ESRF	**Experiment title:** Investigation of the plastification mecanism in copper sub-micron islands with coherent x-ray scattering	**Experiment number**: Si-2196
Beamline: ID01	**Date of experiment**: from: 20th July 2011 to: 26th July 2011	**Date of report**: 12th January 2012
Shifts: 18	**Local contact(s)**: Vincent JACQUES	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Guillaume Beutier* SIMaP
Marc de Boissieu* SIMaP
Bruno Gilles* SIMaP
Frederic Livet* SIMaP
Marc Verdier* SIMaP
Stéphane Labat* IM2NP
Marie-Ingrid Richard* IM2NP
Olivier Thomas* IM2NP
Thomas Cornelius* ESRF

Report:

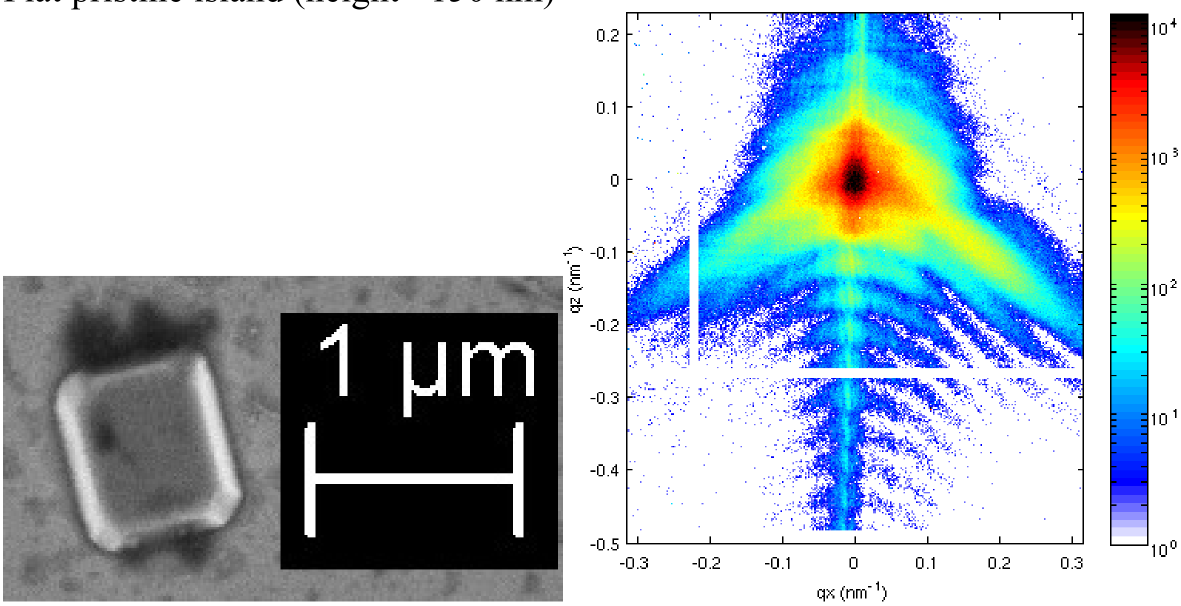
The purpose of this experiment was to investigate the plasticity mechanism in Cu islands with coherent x-ray diffraction. We proposed to prepare samples *ex situ* by applying a controlled load on as deposited islands.

The islands were grown by solid-state dewetting of a copper thin film on a tantalum (001) substrate. This process leads to the formation of faceted islands of typical size ~1x1x0.4 µm, well oriented with respect to the substrate crystallographic axes. Controlled loading / deformation was applied to selected islands.

