Experiment Report Form

ESRF

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: Stress micro-mapping of mesas etched HgCdTe photodiodes**	**Experiment number**: 32-02-775
Beamline: BM32	**Date of experiment**: from: 13 May 2015 to: 19 May 2015	**Date of report**: 09/09/16
Shifts: 18	**Local contact(s)**: Jean-Sébastien Micha	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

Technical aspects:
The experiment was clearly successful with enough available beamtime, an intense Ø300nm white-beam X-ray beam with excellent stability. Therefore, with our dedicated horizontal sample support, we achieved a 500nm height resolution inside the sample, a mandatory requirement here. Using a rigid Ge wafer as an intermediate support, we avoid any possible source of external strain on our samples. Finally, combined to a local strain-free reference, image averaging and a CCD camera as far as possible, we achieved an unprecedented strain resolution of $5.\ 10^{-5}$.

Scientific aspects:
We were able to reach the main objective of this proposal which was to determine the stress induced by the etching and passivation processes on a smaller scale than the trenches height and spacing to assess the stress field magnitudes and their possible interaction with neighbouring pixels. Therefore, the data collected during this experiment is the basis for a congress oral presentation during the II-VI workshop, 17-20 October in Baltimore and its subsequent publication in the reference journal for HgCdTe studies: Journal of Electronic Materials.

The study of the diffraction peaks displacement, perpendicular to the trench, reveals the same pattern for all samples: the edges of the trenches are tilted. Indeed, average diffraction peak position indicates an orientation tilt of the lattice in the few microns around the etching (see figure 1 and 2). This tilt is at its maximum at the top edge of the trench, and an inversion seems to occur at the bottom edge. Furthermore, this observation seems to very much depend on process parameters. The passivation itself leads to various values of tilt (see figure 1.a and 1.c). The sample of figure 1.a represents the process resulting in a hard passivation, and the soft one is shown on figure 1.c. The deformation pattern is similar but the value of the tilt is stronger in the first case. As expected, it is found that the annealing tends to reduce the overall strain in the layer (compare figures 1.a and 1.b, as well as 1.c and 1.d). The opposite behaviour of the positive displacement at the bottom edge in figure 1.d is not understood yet. And even after annealing, we still observe a difference between the hard and soft passivation. In either case, the maximum tilt remains below 170 arcsecs. Comparing this to the 50 arcsecs full width at half maximum of the diffraction peaks, the order of magnitude is the same. Then the orientation tilt does not result in any plastic deformation.

On the other hand, the sample presented in figure 2 has a distinct behaviour. Although we found the same overall shape of the displacement, the values do not match. Using the same scale as before, we may appreciate the evolution far from the top edges. We found a maximum displacement around 1000 arcsecs, which is incoherent with the value of the previous samples. Here, we assume a plastic deformation occurred in the saturated region. If we take a look at the shape of the diffraction peaks in this area (see figure 2.b), we observe the peak breaking-up, which is a clear evidence of a plastic deformation, while the same peak has a normal shape away from the edge (see figure 2.c). Moreover, this huge deformation is propagating down to several microns, even into the substrate.

Thus, the study on the peaks displacements highlights the lattice orientation tilt after etching, passivation and annealing. In order to link this tilt to the strain within the layer, we have to take into account the relative peak movement one from another, not an average displacement. Due to the very low values of strain expected (between 3 and 5.10^{-4}) [P. Ballet et al., *J. Electron. Mater.* 42, 3133 (2013)], the position measurement of the peaks is critical for the strain mapping. In addition, while the analysis of the displacement in the x axis (perpendicular to the trench) is easily done, in the y axis (along the trench) some phenomenon must be considered that considerably complicate the analysis. In particular, modelling of the penetration length, retro-diffracted peaks contribution and tilt of the sample has been investigated. The strain mapping is still underway.

