ESRF	**Experiment title:** Ordering on the InSb(001) surface	**Experiment number:** SI 440
Beamline: ID3	**Date of experiment:** from: 12/4/99 to: 19/4/99	**Date of report:** 20/8/99
Shifts: 18	**Local contact(s):** Kevin Peters	*Received at ESRF:*

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Report:

The (001) surface of the III-V compound semiconductors exhibits many reconstructions characterised by large unit meshes. The appearance of a given reconstruction depends on the preparation conditions and, in particular, on the ratio of the group III and group V atoms at the surface. The structures have been the focus of much activity over the last decade, due to their complexity and the extensive use of the (001) surface for epitaxial growth of semiconductor heterostructures.

InSb has attracted increased attention due to its potential application in near infra-red detection and high speed optoelectronics [1]. We have previously identified the atomic arrangement of the two most stable reconstructions of the InSb(001) surface, namely the Sb rich c(4x4) [2] and the In rich c(8x2) [3]. The model proposed for the c(8x2) arrangement is consistent with scanning tunneling microscopy (STM) and a significant departure from other models suggested for the III-V's. It is characterised by In chains oriented along the [110] axis and separated by Sb dimers on the Sb terminated bulk. The arrangment of the In atoms in the chains closely resembles that of the bulk metal, suggesting that they form one-dimesional conducting paths.

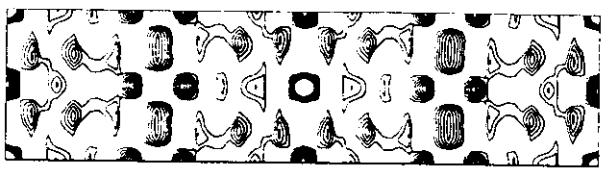
The majority of the measurements of the InSb(001) surface, like those of other III-V's have been made at room temperature. Little is known of the modifications that are expected as the temperature is varied. At low temperatures, it is likely that the In chains will become unstable and reorder. A simple dimerisation, for instance, would maintain the c(8x2) symmetry, but

alter the relative intensity of the reflections. The six days of beamtime on station ID3 in April were used to make surface X-ray diffraction (SXRD) measurements of both the room temperature and cooled c(8x2) structures, in order to establish these differences.

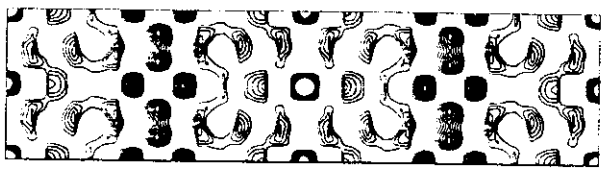
The sample was produced by first desorbing the protective Sb cap from a wafer previously prepared by molecular beam epitaxy (MBE). Cycles of gentle sputtering and annealing under an Sb flux were then used to produce the c(8x2) structure, which was optimised by monitoring the intensity of the fractional order reflections. Having allowed the sample to cool to room temperature, a large data set was recorded. This consisted of approximately 200 in-plane reflections and six crystal truncation rods (CTR's).

After completing the data set for the room temperature sample, it was cooled to 77K. Re-alignment of the sample was necessary to accommodate the movement of the holder during this cooldown procedure. A second set of data, larger than the first (~250 in-plane and 6 CTR's) was recorded, to establish the structural changes that occurred on cooling.

Comparison of the structure factors (corrected for the polarisation and lorentz terms) shows that the changes induced by lowering the temperature are small. This is illustrated by the two Patterson maps derived from the in-plane data and shown in the figure. The features are essentially the same; the slight sharpening in the cooled plot can be associated with a reduced thermal vibration. The data sets are significantly better than those obtained at the SRS, Daresbury in earlier experiments. From the low temperature data, we have derived electron density maps by the Maximum Entropy Method (MEM) using the MICE program developed at Glasgow. Our preliminary observations indicate that the earlier published model [3] is not complete and that the reconstruction extends deeper into the bulk. The analysis is continuing, in order to identify the extent of the distortion.



Room Temperature



Liquid Nitrogen Temperature

[1] C.Y. Wei *et al*, IEEE Trans. Electron. Devices 27 (1980) 170.
[2] N. Jones *et al*, Surface Science 398 (1998) 105.
[3] N. Jones *et al*, Surface Science 409 (1998) 27.