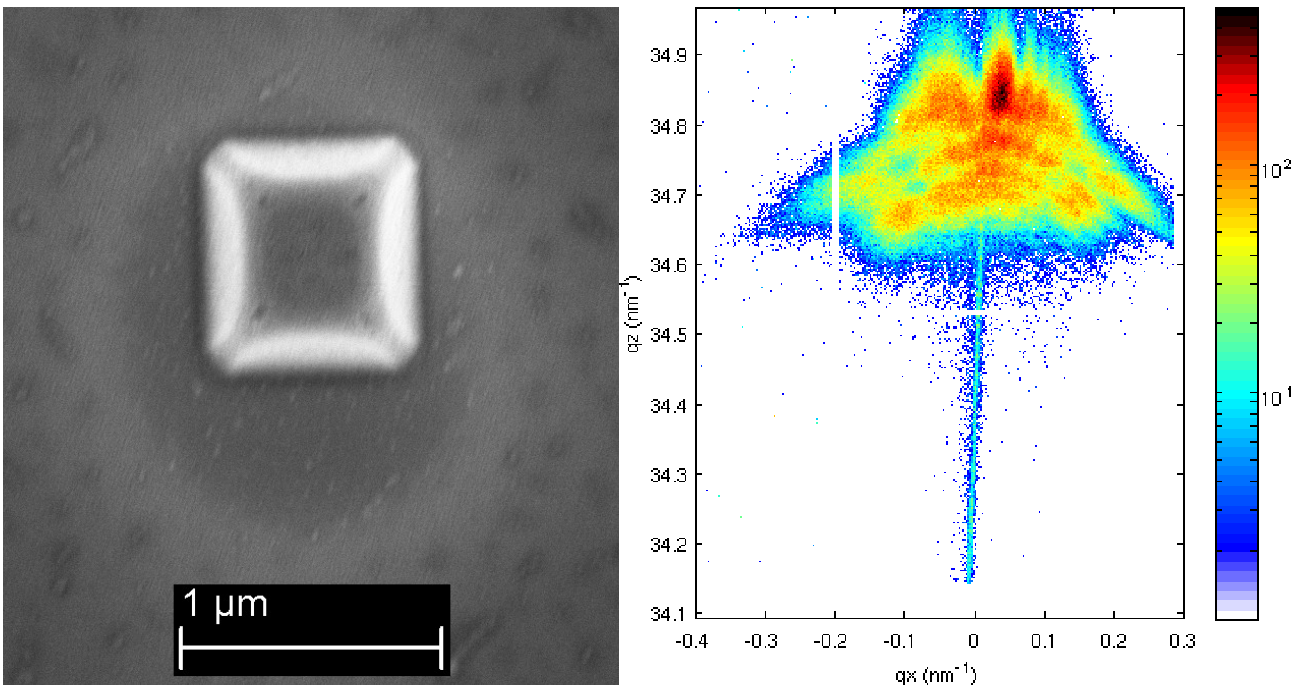
The coherent diffraction patterns of individual islands were measured at beamline ID01 of the ESRF. The beam was focused to ~0.5x0.5 µm² with Fresnel Zone Plates and the

coherence was achieved by slitting down the beam to its transverse coherence lengths (20x60 µm²) in front of the Fresnel Zone Plate. The 3D diffraction pattens were recorded with a 2x2-module Maxipix, either by rocking the sample around the Bragg reflection or by scanning the energy of the incident beam. The optical microscope installed on the diffractometer was used to pre-align the selected islands with the beam, the fine alignment being achieved by mapping the sample in diffraction geometry: there was no need for the AFM to find the samples.
The experiment worked rather well, and we present below a couple of islands that have been investigated. For each of them, we show a SEM image and a slice through the 3D diffraction pattern. The load-displacement curve of indented islands is also shown.

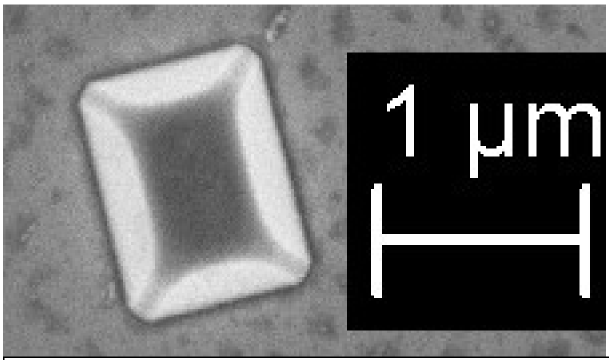
1. Flat pristine island (height ~150 nm)

