ESRF	**Experiment title:** Directly bonded silicon: an investigation of the interface atomic structure by x-ray diffraction	**Experiment number:** S1363
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Names and affiliations of applicants (*indicates experimentalists):

*R. Feidenhans'l, Department of Physics, Risø National Laboratory, DK-4000 Roskilde, Denmark
*P. B. Howes, Department of Physics, Risø National Laboratory, DK-4000 Roskilde, Denmark
*M. Nielsen. Department of Physics, Risø National Laboratory, DK-4000 Roskilde, Denmark
*F. Grey, Mikroelektronik Centret, Danish Technical University. DK-2800, Denmark.

Report:

We have studied silicon-silicon interfaces formed by the direct bonding of silicon wafers using x-ray diffraction. The experiments are a continuation of our earlier measurements on ID32 (SI323) and a number of advances have been made.

UHV-bonded samples Two clean Si(111) surfaces were bonded in ultra-high vacuum. One of the exciting possibilities of the direct wafer bonding method is that surface reconstructions may be preserved at the resulting interface. UHV bonding is still in its infancy and strongly bonded interfaces could only be achieved by annealing the sample, after which, the interface was still not uniformly bonded. We attempted to measure the Si(111)7 x 7 reconstruction, however, no superstructure peaks were measured, indicating that the reconstruction was probably destroyed by the annealing used to strengthen the interface.

Transmission geometry Bicrystal interfaces were measured using transmission geometry where the scattered beam exits the back of the sample. This is an important advance since it makes it possible to measure peaks in the h, k plane where the scattering is sensitive only to the lateral relaxations of the atoms. Another advantage of this geometry is that the x-ray path length in the sample is greatly reduced, allowing the possibility of studying full thickness wafers. This development will allow us to to study van der Waals-bonded samples that are too weak to withstand mechanical polishing.

Hexagonal interfaces We have, for the first time, seen superstructure peaks from the interface between two Si(111) wafers. The peaks appeared at positions in reciprocal space predicted by a simple theory based on the elastic modulation of one crystal by the presence of the second crystal lattice.

Strain depth We have measured a series of Si(001) bicrystal interfaces with increasing misorientation angle, w, from 2° to 9.4°. In each case, superstructure peaks were measured close to the (0,2,2) Bragg reflection, along with the associated Bragg rods. The main feature of each Bragg rod was a single peak at l = 2, the position of the nearby Bragg peak. The width (in l) of the feature enables us to estimate the depth of the strain field associated with the interface. A systematic trend was measured - the depth of the interface region was found to be inversely proporitonal to the misorientation angle? w. Moreover: the absolute value of the measured depth was approximately equal to the spacing of the dislocation grid associated with the twist boundary.

Correlation length of the interface structure The radial and azimuthal widths of one of the satellite peaks were measured with small detector slits to try to determine the correlation length of the interface structure. The peak widths were resolution limited indicating that the dislocation array is well ordered on a length scale of several thousand Å. In a future experiment. we plan to measure the profile of the satellite peaks using an analyser.

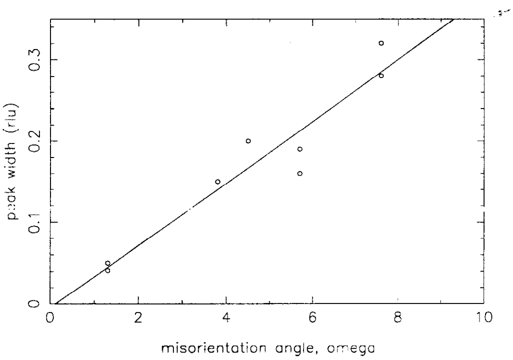

Fig. 1. Measured width of the peak on the superstructure Bragg rod for a series of misorientation angles, ω. The peak width is inversely proportional to the depth of the strained region associated with the interface.

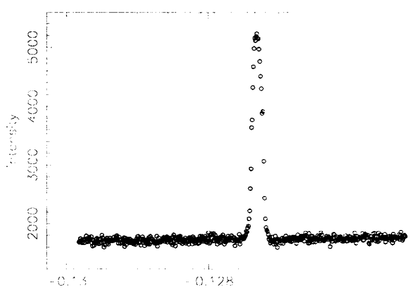

Fig. 2. One of the superstructure peaks close to the (1,1,1) Bragg peak measured with small detector slits. The width of the scan is still resolution limited and corresponds to a remarkably well-ordered interface with a correlation length several thousand Å.