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Experiment Report Form

ESRF	**Experiment title:** **Ordering and kinetics of Ag-induced nanofaceting of Cu vicinal surfaces**	**Experiment number**: SI 1146
Beamline: ID03	**Date of experiment**: from: 09 March 2005 to: 15 March 2005	**Date of report**: 23 February 2007
Shifts: 18	**Local contact(s)**: Dr. Ioana Popa	*Received at ESRF:*

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Report:

The self-organisation of nanometric systems has been intensively studied [1] due to their potential application for the fabrication of magnetic, optoelectronic or catalytic nano-objects among others. The faceted surfaces represent a promising way for the realisation of nanostructured templates. The study of the faceting in the nanometric range of Cu vicinal surfaces induced by Ag deposition [2, 3] is very interesting in this context: by means of the Ag coverage in the sub-monolayer range one can easily tune the period and the morphology of the substrate surface, giving a potential template for further growth of nano-objects.

We have performed a series of experiments on ID03 beamline at ESRF in March 2005 (exp. SI 1146), using Grazing Incidence X-Ray Diffraction (GIXD). During the 18 allocated shifts we studied thermal stability of the faceting process of the Cu vicinal surface after Ag deposition. The present report concerns the results obtained on Cu vicinal surfaces, constituted by (111) terraces around 1 nm wide.

The deposition of Ag atoms on a Cu vicinal surface induces the formation of a striped system [2, 3], with an alternated succession of bare Cu and Ag covered facets. The hill to valley structure obtained in this way is periodic and the period varies in the ten nanometer regime, accordingly to the Ag coverage.

Ag was deposited on the surface at room temperature; a subsequent annealing at 500 K allows the system to organise in facets, as sketched in Fig.1.c. In order to study the influence of the annealing on the system ordering, we performed a series of reciprocal space scans which are sensitive to the type of facets and/or to the superstructure period. In Fig.1 we report the measurements obtained after the deposit of 0.43 Ag ML. The data are shown by using a reciprocal space lattice basis built on the vicinal substrate surface periodicity [3]: in this case *H* spans the direction normal to the step edges, *K* the direction parallel to the steps and *L* the normal to the sample surface. The two (*H, L*) reciprocal space maps reported in Fig.1, obtained for two *K* values show diffused rods due to the facets. The map in *K*=2 presents the facets rods which cross at the substrate Bragg peaks, in anti-Bragg positions a "*H*-scan", sketched by a red row on the map and represented

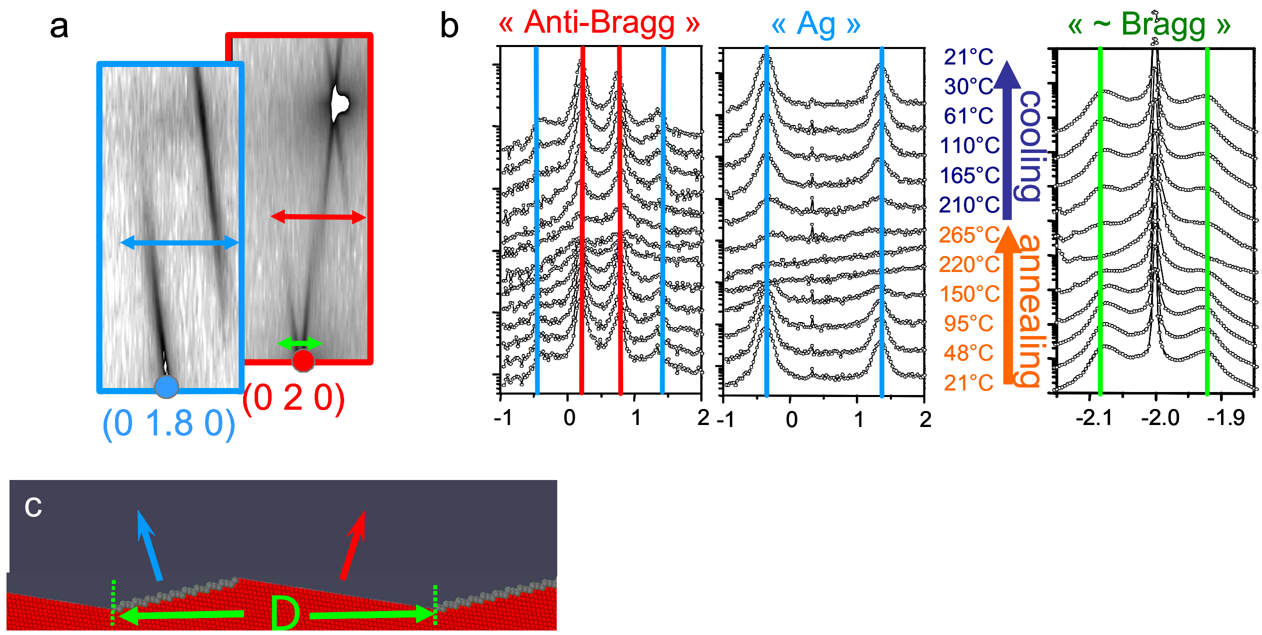

Fig.1. a. Reciprocal space maps in planes normal to the step direction. The rods diffused by the facets are clearly visible. b. "H-scans" sensitive to the facets and the period, showing the evolution of the surface morphology along the thermal treatements. c. sketch of the surface morphology.

