ESRF	**Experiment title:** Temporal dynamics of InSb-I to InSb-IV phase transition	**Experiment number**: HC 2538
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Names and affiliations of applicants (All experimentalists):

Amelie Jarnac, Chien-Ming Tu, Anna Persson, Xiaocui Wang, Carl Ekström, Åsa Bengtsson – Atomic Physics Division, Lund University, Sweden

Jörgen Larsson, Andrius Jurgilaitis, Matthias Burza – Max IV Laboratory, Lund University, Sweden

Report:

In this allocated beamtime, we aimed at investigating the dynamics of a laser-induced crystalline phase transitions in InSb.

The sample consisted of a thin layer of aluminium (300 nm) deposited on a wafer of InSb (111). We first investigated the strain generated by one laser shot (400 mJ/cm^2) along the [111] direction in InSb at a delay of 300 ps. To access different values of strain, we performed partial rocking curves with and without laser (Figure 1a). We did not record the central part of the rocking curve since such a high intensity could have damaged the detector. The rocking curve without laser is shown in blue and the rocking curve with laser at 300 ps is shown in red. All angular offsets were measured at least three times and the error bars reflect the highest and lowest recorded intensity for each angular offset. Without laser, we obtain a good fit (dashed blue curve) of the experimental rocking curve when we convolute the theoritical InSb (111) rocking curve with the 150 eV spectral bandwidth of the multilayer monochormator. With laser, the peak at 6.95° indicates a compression up to 10%. A 10% compression is obtained by a pressure of 8.7 GPa in InSb. This pressure is in the range of interest to induce the transition InSb-I – InSb-III. The transient nature of the strain was confirmed by recording time-dependence of the reflectivity at an angle of 6.85° (not shown). After a nanosecond, the strain is not present in the probed volume. The timescale is consistent with 3900 m/s propagation velocity in InSb and a probe depth of 2300 nm for 15 keV x-rays. To interpret the strain measurement, we collaborate with Fabien Dorchies to perform laser-induced hydrodynamic simulations by using the ESTHER code [1]. Simulations are on going, but one can see in Figure 1b, the rocking curve obtained from the stepanov server (black curve) [2] when InSb is compressed by the strain profile shown in Figure 1c. When the strained rocking curve is convoluted by the spectral bandwidth of the monochromator (green curve), we obtain a good agreement with the experimental data. We can see that the simulated strain pulse delivers a transient compression up to 10% (9 GPa) with a pulse duration of 20 ps only.

