ESRF	**Experiment title:** **Magnetism in self-organized Fe clusters on Au(111)**	**Experiment number:** HE 653
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Report:

This work on Fe grown on a Au(111) surface is part a more general project on the magnetic **properties of nanostructures** obtained by self-organization of an adsorbate deposited on a specific substrate. The first part of this work concerned Fe/Cu(111)-vicinal where Fe stripes are easily obtained by step decoration.[1] We demonstrated the sensitivity of the magnetic spin moment to the structure as we observe a magnetic phase transition at 0.8 ML which corresponds to the coalescence of the islands in stripes.[2] In the continuation of this work the Fe/Au(111) system is a good candidate. Indeed in the sub-monolayer range Fe is known to grow on the reconstructed $(22\times\sqrt{3})$ Au(111) as organized clusters nucleated on the Au reconstruction.[3] This study by XMCD needs a very large sensitivity since we are interested in coverages down to few percents of a monolayer (ML) in order to obtained **clusters of a hundred atoms** (or less). These measurements were difficult as the Au cross section, unlike the Cu substrate, is very high at the Fe-$L_{3,2}$ edges.

In figure 1 we plot the variation of the magnetic spin moment (m_S) per hole versus the Fe coverage. Three main regions can be observed. Above 3 ML, where the structural transition from fcc to bcc take place, m_S reaches the value commonly expected for bulk bcc (0.6 μ_B per hole). Below this thickness and down to ~0.5 ML m_S shows a continuous increase. Since in this region the Fe film has a fcc structure induced by the Au substrate we can ascribe this behavior to a **high spin fcc phase.** Indeed this pseudomorphic growth means an atomic volume for the Fe expand by ~13% compare to its value for stable fcc phase. This kind of behavior leads usually to a high spin phase as in the case of Fe/Cu(111) below 4 ML.[4] The slow decrease from 0.5 ML to the bulk value around 3 ML is certainly caused by the appearance of bcc clusters with lower magnetic spin moment values. But the most striking feature is the abrupt drop of m_S going toward very low coverages. Indeed for these low coverages the growth is also expected to be pseudomorphic so we should expect the same behavior than for higher coverage, i.e. a high spin phase. However m_S actually does not drop to the value commonly measured for fcc Fe (0.17 μ_B per hole)[2] but to ~0.45 μ_B per hole which has been also measured in Fe/Cu(111) below the 1D coalescence and ascribed to a slight expansion (~2%) of the γ-Fe lattice parameter. Similarly to this previous observation we can point out that this sharp transition in m_S takes place at the coverage where the 1D coalescence is expected (~0.5 ML). Therefore a structural relaxation, leading to a different spin phase, is not excluded. However we should also mention that in the case of Fe/Au(111) site exchange mechanisms, between Fe and Au atoms, are probably of great importance in the initial growth and this interdiffusion could play a role on the magnetic properties.

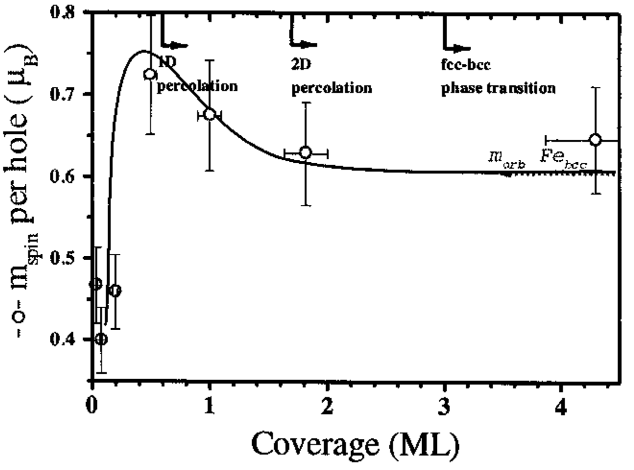

Figure 1. Magnetic spin moment per hole for Fe/Au(111) (Nh = 3.39 holes for bulk bcc Fe) (the line is only a guide for the eyes)

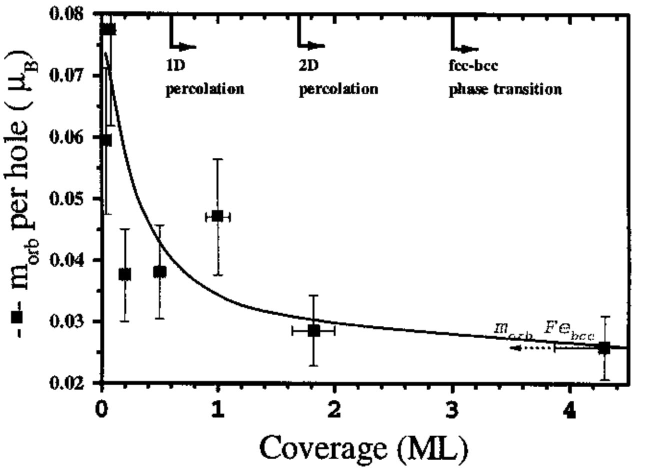

Figure 2. Magnetic orbital moment per hole for Fe/Au(111) (Nh = 3.39 holes for bulk bcc Fe) (the line is only a guide for the eyes)

Figure 2 shows the magnetic orbital moment (m_{orb}) per hole. The expected behavior is observed : an increase of m_{orb} going toward low coverages. However the intriguing point comes from the values we measured: indeed a factor two is observed if we compare these values to our former work of Fe on Cu(111) for similar coverages. This translates to much larger anisotropy values. Using the model of Bruno[5] for the Fe/Cu(111) case to calculate the anisotropy energy (K_2) we find a very good agreement with the theory (K_2 = $-0.61.10^{-3}$ $eVatoms^{-1}$, for a fcc(111) Fe surface) but the in the case of Fe on Au the same calculation leads to an **in-plane anisotropy** and an absolute value twice as big ($K_2 = 1.3.10^{-3}$ $eVatoms^{-1}$). This increase of the anisotropy energy is also observed in the superparamagnetic behavior where we observe higher blocking temperature for clusters of similar size and very high coercive field. This observation points out the important role of the substrate in the such magnetic properties but the exact mechanisms inducing these changes in m_{orb} are still to be found.

References:

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