in Fig.1.b, is sensitive to facets signals. Moreover, a "*H*-scan" performed in a region near the Bragg peak, indicated in green and represented in Fig.1.b ("Bragg") shows oscillations related to the period of the faceted structure. The *K*=1.8 value is related to the "X 10" period of the surface reconstruction induced by Ag on the Ag-covered facet, and the map (*H, L*) is thus sensitive only to the Ag-covered facets; once more, the "*H*-scan" indicated by the blue row can be used to observe the evolution of these facets and is reported in Fig.1.b ("Ag").

The three types of "*H*-scans" constitute a fast way to obtain information about the "morphological state" of the surface: the facets and the period. We performed the series of scans for different annealings, from room temperature to 265°C and along the cooling down of the sample. The data, reported in Fig.1.b, show that, for the different annealings, no major evolution of the surface morphology is observed. Nevertheless, the signals due to the facets disappear at 265°C, and, when the sample is cooled at room temperature, the facets appear again at the same positions, with the same periodicity.

Analogous measurements, carried out for several coverages, give the same results. This is a very important point, because it clearly indicates that the faceting mechanism does not depend on the annealing procedure and that, for a given Ag coverage, there is a unique morphology of the system (a unique type of facets and a unique period).

The high resolution of ID03 allowed us to collect detailed reciprocal space maps around the (0 2 0) Cu Bragg peak, a sort of "zoom" of the map in Fig.1.a. The map reported in Fig.2.a was collected after the deposit of 0.54 Ag ML, followed by an annealing at 500 K. The intensity is modulated by the 'facet enveloppe', corresponding to the facet rods previously described. Near the Bragg peak the map shows the signature of the faceting period: the interference due to the periodic structure is very clear; moreover, we can even observe the second order of this interference, meaning that the system well organized.

This measurement give us the opportunity of a fine study of the system order, which is now in progress, with the collaboration of F. Leroy (CRMCN – CNRS – Marseille), who developed a program for the simulation of diffused scattering, by using a paracrystal model [4], which is well adapted for the actual study. In Fig. 2.b the simulation of the reciprocal space map is represented. The results of this analysis support the conclusions reported in Ref.3 and adds more information about the order of the surface. In this case, the relevant parameters obtained from the map are: the facets orientation, the facets widths, their roughness and the period. The information is thus very rich and we hope that the complete analysis of the data, collected for several Ag coverages, will allow a deeper comprehension on the system order.

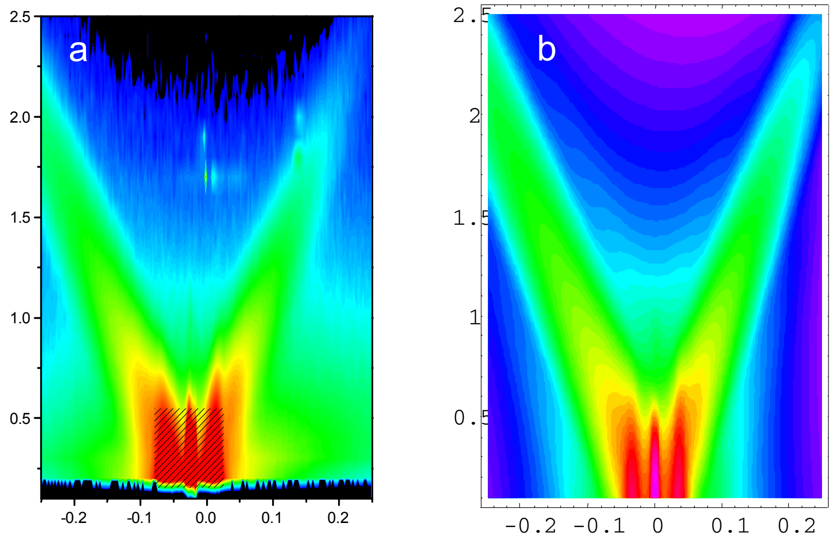

Fig.2. Reciprocal space map (H, L) near a Cu Bragg peak. a. Measured intensity. b. Simulation (coll. F. Leroy).

The experiments performed during the allocated shifts will allow us a deeper comprehension of the self-organisation of our system. The high resolution of ID03 has permitted to obtain new and original results on the system, in partucular to study its thermal stability and its desorder.

References

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