EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** **Structure of Quantum Rings formed by Local Droplet Etching**	**Experiment number**: HC-1441
Beamline: ID03	**Date of experiment**: from: 18 Feb 2015 to: 24 Feb 2015	**Date of report**:
Shifts: 18	**Local contact(s)**: **Francesco Carla (email: carla@esrf.fr)** **Jakub Drnec (email: jakub.drnec@esrf.fr)**	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Christian Heyn, Taras Slobodskyy*, Insitute of Applied Physics, University of Hamburg

Report:

We intend to study the atomic structure of quantum rings formed by local droplet etching. Metal nanodroplets are used to locally etch holes in GaAs substrates. During this process, quantum rings (QRs) are formed on the rim of these holes. Such QRs have potential application as single photon sources in quantum computing. The atomic and electronic structures are directly related to the photonic properties, which in turn can be controlled by the QRs' size, composition and strain. The goal is to fabricate designer quantum structures, for which it is mandatory to understand and control the growth process. These aspects lead to our motivation of understanding the structure, composition and strain state of the quantum rings and more general etching in nanoconfinement. **We propose to study already grown rings and perform in-situ observation of the etching process by surface x-ray diffraction. This study will give first insights about the structure, faceting and growth of the nanoholes and QRs thereby unravelling the atomic mechanism of LDE.**

Several samples were brought to the beamline. Some of these were decorated with Pt markers, in order to find back the holes as mapped out with our SEM at the Desy Nanolaboratory. Unfortunately, there was quite some overlap of the fluorescence of the Ga with that of Pt, which made it much more difficult to find the markers. In addition, the software control of the hexapod, which is mounted on the diffractometer, was not yet bug free so it turned out to be impossible to reproducibly find back the positions within the needed submicron resolution. In any case the proof of principle that SEM in combination with fluorescence markers work, has been established. The final alignment step, which should be done with sub-micrometer precision needs still to be established.

Unfortunately, due to man-power issues, it was not possible to construct the vacuum transfer suit case in time. Therefore, the in-situ heating experiments could not be performed. Nevertheless, about 10 samples have been thoroughly structurally characterized. The sample were mounted in a small cell, which allowed to flush the a small volume around the sample with nitrogen, while holding it through under-pressure on a holy support. A Mylar foil was used as x-ray window. We found out (unwantedly) that radiation damage is certainly an issue. Flushing with nitrogen was necessary.

Figure 1 shows reciprocal space maps around the GaAs 111 Bragg reflection of an In-etched sample. The relatively large beam (30x100 μm^2) illuminated many holes. These maps therefore represent the ensemble average. Interestingly, the inhomogeneous intensity distribution around the central crystal truncation rod indicates facetting signal, which would mean that not only every hole has the same orientation of the inner facets, but also that only a few preferred facets occur. Another interesting observation is that the two directions show different facets: the holes are anisotropic with respect to the [110] and [1-10] directions, not only in shape but apparently also in type of facets that have formed.

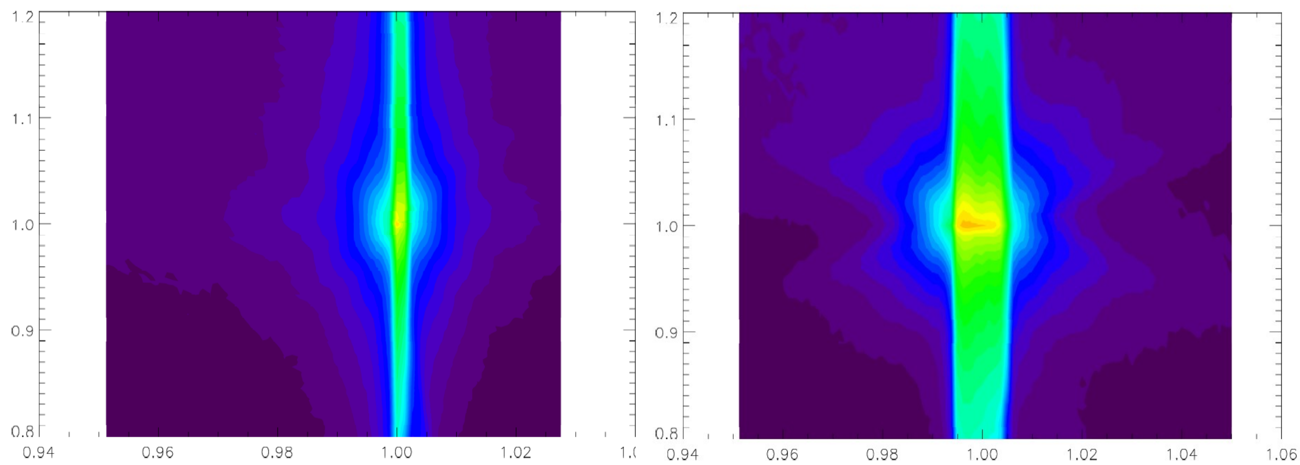

Fig. 1 Reciprocal space maps in the HHL and H-HL planes around the 111 Bragg reflection of an In-etched GaAs sample. The inhomogeneous intensity distribution around the central crystal tyruncation rod (centred at H=K=1 and running along L) is originating from facetting inside the holes.

The data of the other sample are presently being worked out. First glance over the data indicates that not only facetting signal could be observed, but also Bragg scattering due to the strained quantum rings forming at the rim of the holes.

In conlcusion, we have had a very succesful beamtime with respect to the structural characterization of these LDE samples. In order to take these kind of experiments one step further, we would need to be able to rely on the hexapod properly working, choosing another material than Pt as fluorescence markers and establsihing an in-vacuum sample transfer in order to perform temperature-dependent measurements.