

Experimental Report (30/06/2014)

Proposal MA2099

“Structure, morphology and ordering of preformed size-selected Fe and FePt nanoclusters deposited on graphene/Ir moiré patterns”

Beamline: IF-INS BM32

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Number of shifts: 18

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Objective and expected results:

We aimed at determining the structure, epitaxial relationships, lattice relaxation, shape, organization and possibly locations of preformed and size-selected Fe and FePt nanoparticles (NPs) deposited on the moiré pattern of graphene/Ir(111). We had planned to consider 1.5 nm in diameter Fe and FePt particles, and follow the evolution of the system with the annealing temperature (up to 300°C). The purpose was to gain insight on both the cluster/cluster and cluster/surface interactions (diffusion, pinning, ordering, coalescence). This proposal is part of the NMGEM ANR project which aims to explore nanomagnetism on graphene/metals. Due to the original behaviour of size-selected Pt clusters deposited on graphene/Ir(111) (50 % of the Pt clusters are pinned on the moiré of graphene/Ir(111)), [1] we expected to observe a self-organization of the Fe and FePt nanoparticles on the moiré lattice (periodicity of 2.5 nm).

Results and preliminary conclusions:

Three samples have been studied. For each sample, a graphene monolayer has been grown on the (111) surface of an Ir single crystal following the procedure described in ref. 2, and characterized by x-ray diffraction. The sample has then been transferred, under UHV, to the PLYRA platform of Lyon university for cluster deposition (LECBD technique). Size-selected Fe and FePt clusters, with a diameter around 1.5 nm have been soft-landed (random deposition) on the moiré pattern. The three samples correspond to different clusters: Fe for S1, FePt for S2 and S3 with a density of 30 000 NPs. μm^{-2} , corresponding to a coverage ratio of 5%. Depositions were performed at room temperature (RT) for S1, S2 and at c.a. 150°C for S3. S3 was also protected with a thin layer of amorphous carbon. It should be noted that, given the particle size and the moiré lattice parameter (2.5 nm), a full occupation of each site corresponds to a coverage $\sim 25\%$. S1, S2 and S3 have been annealed during the x-ray measurements up to 500°C.

As shown in Fig. 1, the GISAXS pattern along the Ir[100] direction indicates that some Fe and FePt particles are located on the moiré hexagonal lattice. This implies that they have been able to diffuse on the surface and self-organize at room temperature. The ratio of organized particles has to be evaluated by fitting the GISAXS pattern [1]. The increase of the correlation peak between sample 2 and 3 indicate that increasing the deposition temperature enhances the ratio of organized FePt NPs.

The correlation peak for the sample 3 (coated with a-C) is slightly decreasing with temperature, up to 650 K (Fig, 3). This implies that the organisation of the clusters is preserved up to 650 K which is close to the chemical ordering phase transition temperature ($A1 \rightarrow L1_0$) for FePt clusters [3]. For higher temperature the system is modified, possibly due to intercalation of the NPs under the graphene.

References:

- [1] S. Linas *et al.*, Moiré induced organization of size-selected Pt clusters soft landed on epitaxial graphene, To be submitted.
- [2] N. Blanc *et al.* *Phys. Rev B*, **86**, 235439, (2012).
- [3] F. Tournus *et al.*, PRL **110** 055501 (2013).

