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Effect of rapid thermal annealing on layer disorder in Raman scattering and photoluminescence of $GaAs_{1-x}Bi_x$ heterostructures

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Diluted bismides have attracted increasing interest due to a large band gap reduction of ~90 meV/% Bi for $GaAs_{1-x}Bi_x$, temperature insensitive band gap, and large spin-orbit splitting. However these semiconductors are substantially disordered due to low temperature growth by means of molecular beam epitaxy. Thermal annealing has to affect the degree of disorder. In this work the vibrational and optical properties of high-quality $GaAs_{1-x}Bi_x$/GaAs heterostructures with Bi concentration varying up to 4.6% have been studied by means of Raman scattering and photoluminescence (PL) under different temperatures and excitation intensities. Samples were undergone to rapid thermal annealing.

Polarization Raman spectra show that incorporation of Bi into bulk GaAs leads to appearance of new features at ~186 cm^{-1} and at ~210 cm^{-1} related to transverse optical (TO) and longitudinal optical (LO) BiAs phonon modes. Redshift in LO(GaAs)-like optical modes due to alloying is observed. The strong broad band at ~268 cm^{-1} is attributed to the phonon-plasmon coupled mode (LOPC).

PL measurements under different temperatures and excitation intensities have been carried out in order to determine the energies of the exciton transitions and the peculiarities of the carrier relaxation in the quantum well $GaAs_{1-x}Bi_x$/GaAs heterostructures. The peak energy of the exciton PL and the PL lineshape are found to be strongly excitation intensity and temperature dependent. The typical S-shaped temperature dependence of PL peak energy at low excitation intensities is observed giving evidence of significant disorder in quantum well structures. The origins of disorder are clarified. A rapid thermal annealing leads to a pronounced blue-shift of the emissions ascribed both to the exciton ground state transition in quantum well and to the spin-orbit split valence band in $GaAs_{1-x}Bi_x$. The effect of rapid annealing on the Bi distribution and on the structure disorder in $GaAs_{1-x}Bi_x$/GaAs heterostructures is discussed.