fe thickness and temperature dependencies of Mn/Fe XMCD signals. Moreover the comparison between total electron yield (TEY) and photon yield (PY) detection mode will give some rough depth resolved information, based on the different probing depth of the two techqniques.

We wis to stress that our system required both elemental and chemical selectivity of XMCD, to resolve Fe and two distinct Mn contributions to the total magnetic signal. The low level of the XAS and XMCD signals, due to the presence of Au-capping layer and low Mn concentration, required the high flux and stability of ID08 beamline. The

XMCD/XAS spectra in our posses will be the starting point for the interpretation of X-Ray Resonant Magnetic Scattering (XRMS) measurements, that we planned to perform in order to have a depth resolved full picture of the magnetic moment distribution across the interface.

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