Dependence of Electron-Optical Phonon Interaction on the Al Composition in GaAs/$Al_xGa_{1-x}As$ Quantum Well Structures

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The relaxation of hot electrons in quantum wells via optical phonon emissions has been extensively studied both experimentally and theoretically [1-3]. In this work we used the dielectric continuum model of optical phonons in GaAs/$Al_xGa_{1-x}As$ quantum wells to estimate the effective energy of optical phonons emitted during the hot electron relaxation. The calculations were compared with the experimental results reported in Ref. [2].

The electron-optical phonon scattering rates were calculated via the Fermi's golden rule for types of phonon modes based on the dielectric continuum model: interface symmetric plus (S+) phonon mode, interface symmetric minus (S-) phonon mode and confined LO phonon mode. We first calculated the dependence of scattering rates on the Al composition in the barriers. Figure 1 shows the calculated results for interface S+, interface S- and confined LO phonon modes. We discovered that the increase of the scattering rate by confined LO phonon as the Al composition was increased was due to the enhancement of quantum confinement. However, the increase of scattering rate due to interface S+ phonon and interface S- phonon were attributed to the stronger electron-optical phonon interaction at larger Al composition. The effective phonon energy emitted by the hot electron at different Al composition was determined by averaging the contributions from all phonons and the contributions were weighted by the electron-optical phonon scattering rates. Figure 2 shows the comparison of effective phonon energy from the measurements [2] and the calculations. The calculated values of the effective phonon energy agree well with the experimental results.

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[2] K.W. Sun et al., Solid State Communications 115, 563 (2000).
[3] M.P. Chamberlain, Phys. Rev. B48, 14356 (1993).

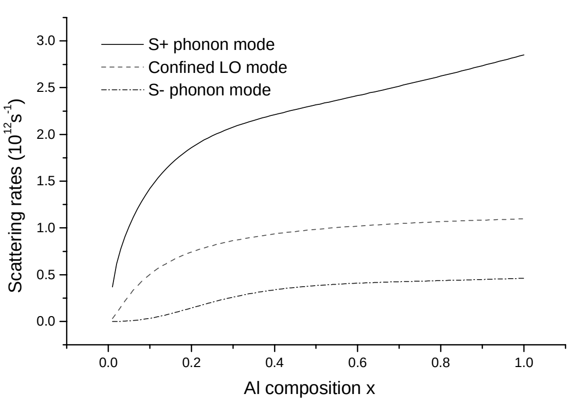

Fig.1

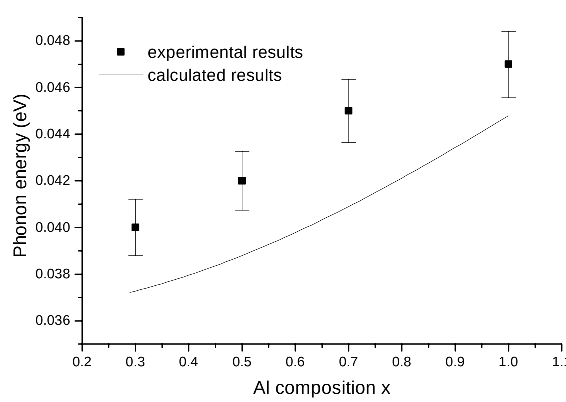

Fig.2