ESRF	**Experiment title:** **Amplitudes OF ATOMIC MOTIONs ON Ultrasonically EXCITED CRYSTALS**	**Experiment number:** **HC-290**
Beamline: ID15A	**Date of experiment:** from: 20. Sep. 957:00 to: 25. Sep. 957:00	**Date of report:** **27.** Feb. 1996
Shifts: **15**	**Local** contact(s): K.-D. LISS	

ames and affiliations of applicants (* indicates experimentalists):

Hock, University of Würzburg, Germany *

K.-D. Liss, ESRF *

A. Magerl, Institut Laue Langevin, Grenoble, France *

A. Remhof, Institut Laue Langevin, Grenoble, France *

Report:

We have studied 10 mm thick perfect silicon single crystals which have been excited by piezoelectric transducers with a longitudinal acoustic wave field in the 111 direction. The ultrasound frequencies were in the MHz range and the corresponding wavelengths are in the mm range.

The diffraction was performed in Laue geometry on the 3-axis diffractometer at the high-energy beamline ID15A. Data were taken for the -351 and 111 reflections between 90 keV and 200 keV. Typical rocking curves in the two axes mode on the -351 reflection are presented in figure (1). The reflection curve of the unexcited sample is a Lorentzian as expected from the dynamical theory of diffraction. The maximum intensity of 50 % compared to the excited crystal and the FWHM of 0.2 " fit within 5 % to the expected values. Applying the sound wave, the maximum of the reflection curve first doubles. Additionally, a flat plateau forms for higher sound amplitudes. The sound wave can be understood as elastic strain creating a reciprocal lattice vector distribution $\Delta\vec{G}/G$ and the shape of the reflection curves can be understood using a formalism for gradient crystals. Integrated intensity gains of 50 have been achieved. The atomic amplitudes $\Delta d/d$ can be deduced directly from the rocking width which according to figure (2) is perfectly proportional to the intensity gain.

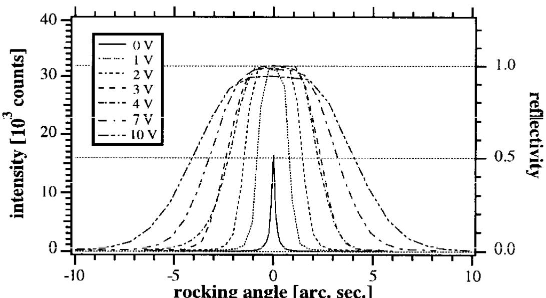

Figure 1:
Rocking curves at 90 keV of the Si -351 reflection at various ultrasonic excitation. For comparison purpose they have been shifted to a common center which is not real due to temperature variations of the uncooled sample.

A series of two dimensional intensity scans have been probed in reciprocal space. Figure (3) shows a contour plot of the intensity distribution around the -351 reflection. Clearly a one dimensional smearing is seen with both, a longitudinal and a transverse component. This inclination can be explained by the geometric angle of 73° between the ultrasonic wave vector and the scattering vector, since the reciprocal lattice vector distribution of the pure longitudinal ultrasonic wave is expected as demonstrated in figure (4).

From the technical point of view the ultrasonically excited crystal can heat to several hundred centigrade which means loss of the resonance and displacement of the Bragg peak. To prevent this effect, we studied different sample environments, one where the crystal is clamped into a cooling device and another one where the crystal is standing free in a water bath. The first has the disadvantage that the crystal had some static strain whereas the second damps the sound amplitudes by coupling roughly half its intensity into the water. Stability, however is increased in both cases. Figure **(5)** shows a frequency scan taken with the sample rotated by 1 to 2 seconds of arc as compared to the Bragg position of the perfect crystal. It reveals a series of narrow resonances which can be interpreted as standing waves in the silicon. The broad up and down is the main resonance of the whole system, where all reflection curves were measured. We think, the silicon resonances should be studied in future in favor to low heating at high excitation levels.

To resume, atomic amplitudes have been measured for various geometries. Both, amount and direction of the displacements could be-determined.

