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Effects of Strain Relaxation on the Carrier Transport Properties on InP-based pseudomorphic High Electron Mobility Structures

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Strained ($\varepsilon = 1.5X10^{-2}$) $In_{0.75}Ga_{0.25}As$ channel modulation doped high electron mobility structures with changing channel layer thicknesses were grown by molecular beam epitaxy on (001) InP. Room temperature van der Pauw Hall measurements showed that the sheet carrier concentration in the InP-based structures decreases by 1 to 3% and the mobility decreases by 10 to 15% as the channel thickness increases from about 20 to 35 nm. To further investigate this, low temperature (0.3K) Hall Bar measurements were performed. For the structure with a channel thickness of 20 nm, along the [110], $[1\bar{1}0]$ and [010] directions, the Hall bar measurements show that the sheet concentration is relatively independent of transport direction ($3.3 \cdot 10^{12}$ cm^{-2}), but the mobility decreased from 64,000 ([110]) to 59,000 ([010]) to 50,000 $cm^2/V \cdot s$ $[1\bar{1}0]$. The InP-based structures possessed misfit dislocations and also exhibited the presence of edge dislocations and surface roughening with a strong asymmetry of misfits in the orthogonal <110> directions. Stacking faults were not observed. For the 20 nm channel sample, the misfit dislocation densities are $\approx 0.03\ \mu m^{-1}$ and $1.61\ \mu m^{-1}$ along the two <110> directions and these results strongly support that the observed directional dependence of the mobility is related to strain-relieving defects.