Experiment MA-3103: Investigation of lattice strain and tilts distributions in optical GeOI using Laue microdiffraction

The purpose of this experiment was to investigate on different length scales the strain distribution in state-of-the-art Germanium-On-Insulator (GeOI) wafers.
The 200-mm GeOI of this study are micron-thick (on the same order as the IR wavelength, hence "optical GeOI") and have been developped as susbtrates for the realisation of a Ge laser. The idea is to take advantage of the strain-dependence of the direct and indirect bandgap in Ge to enhance the light emission by strain engineering. The as-grown GeOI have a small built-in strain (0.15-0.20% biaxial) that is then concentrated locally (up to 5% uniaxial) using advanced lithography to realize suspended microdevices (micro-bridges, micro-crosses).
The key issue adressed in this experiment is the determination of the distribution of the initial small biaxial strain (amplitude, typical length scales of variation) in the as-grown GeOI. The understanding of the initial strain distribution in the GeOI is of paramount importance, as any small variation will be strongly enhanced by the geometrical strain concentration during the device processing.

During the experiment, we used Laue micro-diffraction to perform strain and orientation mappings over different length scales, in small samples (1x1 cm^2) coming from different regions of the original GeOI wafer. Another piece of pure Ge was used as "zero-strain" reference. In order to be sensitive to very small varations around a small biaxial strain, we also used specially-made GeOI wafers, were the Ge layer is twisted with respect to the underlying Si handle wafer. The foreseen advantage of this approach is that the peaks from the Ge layer would be well separated from the much stronger peaks from the thicker Si substrate on the detector (Figure 1).

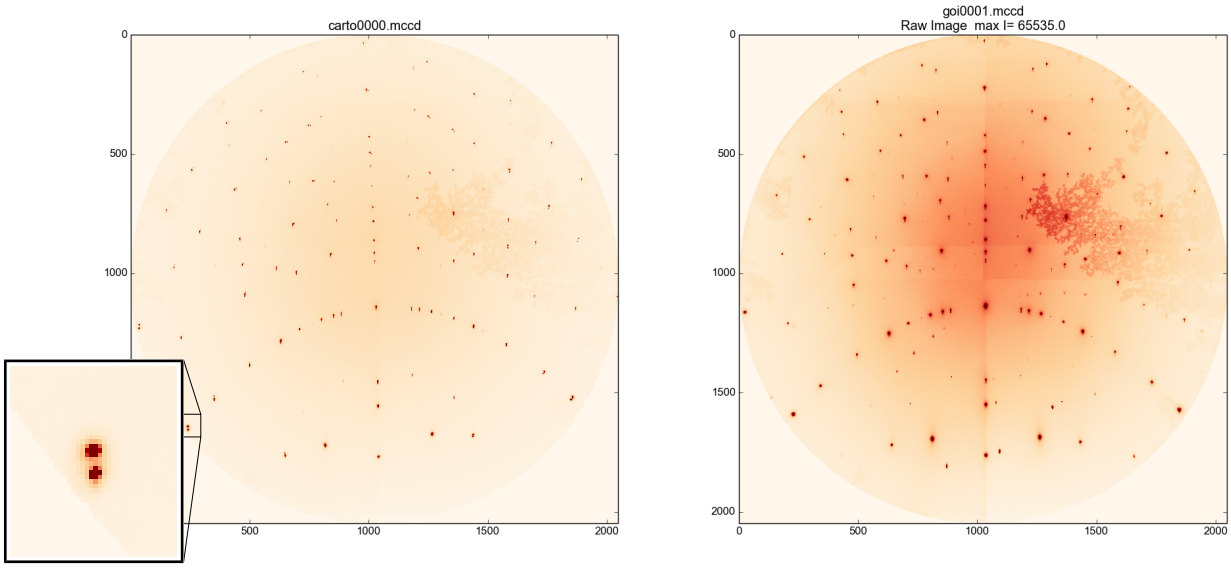

Figure 1. (left) Unrotated GeOI, the twist between the Laue patterns of the Ge and the Si is barely noticeable (see inset) and (right) intentionally rotated GeOI, the angle between the Ge (green) and the Si (blue) patterns around the <00L> axis (normal to the surface) is about 20°.

The data analysis is still underway, but a quick view of the acquired information can be displayed using the mosaic module of the LaueTools analysis software : a single peak is selected and the 30x30 pixels box is plotted as the sample is raster-scanned (Figure 2). The film quality in the rotated samples seemed lower than in the usual GeOI, with larger peak movements over the same length scales.

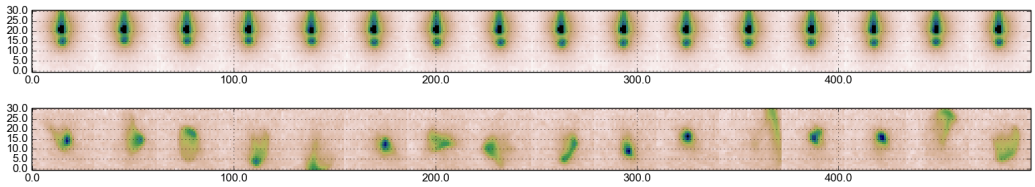

Figure 2. Same Bragg peak over 16 locations on a line in (top) an unrotated GeOI (thus showing also the corresponding, elongated Si Bragg peak) and (bottom) an intentionally rotated GeOI.