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Experiment title: Picosecond X-ray diffraction from coherent phonons in thin films, and the study of non-thermal melt.	**Experiment number:** HS-1424

Beamline: ID09	**Date of experiment:** from: 03 July 2001 to: 09 July 2001	**Date of report:** 14-08-2001
Shifts: 9	**Local contact(s):** Dr. Anton PLECH	*Received at ESRF:*

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Report:
In this experiment we investigated the observation of coherent phonons in thin layers and multilayers by use of picosecond X-ray diffraction The most interesting results were observed using InAs/GaSb multilayers. These superlattices were grown at the University of Oxford. Typical layer spacings ranged from 50 - 150 nm. Typical data is shown in Figure 1. When irradiated with the femtosecond Ti:sapphire laser, the X-ray reflectivity showed clear oscillations, which initial data analysis indicates are associated with the folded acoustic phonons within the superlattice. Clearly some part of this phonon spectrum propagates, as after a couple of hundred picoseconds there is a large change in reflectivity, which we associate with the disturbance of the underlying GaSb single crystal, as the phonons cross the interface. We believe this data to be signicant: conventional methods of observing the folded acoustic phonons on superlattices rely on optical methods – i.e changes in optical reflectivity. With such methods it is often difficult to directly extract the phonon amplitudes (this problem is related to the the problems in accurately determining the so-called sensitivity function, which relates strain to changes in optical properties). In contrast, with the X-ray technique, we can relate the changes in reflectivity far from the peak of the rocking curve to the instantaneous strain profiles within the superlattice. Furthermore, the X-ray technique allows us to follow the strain amplitudes as they propagate across the interface into the substrate crystal. It is our intention to follow up on this work with a new proposal dedicated to observing folded acoustic phonons in superlattices with shorter spacings, with higher phonon frequencies – close to the

picosecond limit set by the jitter-free streak camera. Results from such an experiment could shed considerable light on the timescales for ambipolar diffusion within such systems, and the persistence of surface modes.

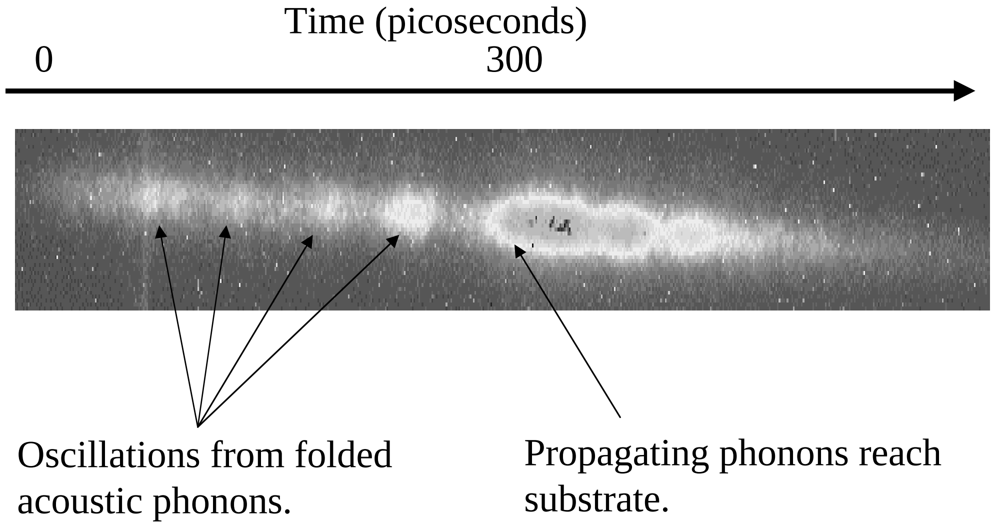

Figure 1

Streak camera image of oscillations in X-ray reflectivity from laser-irradiated superlattice. The large increase in reflectivity at 300 psec is due to the travelling phonons impacting upon the substrate.

Unfortunately within the last experimental period we did not have time to look at the phenomenon of non-thermal melt. We were only allocated half the beamtime for which we applied (the experiment ran concurrently with 1422). These picosecond-resolution experiments on ID09 are experimentally challenging, producing as they do the best temporal resolution of any synchrotron in the world, and we are convinced that cutting beamtime for particular experiments is a false economy. The work described above was only completed one month ago. After detailed analysis, we expect to publish the results in Phys. Rev. B (to which we have submitted work completed in previous allocations of beamtime – see below.)

References

1. J.S. Wark, A.M. Allen, P.C. Ansbro, P.H. Bucksbaum, Z. Chang, M. DeCamp, R.W. Falcone, P.A. Heimann, S.L. Johnson, I. Kang, H.C. Kapteyn, J. Larsson, R.W. Lee, A.M. Lindenberg, R. Merlin, T. Missalla, G. Naylor, H.A. Padmore, D.A. Reis, K. Scheidt, A. Sjoegren, P.C. Sondhauss and M. Wulff *Proc. of SPIE* **4143**, 26 (2001).
2. J. Larsson, A. Allen, P.H. Bucksbaum, R.W. Falcone, A. Lindenberg, G. Naylor,T. Missalla, D.A. Reis, K. Scheidt, A. Sjgren, P. Sondhauss, M. Wulff, and J.S. Wark, submitted to *Phys. Rev. B.*