ESRF	**Experiment title:** Magnetism in one dimension: Fe on Cu(111)	**Experiment number**: HE-558
Beamline: ID12B	**Date of experiment**: from: 17/02/99 to: 22/02/99	**Date of report**: 22/03/99
Shifts: 18	**Local contact(s)**: N. Brookes (ESRF)	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Ph. Ohresser, N. Brookes, O. Tjernberg, G. Ghiringhelli, ***ESRF***

Report:

Epitaxial growth of Fe on a stepped Cu(111) surface leads to the formation of stripes if the coverage is less than 1.5 monolayer (ML) [1]. Therefore this "self organized" system allows us to produce easily magnetic 1D nanostructure which are of great potential. Actually the sensitivity of the XMCD technique on ID12B allowed us a study far below the 1D percolation in the ~5% of a monolayer thickness range where the clusters are made of few hundred atoms.

In order to make a correlation with the previous result on this system obtained with Kerr effect [1] we plot in figure 1 the blocking temperature (T_B) for different coverage in the superparamagnetism thickness range. This temperature can be estimated from the vanishing of the coercivity. We can see that both sets of experiments agree quite well (the result from ref. 1 are indicate by the dashed areas). The upper X-scale consist of the average number of atoms per island resulting from the fit by a Langevin function of the superparamagnetic hysteresis curve. Actually this model is not well suited in our case as our growth mode does not lead to homogenous islands size but it allows a fair estimation of the morphology and in fact the values we obtain for the lowest thickness (i.e. where the morphology is the most homogenous) are consistent with the previous STM-Kerr study [1].

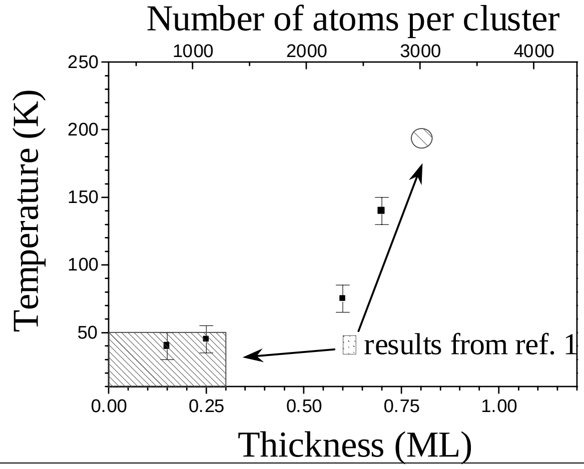

FIG. 1. T_B for Fe/Cu(111) at different coverage in the superparamagnetic thickness range. The MOKE results from ref. 1 mention a T_B below 50K for film thinner than 0.3 ML, and T_B = 200 K for 0.8 ML (dashed areas). The upper X scale is the average atoms number per cluster before the percolation (see text).

Using the specificity of the XMCD and the high sensitivity at ID12B we determine the magnetic moments using the sum rules. Due to the very small coverage considered in our experiment we expect an increase of the orbital magnetic moment (m_L) and the spin moment (m_S) due to the isolated atoms effect. More, correlated to the 1D and 2D percolation we can also expect some slight structural changes in the fcc Fe parameters which can lead to some modification of m_S. In order to be sensitive to these changes we plot m_L and m_S in figure 2 rather than the ratio m_L/m_S. Assuming uniaxial anisotropy, we use Bruno's model describing the orbital magnetic moment m_L^γ at an angle γ from the normal :

$$m_L^\gamma = m_L^\perp + (m_L^{//} - m_L^\perp)\sin^2\gamma,$$

where $m_L^\perp$ and $m_L^{//}$ denote, respectively, the orbital magnetic moment measured along and perpendicular to the easy axis of magnetization.

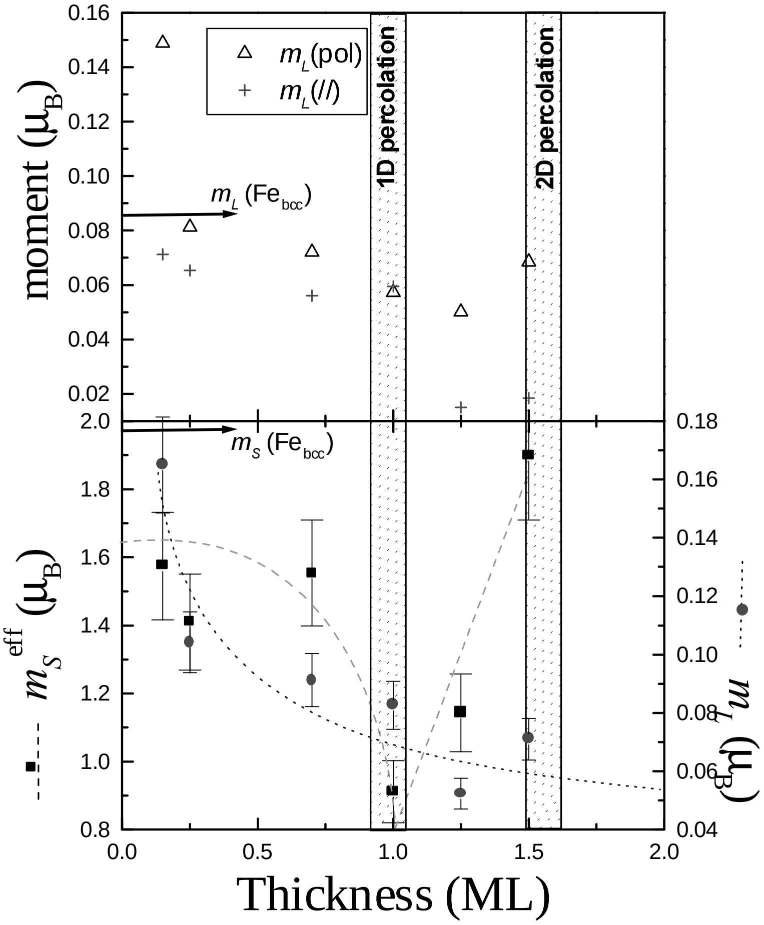

FIG. 2. Effectif spin moment (include the magnetic dipole term) and orbital magnetic moment for Fe/Cu(111) deduce from the XMCD spectra using the sum rules.

We can see from this plot that m_L show the expected behavior with an increase of 100% for the lowest coverage compared to the 2D value. However surprisingly we found for the coverage's below 1ML an in-plane contribution for the magnetic anisotropy, and even if it goes to fully polar above 1 ML this result is quite different from the Kerr experiment where a strict polar anisotropy is observed in the full fcc thickness range, i.e. below ~2.5 ML. This discrepancy is certainly due to the highest sensitivity of XMCD. But we still do not know if our observation is due to a quenched anisotropy or a mixing of domains with polar and in-plane anisotropy. But the more striking result come from the spin moment indeed it shows very important features which are correlated with the morphological transition, i.e. decrease of m_S at the 1D percolation and increase when the film reach the 2D percolation.

We tentatively ascribe these features to some slight changes in the Fe atomic volume taking place at these morphological transformation, as it is well known that such change can drastically modify the γ-Fe magnetic properties [2].

References

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[2] U.L.Moruzzi, P.M.Markus and J.Kubler, Phys. Rev. B 29, 6957 (1989), Yu-Mei Zhou, Wen-ying Zhong and Ding-sheng Wang, J.Magn. Magn. Mater **145**, L273 (1995)