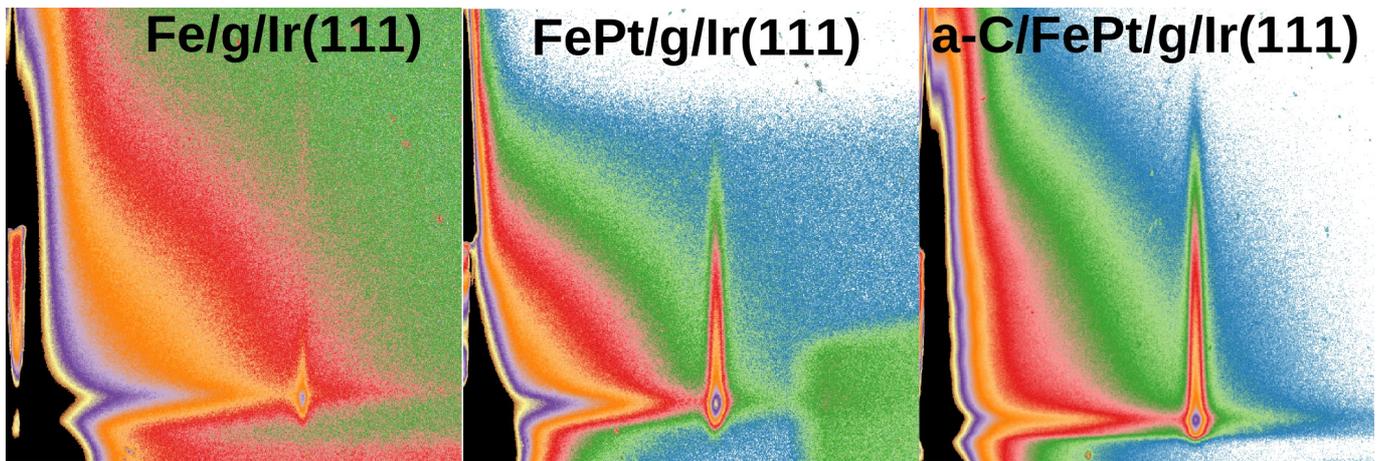


Fig. 1: GISAXS pattern at room temperature for sample S1 (Left), S2 (middle) and S3 (right). The peak corresponding to the moiré superlattice is clearly visible for the three samples. The beam was aligned along the Ir[100] direction.

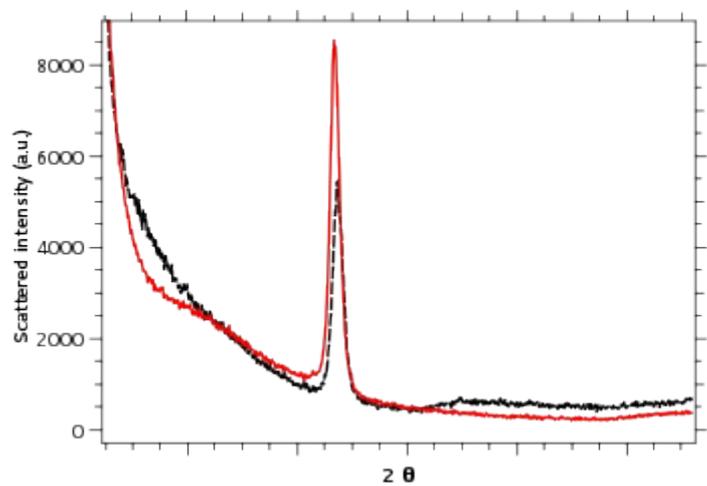


Fig. 2: (Left) Comparison of the GIXAXS correlation peak for a deposition of FePt clusters at RT, (sample 2, black dashed line) and at $150 \pm 100^\circ\text{C}$ (sample 3, red line).

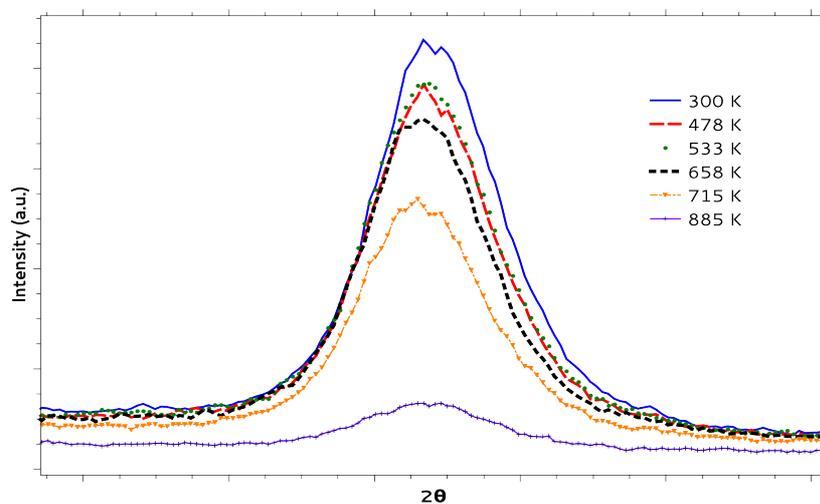


Fig. 3: Evolution of the GISAXS correlation peak for sample S3 upon annealing.