

Anisotropic Electron Transport in Lattice-Mismatch-Strained GaInAs Alloys

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Besides $\text{Ga}_x\text{In}_{1-x}\text{As}$ with compositions nearly lattice-matched to GaAs and InP substrates both In-rich and highly strained alloys become increasingly important for heterojunction transistors and emitters also for room temperature applications. Based on deformation potential theory we first express the strain induced shifts of the conduction and valence band edges under biaxial stress. Using k-p theory we calculate the anisotropic effective mass tensor of the direct conduction band minimum. The tetragonal distortion of the cubic crystal results in different masses m_{\parallel} , m_{\perp} for in-plane and perpendicular directions, respectively.

Then we calculate the electron mobility using a steady-state single particle Monte Carlo procedure employing a nonparabolic ellipsoidal band structure including a set of phonon and alloy scattering mechanisms. Compressive strain decreases the mobility while tension can enhance it significantly. The parallel component μ_{\parallel} is higher than the perpendicular μ_{\perp} in the first case and lower in the second. We observe that $\mu_{\parallel}/\mu_{\perp} = m_{\perp}/m_{\parallel}$ as one expects from a first-order perturbation calculation of the Boltzmann transport equation for an ellipsoidal valley and isotropic relaxation rate. Second, defining an average mobility $\bar{\mu} = (\mu_{\perp} \cdot \mu_{\parallel}^2)^{1/3}$ we find that it scales as $\bar{\mu} = \mu_0 \cdot (m_0/m_d)^{\beta}$. Based on these observations we propose a new model which relates the strained mobilities to the unstrained mobility μ_0 virtually by use of the model for the strained masses. Furthermore, the effect of strain on high-field transport properties is outlined.

KEYWORDS: electron mobility, anisotropic electron transport, compound semiconductors