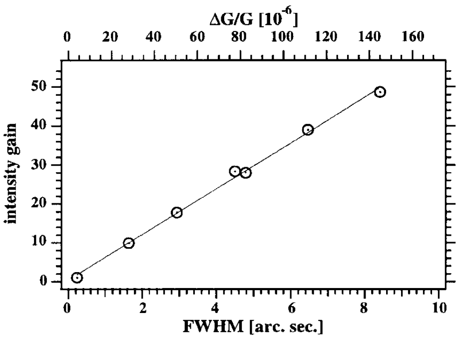

Figure 2:
The intensity gain is proportional to the FWHM and *thus proportional* to the widening of the scattering vector $\vec{G}$.

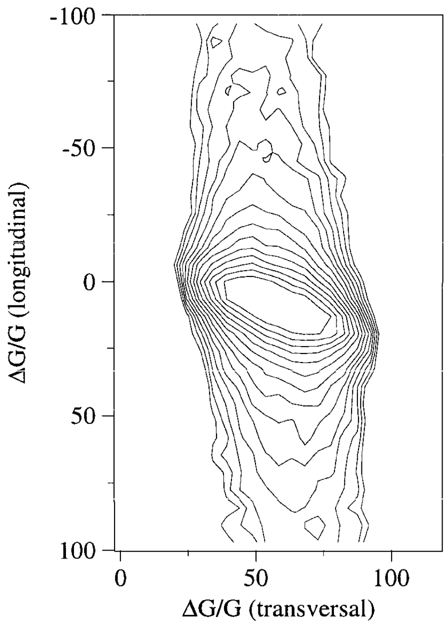

Figure 3:
Two dimensional representation of the reciprocal lattice *plane* around the *Si-351* reflection, measured at 90 keV. The broadening due to the ultrasonic wave has a transversal and a 3 times smaller longitudinal component, which reflects the inclination of the acoustic wave in the *111* direction to the scattering vector, as demonstrated in figure (4).

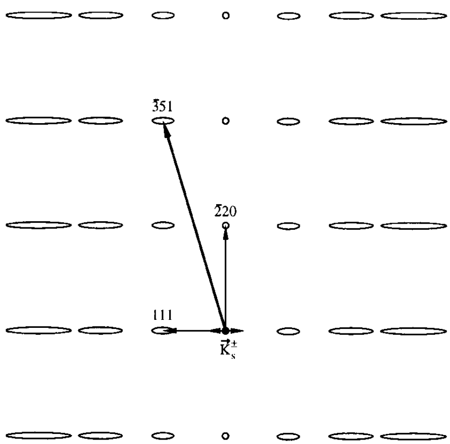

Figure 4:
Distortion of the reciprocal lattice vector by a longitudinal ultrasonic wave K_S *applied* in the *111* direction, The initial reciprocal lattice points are smeared one- dim en - *sionally* proportional to their distances to the reciprocal *111* plane.

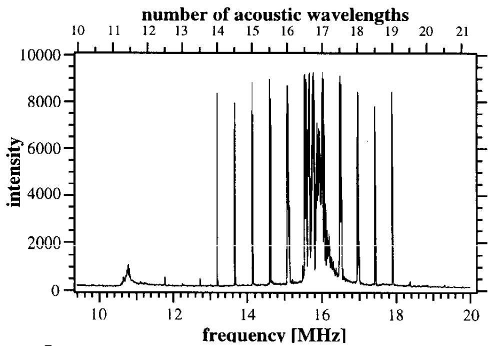

Figure 5:
A frequency scan *slighly* beside the Bragg condition of the unexcited crystal, *The* crystal is *highly* excited at resonances where a standing wave fits *into* its *macroscopic* thickness which acts on the increase of the *rocking* width and thus fulfills a scattering condition. The very sharp resonances are numbered on the top scale by the corresponding number of acoustic *wavelengths*. The broad maximum around *16* MHz is the *3rd* order main resonance of the $LiNbO_3$ transducer.