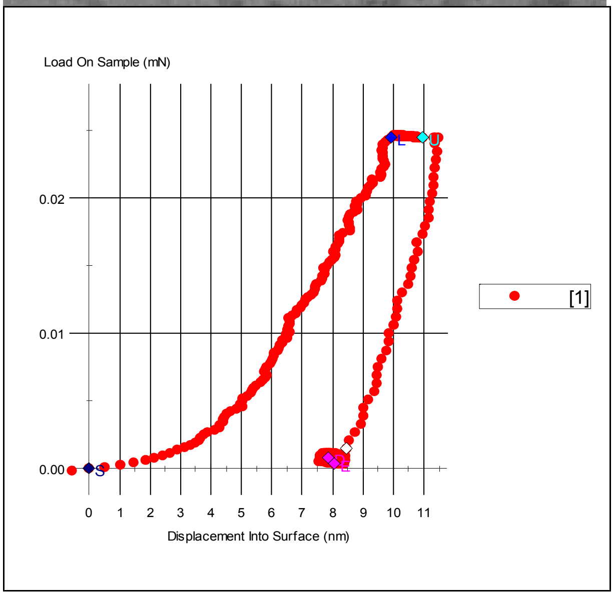


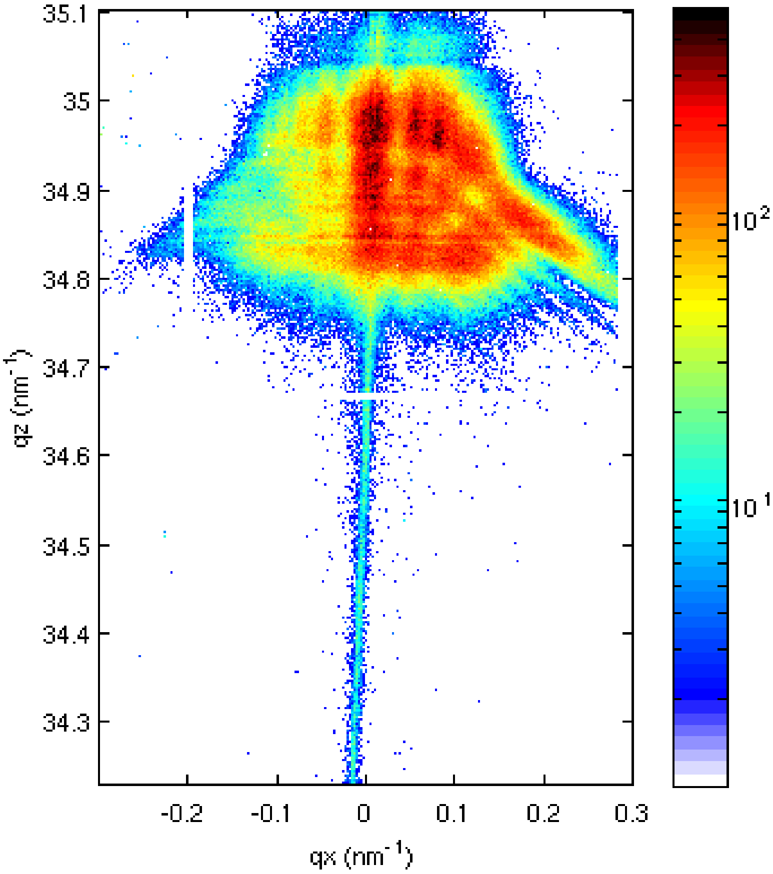
2. Regular pristine island (height ~300 nm)



