EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF	**Experiment title:** Origin of fracture in highly strained Ge micro-bridges investigated by 3D Bragg ptychography imaging	**Experiment number**: MA2046
Beamline: ID13	**Date of experiment**: from: 22/06/14 to: 27/06/14	**Date of report**: 1/03/20
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Report:

The MA2046 experiment aimed at understanding the mechanisms by which highly strained Ge micro-bridges breaks. Strained Ge layers with strain maxima up to 3% are promising candidates to realize a laser for integration into advanced Si microelectronics [1]. Suspended Ge microstructures exhibit indeed the required strain level but are highly susceptible to failure due to the presence of strain gradients. We proposed to resolve the three-dimensional strain distribution into a Ge micro-bridge, using 3D ptychography imaging in Bragg diffraction at the ID13 beamline.

To this aim, a large serie of samples were prepared using 200 nm Ge GOI wafers, of various sizes and strain level. Prior to the experiment Raman characterization was performed to provide a first evaluation of the strain level.

The whole experiment was focused on the investigation of a single Ge bridge (chip3_ps4_H20), with dimension 6 x 0.6 μm^2 (Figure 1). We worked at an energy of 14.9 keV, focusing the beam with a set of Si refracive lenses. The experiment started with a careful evaluation of the coherent direct beam using two different appraoches (Quiney and forward ptychography).

The difficulty for this experiment was to find a Bragg reflection close enough to the horizontal plane so that we can measure its coherent diffraction pattern with the far-field maxipix mounted on a trail. This was successfully achieved for the 117 Bragg reflection and a high quality full Bragg ptychgraphy scan could be measured, at a single fixed angle along the rocking curve (Figure 2).

The inversion of this Bragg ptychography data set was performed using our new Back Projection Bragg ptychography inversion code. Note that the Bragg angle of the 117 reflection (2θ around 63°) is very favorable for this approach, which requires that the intersection between the incoming and exit beam is as small as possible (ideally 2θ close to 90°)). The result of the reconstruction is shown in Figure 3. Some pending questions remain due to the non-symmetry of the geometry and the complexity of the retrieved displacement field, as expected for the 117 reflection. We expect to answer these questions in the near future.

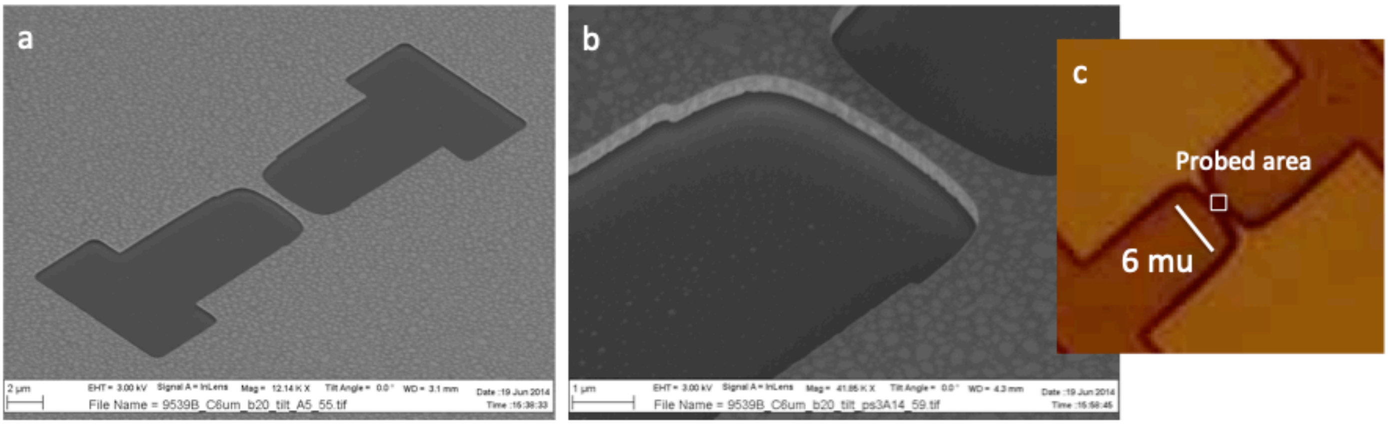

Figure 1: Highly-strained Ge bridge description. (a, b) as seen with scanning electron microscopy. (c) as seen with the on line microscope of ID13. The area probed during the Bragg ptycho scan is indicated

