ESRF	*In-situ* anomalous GISAXS study of the self-organised growth of Cobalt on the herringbone reconstruction of *Au(111)*	**Experiment number:** SI-920
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Report:

Co/Au(111) is a prototypical system of self-organised growth: *Co* grows on the *Au(111)* $22 \times \sqrt{3}$ herringbone reconstruction, as a regular array of 2 atomic layers high dots with a rectangular lattice of parameters $\Lambda \sim 7.6nm$ and $2\kappa \sim 20nm$, with 2 *Co* islands per unit cell (see fig. (a)) [1]. This peculiar growth process has been investigated in many STM and theoretical studies; however several question were left unanswered. GISAXS and anomalous-GISAXS have been used to address them.

The first issue is the degree of ordering of the Cobalt dots at the different stages of growth. The advantage of GISAXS over STM is indeed that it probes a large area, providing statistical information. It has been shown that the order along the $< 11\bar{2} >$ (Λ periode) directions is very long-range; this is well understood since this periodicity is directly related to the $22 \times \sqrt{3}$ reconstruction. In constrast, a cumlative disorder can be observed along the $< 1\bar{1}0 >$ directions, which is related to a much more subtle energy balance of the "kinks" periodicity [1,2].

The second unanswered question relates to the morphology of the *Co* film for thick deposits (continous film) and of its interface with the *Au* substrate. Indeed in a naive way, we would expect that the GISAXS intensity would dramatically decrease beyond coalescence of *Co* dots into a continous film (i.e. around .16nm equivalent thickness for coalescence along the $< 11\bar{2} >$ azimuts). By contrast, the integrated intensity of GISAXS satellites increases up to 0.5nm, and remains sizable up to 3.5nm while keeping a FWHM of 3%, attesting a degree of ordering which does not degrade [1,2].

A possible origin could be a periodic strainfield in the *Au* substrate, induced by the 18% lattice parameter misfit with *Co*. Another possibility could be that some *Au* atoms have diffused in or around the *Co* dots. Anomalous GISAXS has been used to disantangle this question: after .42nm of *Co* deposit, we recorded GISAXS images at 9 energies around the *Co-K* edge (7.709KeV), with the X-ray beam along the $< 1\bar{1}0 >$ direction. Near an absorption edge, the atomic scattering factor of the concerned element has a complex expression ($f(Q) = fo(Q) + f' + if"$). The *f'* and *f"* have been measured, by recording the transmission factor through a *Co* foil, as a function of energy. The *Fa* (scattering factor of *Co*, anomalous atoms) and *Ft* (scattering factor of all atoms) were then extracted by fitting the intensity of the diffraction rods corresponding to the Λ periode, over the nine energies. The result is shown fig. (b); *Fa* is very similar to *Ft*, which means that the contribution of *Au* to the intensity is negligeable. The two above hypotheses to explain the excess of intensity can then be ruled out. Other possibilities may be the presence of non coherent interfaces at junctions between *Co* islands.

The growth of superparamgnetic *Co* "pillars" was also performed, using a method roughly described by O. Fruchart [3]. GISAXS was used as a "crystallography-like" technique, which we call super-crystallography, to determine the structure of these pillars within the super-unit cell. We recorded GISAXS images at 180 azimuts, spaced by steps of 1deg.; for each one, the intensity along the line corresponding to *l=0* has been extracted to built the map of in-plane reciprocal space, which is shown fig. (c). It exhibits a 6 fold symmetry arising from the contribution of 3 different variants of the super-lattice. The white arrows denote two crystallographic directions, corresponding to the same variant. This map is beeing analysed using IsGISAXS software [4].

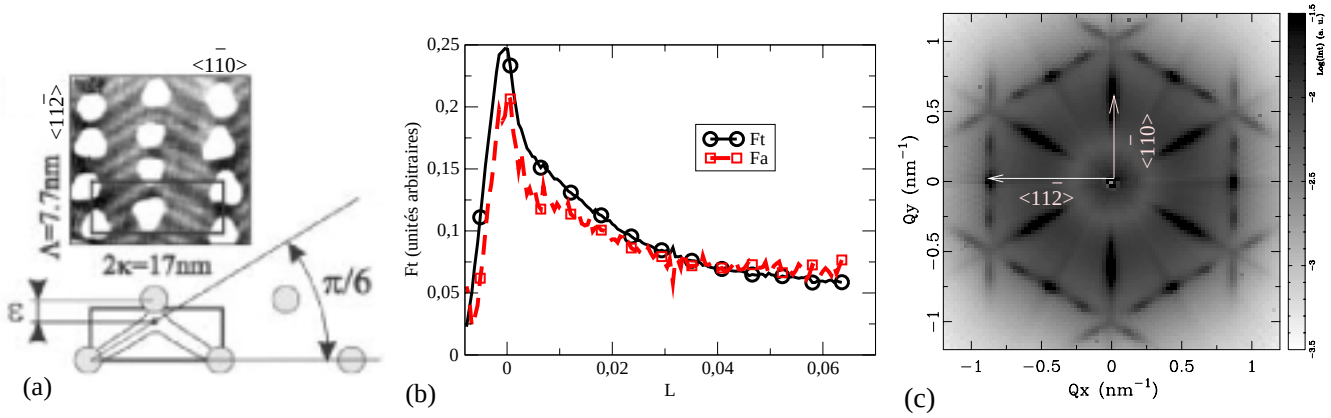

Fig. (a): STM picture of Co/Au(111) with average super-cell. (b): Reconstruction of in-plane reciprocal space. (c): Scattering factors Ft (all atoms) and Fa (Co atoms).

References:

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