ESRF	**Experiment title:** **Self-organization of a metal surface investigated by coherent X-rays**	**Experiment number**: **SI 1081**
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Shifts:	**Local contact(s)**: Dr. Federico Zontone	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Prof. Corrado BORAGNO * , INFM-UdR Genova and Dip. di Fisica, Genova, Italy

Dr. Francesco BUATIER * , INFM-UdR Genova and Dip. di Fisica, Genova, Italy

Dr. Roberto FELICI * , INFM-OGG , c/o ESRF, Grenoble, France

Prof. Ugo VALBUSA * , INFM-UdR Genova and Dip. di Fisica, Genova, Italy

Report:

In this report, we describe the results obtained in the last SI1081 experiment, done at the ID10A beam line.
The goal of this experiment was the study of the growth and of the time evolution of a nanopattern in real time with coherent X-ray scattering. The nanopattern is formed by ion bombarding a metal surface (in the present case, a single crystal of Rh(110)) with energetic ions; depending on the experimental parameters, like temperature, ion energy, ion flux and dose, angle of incidence of the ions, different kinds of nanopatterns can be formed. In particular, a rippled surface can be formed, with a roughness of several Angstrom and a spatial periodicity in the range 10 - 100 nm.
In past experiments done at ID3 (see report SI489 , SI594, SI717 and SI784, and [1],[2],[3],[4]) we demonstrated that X-ray scattering is a powerful real-time technique to study the time evolution of the surface. With the experiments at ID10A, we tried to look if coherent radiation can help to understand in greater details this effect, in particular if it is possible to identify a coherent motion of surface defects created by the ion bombardment. In fact, in a similar experiment on Si, Habenicht et al. [5] observed by a SEM a ripple motion during ion bombardment. On metals, such effect has never been seen, but we have evidence (from previous experiments with STM and SPA-LEED) that a relevant coarsening happens. By using coherent X-ray it should be possible determine the time constant of the nanostructuring process, then enlightening the role ofthe surface defects (adatoms, vacancies).
In the first run, we tested a vacuum chamber, specifically designed for the experiment, and collected the first images by a CCD camera. We were able to follow in real time the nanostructuring process, but analysing the data we recognized that a too long acquisition time (20 sec) had been used. However, a clearly resolved speckle pattern developed after a time,

depending on the experimental conditions. With a spatial integration of this pattern, it is possible to reconstruct the surface profile, but no evidence of any time correlation has been found. In a second experiment, we changed the ion scattering geometry, but a defective crystal and a problem with the vacuum chamber did not allow to obtain significant results.
In the last run, we finally obtained the first relevant results ,by using a shorter integration time (1 sec) and a grazing incidence geometry for the ion beam. In these conditions, which were impossible to obtain at ID3, we could follow for the first time the growth of the nanopattern when the ripples are parallel to the projection of the ion beam. This pattern is determined mainly by the erosion process, while the defect diffusion mechanisms are only important in the coalescence of ripples and in their smoothing at sufficient high temperatures.
The speckle pattern was clearly resolved also in this case (see Fig.1).
The time evolution of the nanopattern has been followed either by the CCD camera, either by a point detector. The data, currently under analysis, show in detail the growth of the ripples at different temperatures.
About the time correlation, the results are at the moment not sufficiently clear. In Fig.2 is reported the time correlation function obtained at 490 K, as inferred by the analysis of the CCD images.

The blue curve is the time correlation function calculated on an area of 20x20 pixels, considering all intensity in this area; the red curve is calculated as the average of the 400 time correlation functions corresponding to each pixels in the area.
It is not clear at the moment if these curves indicate a real fluctuation of the surface-vacuum interface or only the growth in time of the nanopattern. A more detailed analysis and further experiments are needed to resolve the problem.

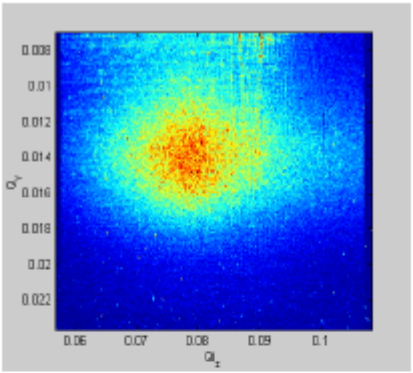

Fig.1 Speckle pattern obtained on a rippled surface – Rh(110)

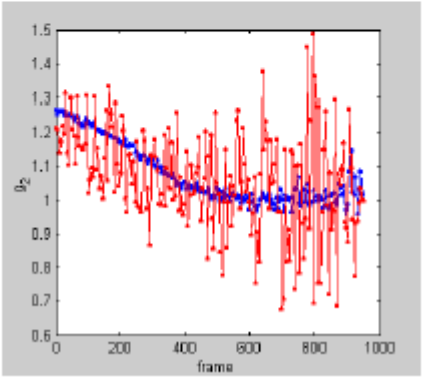

Fig. 2 Time correlation function obtained from CCD images

[1] In-situ X-ray Scattering Study of Ag(110) nanostructured by ion erosion, C.Boragno, F.Buatier de Mongeot, G.Costantini, U.Valbusa, R.Felici, D.Smilgies, S.Ferrer, Phys.Rev.B 65 (2002) 153406

[2] Ion etching of Ag(1 1 0) studied by X-ray and STM, C..Boragno,F. Buatier de Mongeot, G.Costantini,U.Valbusa, R.Felici, D.-M.Smilgies, S.Ferrer, Nuclear Instr Meth B **193** (2002) 590

[3] Time evolution of the local slope during Cu(110) ion sputtering, C.Boragno, F.Buatier, G.Costantini, A.Molle, D.de Sanctis, U.Valbusa, F..Borgatti, R.Felici and S.Ferrer, Phys Rev B **68** , 094102 (2003)

[4] Morphology of ion eroded Rh(110) surface as deduced by GISAXS data, C.Boragno, F.Granone, A.Molle, F.Buatier, U.Valbusa, R.Felici, in preparation

[5] Ripple propagation and velocity dispersion on ion-beam-eroded silicon surfaces, S. Habenicht, K. P. Lieb, J. Koch and A. D. Wieck, Phys Rev. B **65** (2002) 115327