Wavelength selective photoexcitation of picosecond acoustic phonon pulses in a triple $GaAs/Al_{0.3}Ga_{0.7}As$ quantum well structure

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The ultrafast optical excitation of localized picosecond acoustic phonon pulses in quantum wells is a very promising method for high frequency THz phonon transduction[1,2]. In principle, optically tunable picosecond phonon excitation and detection in quantum wells should be possible with appropriate semiconductor band engineering. Here we demonstrate an important step in this direction by using a triple quantum well structure to show how the phonon generation region can be varied at will by tuning the optical wavelength to each well in turn.

A $GaAs/Al_{0.3}Ga_{0.7}As$ quantum well (QW) structure (Fig. 1) is prepared on a GaAs (100) substrate using MOVPE to have three buried GaAs QWs of different thickness (and hence different excitonic optical resonances). Infrared optical pump pulses of photon energy 1.46eV to 1.57 eV (chosen to cover the hh1-e1 transition), duration ~700 fs and fluence ~0.03 mJ/cm^2 are used to excite longitudinal acoustic phonon pulses in the quantum wells. The excited phonon pulses travel through the sample, and those that reach the top surface cause a change in the complex reflectivity. A blue probe beam of delayed optical pulses derived by doubling the pump frequency is used for surface detection of the reflectivity and phase changes with a Sagnac interferometer[3]. The results for the phase change as a function of delay time are shown in Fig. 2. The signal at around 100 ps corresponds to the arrival at the sample surface of the picosecond phonon pulses generated in the quantum wells. Arrows in the inset denote the expected arrival time of the phonon pulses from each well. The excitation wavelength dependence of the echo shapes conclusively demonstrates that we have achieved wavelength-selective phonon excitation in the quantum wells. Theoretical modelling of the pulse shapes based on the deformation potential generation mechanism (not shown here) gives good agreement with the data.

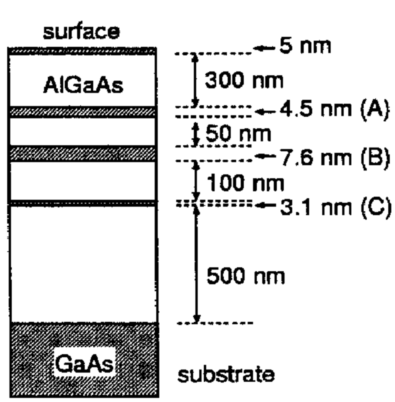

Fig. 1. Sample structure.

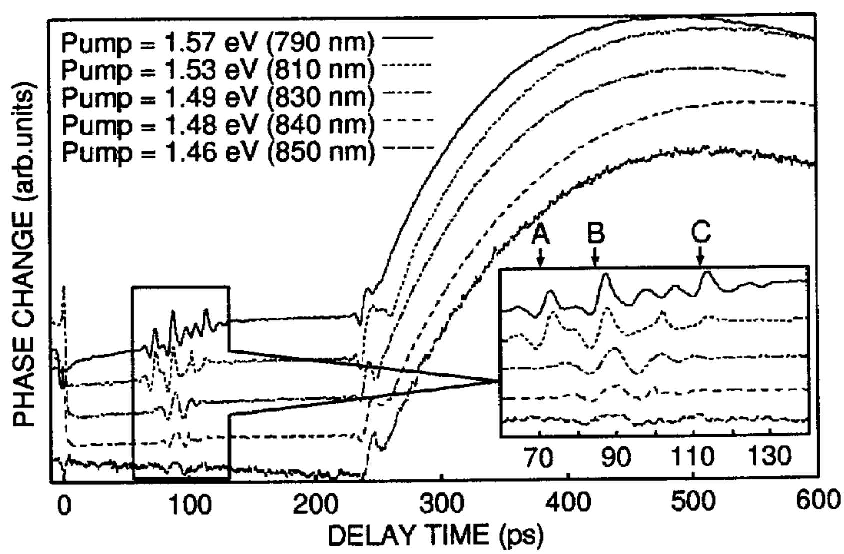

Fig. 2. Optical phase change at various pump light energies.

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