ESRF	**Experiment title:** Coherent control of acoustic phonons in GaSb	**Experiment number:** HS-1422
Beamline: ID09	**Date of experiment:** from: 2001-07-03 to: 2001-07-10	**Date of report:** 2001-07-24
Shifts: 9	**Local contact(s):** Anton Plech	*Received at ESRF:*

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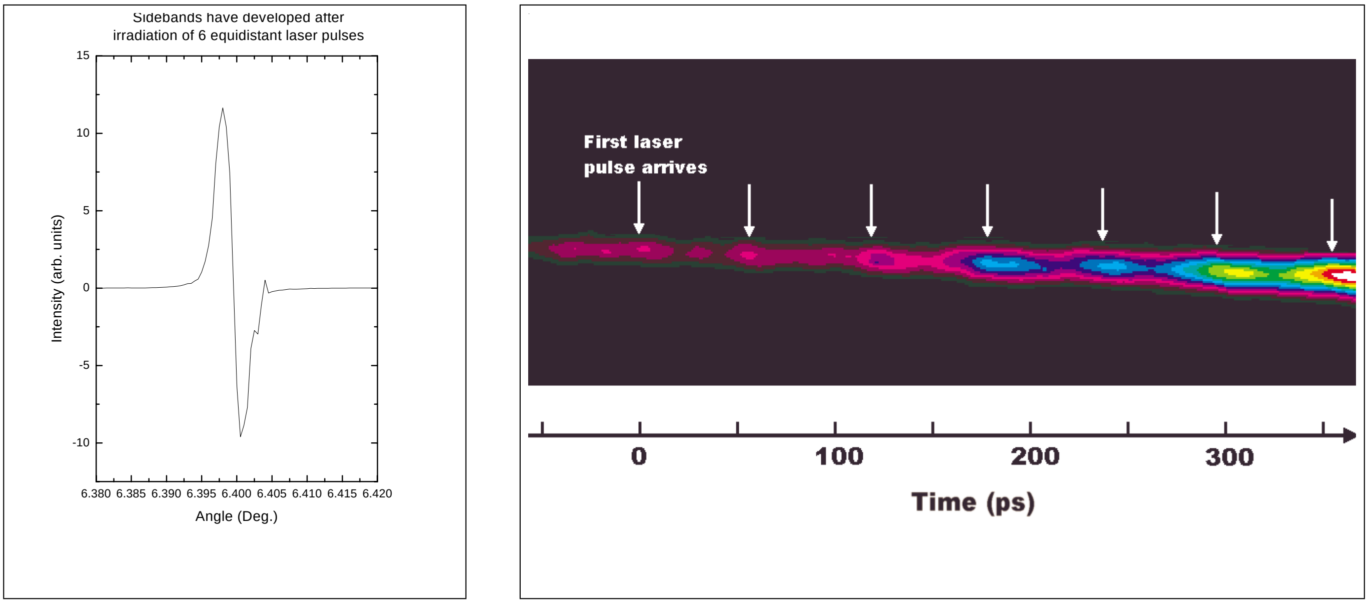
Report:

During this experiment, we have taken the first steps towards control of solid matter using visible radiation. By irradiating a semi-conductor sample with a laser, we have managed to set up a large periodically varying strain in a crystal and by using that induced sidebands in the X-ray rocking curve A differential rocking curve is shown in Figure 1a.(A subtraction of a rocking curve with laser on and a rocing curve with the laser off). During a previous experiment at ESRF (HS-1122), we have shown that we, by introducing a propagating strain wave in the crystal, can excite a broad distribution of acoustic phonons in InSb, and diagnose them using time-resolved X-ray diffraction. The large amount of high-quality data obtained have given new insights into the propagation of impulsively excited acoustic waves in semi-conductors. [1].
It has been shown that diffraction experiments provide the means to selectively study different longitudinal acoustic (LA) phonon modes that make up the strain wave[2]. We are now able to control the phonon spectrum in the crystal by sending a series of pulses onto the crystal. We used a compact set-up to generate 8 laser pulses of equal strength and variable delays. This device enabled the pulse structure to be modified so that enhancement of given phonon frequencies could be observed. Such data is shown in Figure 1b. The data were recorded on the ID9 sub-picosecond X-ray streak-camera [3],[4]. The data is still under evaluation. Data was also taken with a single pulse with the same energy as the whole pulsetrain. This led to a temperature just below the melt temperature. However, the reflectivity at the optimised rocking curve angle compared to the single pulse data was 2-3 times higher with the multiple pulses, with temperatures well below melt temperature.

The ability to generate larger strains by a pulse sequence will enable us to follow the phonon spectrum to higher frequencies, thereby opening up the possibility of making a highly efficient switch with a temporal resolution in the 10 ps time window. The allocated beamtime of 9 (applied for 18) shifts was not enough to demonstrate this. In order to make most use of the totally 18 shifts allocated for both HS-1422 and HS-1424, it was decided to use the same samples (GaSb and InAs 200) for both studies.(Due to the alignment procedure when the streak camera is used, it is estimated that it would take 4-5 shifts to change diffraction angle. It should also be noted that the initial set-up time is approximately 6 shifts when everything goes smoothly.) The coherent controll of acoustic phonons described in this report is a first step to bringing the field of coherent control (which now is a standard technology in femtochemistry) to the solid phase. A continuation of this project planned for the year 2003 involves (1) Observation of optical phonons and (2) coherent control of optical phonons. Using this technique, it is our aim to control the disordering process in semiconductors and to drive these semiconductor materials into other metastable phases.



(a) (b)

Figure 1: (a) A differential rocking curve.(A subtraction of a rocking curve with laser on and a rocking curve with the laser off) The spacing of the side-bands correspond to the angular shifts that is anticipated from a series of pulses separated by 80 ps. (b) The time-history of the strain for an angle corresponding to the left side-band in (a).

References

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