3. Lightly indented island (~8 nm plastic deformation)

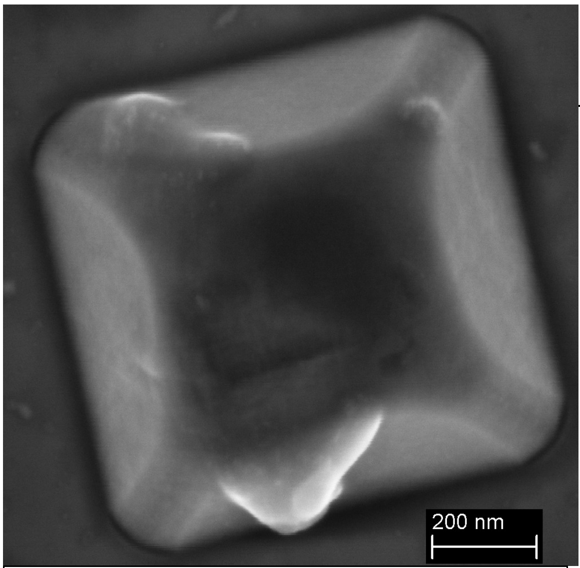


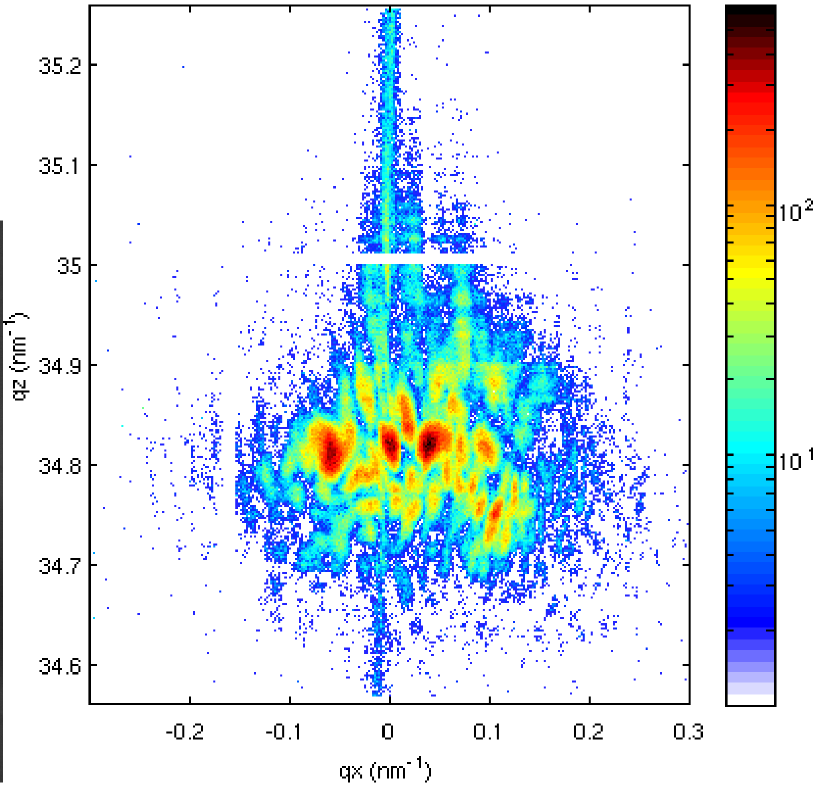


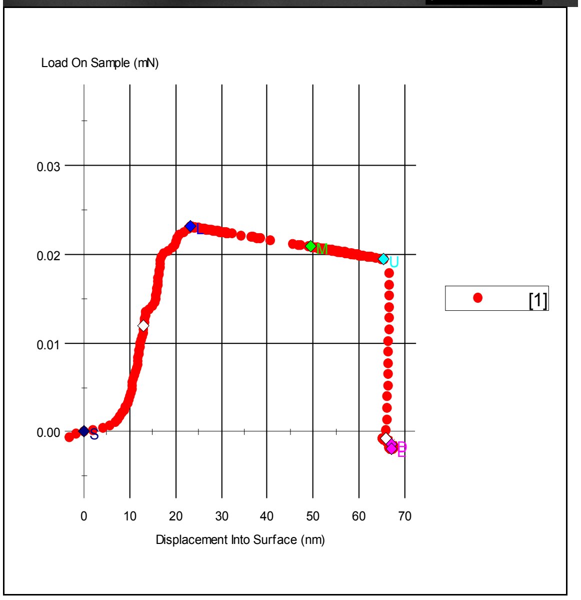


The diffraction pattern from this island does not differ a lot from the diffraction pattern from a regular pristine island, despite having undergone 8 nm of plastic deformation. It sets a lower boundary in the sensitivity of coherent x-ray diffraction in the sensitivity to crystal defects.

4. Deeply indented (~40 nm) island







Here the crystal is so deeply indented that the imprint of the indenter is visible in the SEM image. The diffraction pattern is strongly affected, showing a lot of additional structures. Work is in progress to understand the nature of the defects that are responsible for these structures.

Altogether, this experiment was very satisfactory because we could record a variety of diffraction patterns on well identified islands, which should lead to a better understanding of the influence of the size, the shape, the deformation, and the defects.
However, it was not possible to record a diffraction pattern with the necessary quality to perform an algorithmic inversion and recover the image of the object and its strain field, even in the defect-free islands: the instability of the beam with respect to the sample is to blame, as was already noted during previous experiments.