In-situ Compression of InSb Micro-pillars under Coherent X-Ray Diffraction

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During the last two decades, it has been shown that micro- and nano-objects exhibit different mechanical behavior compared to bulk counterparts, so-called “size effects” associated to increased elastic limit and/or different deformation mechanisms. For semiconductors, the size reduction is accompanied by a drastic change in mechanical response: while bulk semiconductors are brittle at room pressure and room temperature, they become ductile when in the form of micro-objects. The understanding of this transition is crucial for the micro-electronics industry, in continuous search for device miniaturization.

In this project (CharAdiff ANR-16-CE93-0006), we use coherent X-ray diffraction (CXRD) to detect and characterize the very first plastic events of a set of indium antimonide (InSb) micro-pillars, with height in the range 6-10.5 µm and aspect ratio of 3:1. The samples were characterized during in-situ micro-compression at two beamlines, Cristal (SOLEIL) and ID01, respectively with micro- and nano-focused beams. We will present the specific methodology needed for this study, due to the presence of a vastly diffracting pedestal, the size and weight of the compression machine, the artefacts potentially caused by the mechanical test. Then, we will show how this technique complete the already established ones (like electron microscopy and post-mortem CXRD) to characterize the mechanical properties of InSb micro-pillars.

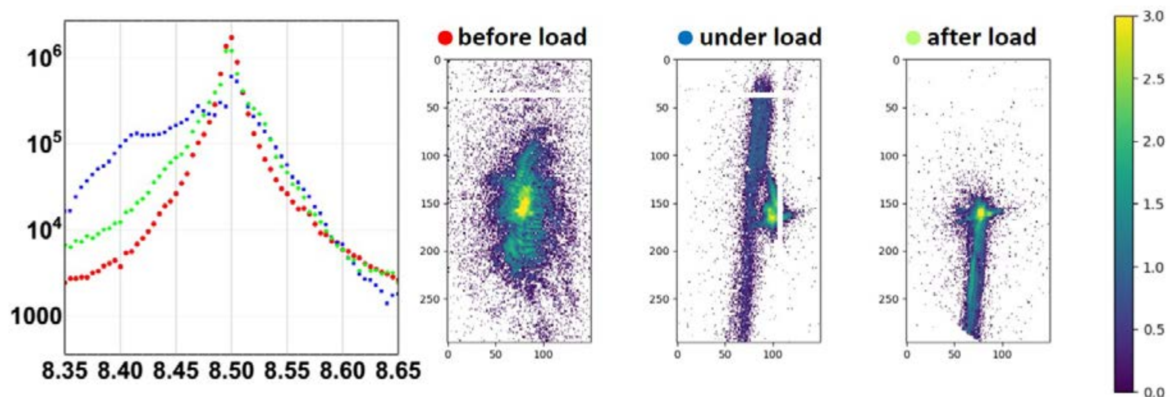

Figure 1: Left: Integrated intensity *vs* energy (in keV) of the InSb micro-pillar before (red), under (blue) and after (green) an applied stress of 550 MPa. Right: Two-dimensional diffraction patterns at 8.50 keV (log scale). Under load, the Bragg peak of the pillar dissociates from the one of the undeformed pedestal. A large elastic bending is monitored. After load, a streak evidences plastic defects in the micro-pillar.