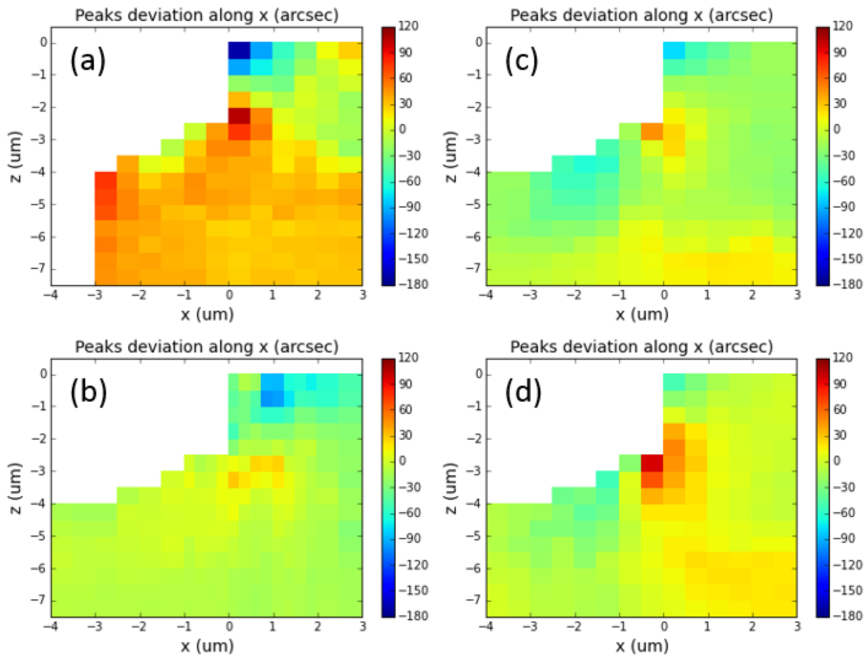

Figure 1: X-section mapping, showing the evolution of the orientation tilt of the material, given by the average lateral displacement of the diffraction peak centre. The orientation tilt which is associated to strain is clearly visible all around the etching. The samples have seen different process: hard passivation with (b) or without (a) annealing, and soft passivation with (d) or without (c) annealing.

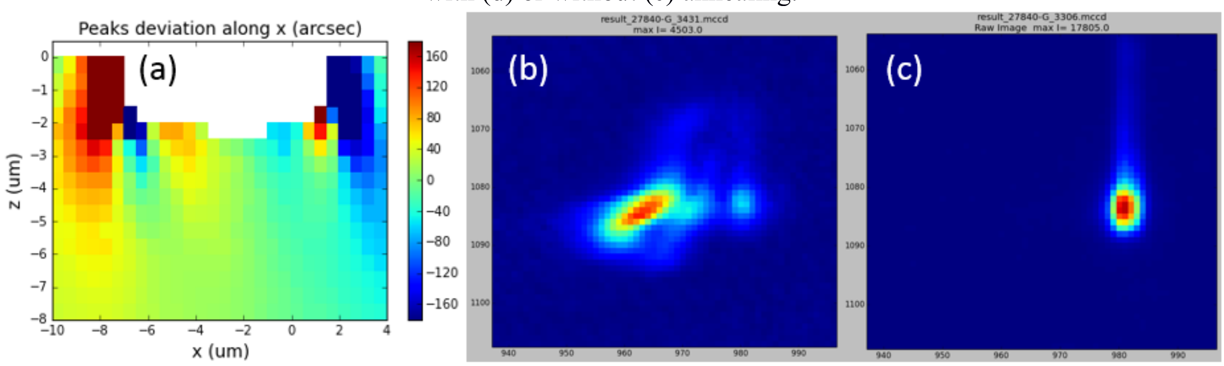

Figure 2: X-section mapping (a), showing the symmetrical effect of the trench. The saturated edges are sign of a plastic relaxation. The shape of the same diffraction peak (b) at the top edge of the trench and (c) 4µm away from the edge is a clear evidence of plastic deformation.