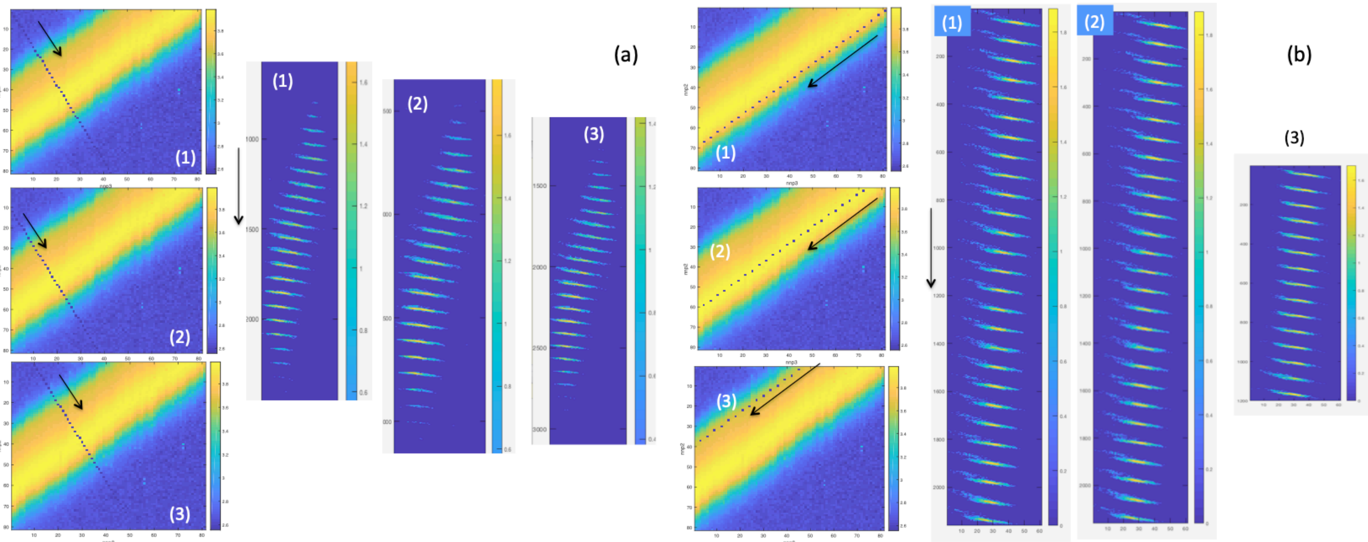

Figure 2: Bragg ptychography scans: data quality analysis. (a) The left column shows the integrated intensity distribution at the 117 Bragg reflection. On the right, a series of diffraction patterns are extracted for three different cross-sections across the bridge. (b) Same as (a) for sections along the bridge.

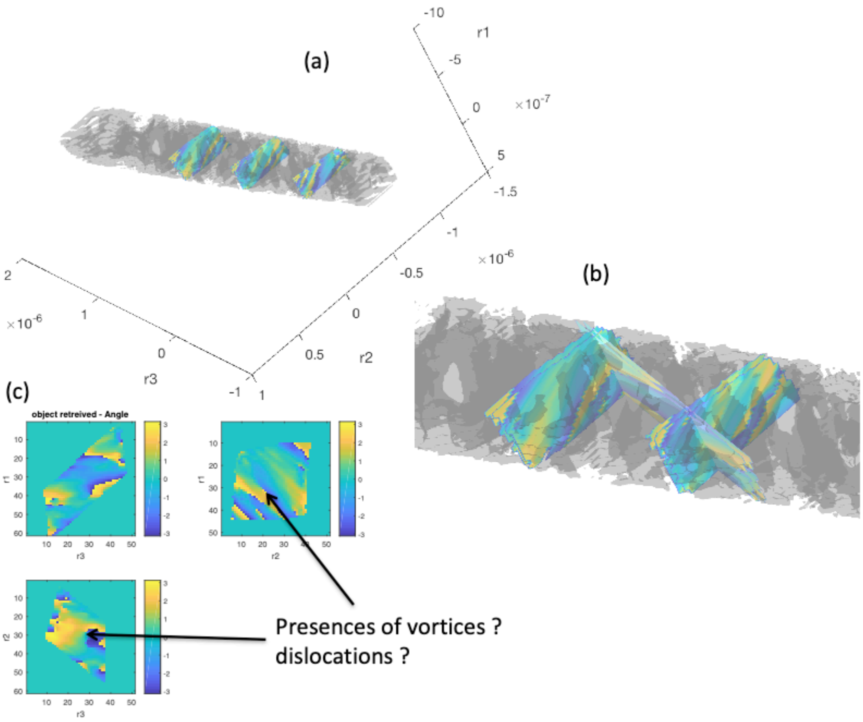

Figure 3: 3D back projection Bragg ptychography reconstruction (a, b) 3D rendering of the smaple density (grey) together with some internal plan view of the phase. (c) 2D plots of the phase showing complex behaviour and some unexpected vortices.