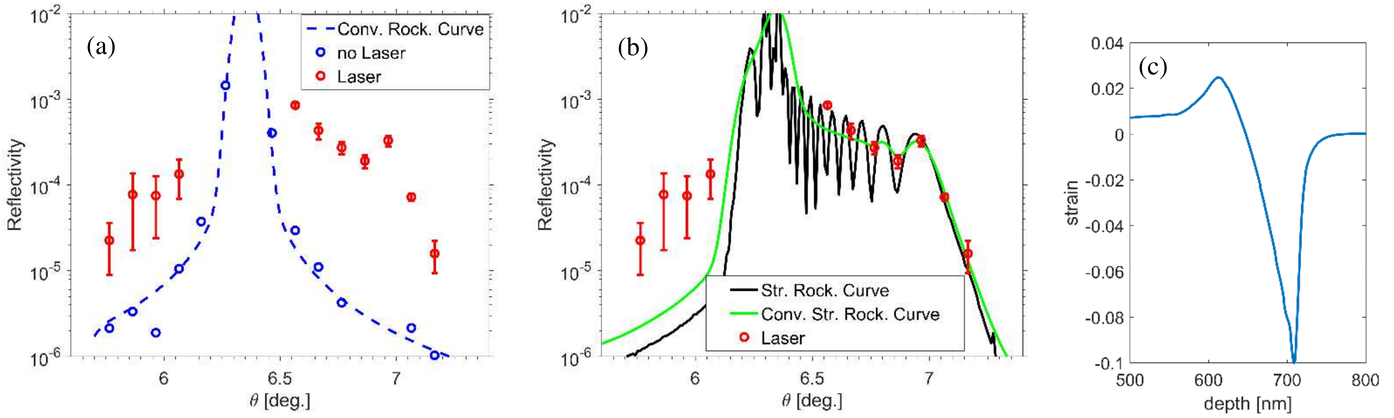

Figure 1: (a) Experimental InSb (111) rocking curves without laser (blue spots) and with laser (red spots) at 300 ps time delay. The dashed blue curve is the convoluted theoritical InSb (111) rocking curve by the 150 eV spectral bandwidth of the multilayer monochormator. The Bragg angle for the x-ray energy of 15 keV is θ_B = 6.35°. (b) Fit of the experimental rocking curve with laser. Simulated (black curve) and convoluted rocking curve (green curve) obtained for the strain profile shown in (c). (c) Transient strain profile simulated by the hydrodynamic code ESTHER [1] for an incident laser fluence of 100 mJ/cm^2.

After having characterized the generated pulse pressure, we acquired the x-ray diffraction pattern on exposed spots. For this acquisition, we set the x-ray incident angle to 1.5 degree to probe a depth of about 700 nm. The radial lineout of the laser-induced crystalline structure of InSb is shown in Figure 2. The black dashed lines denote the InSb-I reflections. The green lines denote the Al reflections. The red stars denote the InSb-III reflections. The reflections found in this work match perfectly with the InSb-III reflections reported in the literature [3, 4].

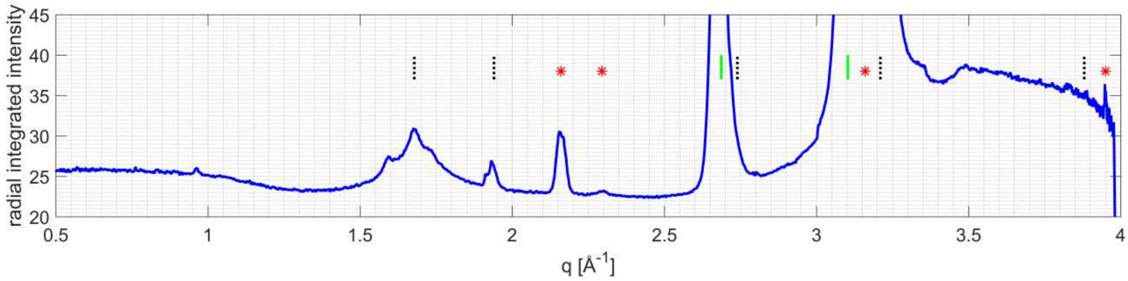

Figure 2: Radial lineout of laser-exposed area on the accessible q-range. The black dashed lines stand for InSb-I reflections. The green lines stand for Al reflections. The red stars stand for InSb-III reflections. Acquisition time: 10 seconds = 10^{11} incident photons.

The static characterisation of the crystalline structure after laser exposure shows evidence of InSb-III. Thus we attempted to perform time-resolved measurement of the phase transition InSb-I to InSb-III. Since we needed to run in single shot mode at 1 Hz repetition rate (10^8 ph/s), even with fully open slits and accumulation, we could not obtain the incident flux of 10^{11} photons that was needed to have a reasonable signal/noise ratio. As a consequence, our attempt of accessing the transition dynamics was unsuccessful.

In this experiment, we fully characterized the generation and propagation of laser-induced transient pressure pulse. The pressure pulse delivers a pressure of 8.7 GPa during 20 ps only. We demonstrated that this pressure pulse can drive ultrafast high-pressure crystalline phase transition in InSb. These results represent a step forward to investigate the atomic rearrangement during high-pressure phase transition.

<u>Publications arising thus far from this work</u>: We are preparing a publication of this work.

[1] J. P. Colombier *et al.*, Phys. Rev. B **71**, 165406 (2005)
[2] S. A. Stepanov, Proc. SPIE **5536**, 16–26 (2004)
[3] R. Nelmes *et al.*, Phys. Rev. Lett. **77**, 663 (1996)
[4] M. Mezouar *et al.*, Phys. Status Solidi **198**, 403 (1996)