ESRF	**Experiment title:** **Antiferromagntisme vs. Paramagnetism of the beta phase in MnAs stripped thin films.**	**Experiment number**: HE 2488
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Report:

The ferromagnetic hexagonal α-phase of MnAs has a phase transition to the non-ferromagnetic orthorhombic β-phase at 318 K. The nature of magnetism in this phase has been the subject of many experimental and theoretical studies. The most recent theoretical work [1] predicts either an antiferromagnetic or paramagnetic state. In a recent experimental study of MnAs films on GaAs the β-phase was assumed to be paramagnetic [2].

We have addressed this problem also from the experimental side, using epitaxial MnAs layers on GaAs [3]. Because of their high carrier spin polarization, their high saturation magnetization and their small coercive field, these layers have attracted interest for spintronic applications. MnAs layers on GaAs are highly strained, which broadens the phase transition over a range of about 30 K. In this range α- and β-phase coexist.

In order to determine the magnetic structure of the beta phase and to complete our recent X-PEEM study that strongly indicates the existence of an antiferomagnetic (AFM) phase, we have performed a combined XMCD/XMLD experiment at the Mn edge (641eV) on the photoemission setup of the ID8 beamline. The aim of this experiment is to demonstrate the existence of a XMLD effect connected to the beta phase and to determine the AFM axis orientation within the thin film. For that purpose we have studied three samples of respectively 20, 50 and 150 nm thickness. All the sample showed a weak (<4%) but clear linear dichroism (LD) effect (see figure). For each sample we have performed an angular study (both azimuthal and polar) of the LD asymmetry. From the first analysis we have a clear evidence that the maximum anisotropy is along the in plane [11-20] axis. With decreasing thicknesses the strong asymmetry axis seems to have a small out-of plane component probably due to the strong strain induced by the GaAs substrate.

However, a LD effect doesn't mean straightforwardly that it's due to an AFM of the system. Indeed, the LD can be attribute to three effects: Electronic, structural which are both connected to the crystallographic phase and a third effect related to the pure AFM effect. In order to evidence that the observed effect is due to the AFM, we have in addition performed a temperature dependant study from RT

(Room Temperature) to 150°C (which the maximum temperature achievable in the setup). From previous experiments (X-PEEM, diffraction...) we know that from RT to 48°C we have the α/β phase coexistence, above there is a first order transition where the film becomes fully in the beta phase. Finally a second order transition happen at 130°C from the β phase to the γ phase which in turn fcc. During the first order transition the beta phase remains in the same structure and there are no structural (lattice parameter..) or electronic changes. When looking to the LD asymmetry behaviour as function of the temperature we have showed that the LD effect remain constant until 48°, then there is a sudden loss of 30% of the LD signal. Above the LD effect remains constant until the second phase transition (130°C) where it starts to slowly decreases as the γ phase appears.

As far as the crystallographic and the electronic structure remain the same across the first order transition (48°C), we can definitively rule out any structural contribution of this LD decreases. The measured loss of the LD effect is then purely due to the existence of an AFM during the phase coexistence.

We can then conclude that during the α/β phases coexistence the β phase is purely AFM, above the β phase become paramagnetic. We have to note that this conclusion is coherent with recent abinitio calculation that show that an AFM alignment of the Mn moment within the basal plane can be stabilise during the phase coexistence.

Finally we have also performed on two samples (20 and 50nm) a field cooling process. From other group measurements these samples must showed an exchange bias effect and then confirm the AFM scheme. A first analysis confirms again our conclusion, but more refined analysis is required. Multiplets calculations are also considered in order to understand the origin of the XMLD effect in our system. The sample has been capped with a gold layer at the end of the experiment, in order to perform ex-situ extra magnetic measurements.

In conclusion the experiments were very successfully thanks to the beam stability and the fast measurement available on the ID8 beamline at ESRF.

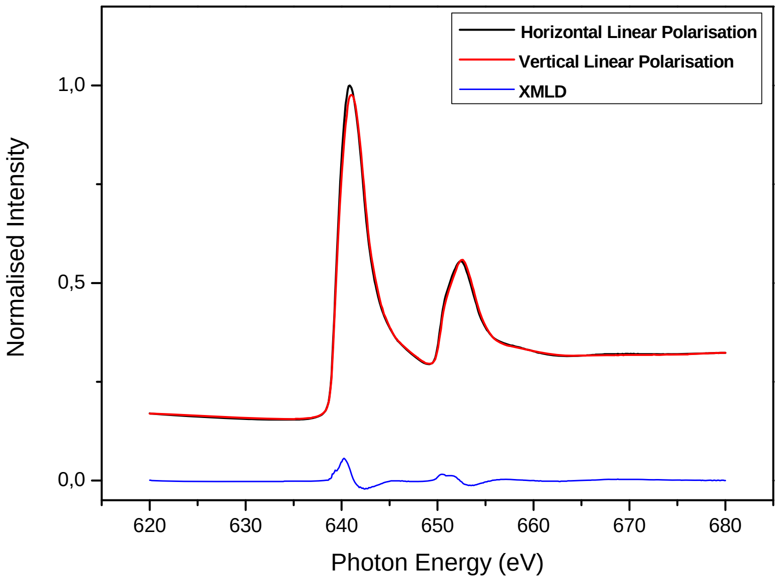

Figure : $L_{2,3}$ Mn edge taken with linear verical/horizontal polarisation in normal incidence.The vertical linear polarisation is aligned along the [1-120]which correspond to the easy magnetic axis. The XMLD effect is 3.7% of the total Mn signal.

References

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