ABSTRACT OF THE DISSERTATION

DX Centers in InAlAs Heterostructures

by

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DX centers are point defects observed in many n-type doped III-V compound semiconductors. They have unique properties, which include large differences between their optical and thermal ionization energies, and a temperature dependence of the capture cross-sections. As a result of these properties DX centers exhibit a reduction in free carrier concentration and a large persistent photoconductivity (PPC) effect. DX centers also lead to a shift in the threshold voltage of modulation doped field effect transistors (MODFET) structures, at low temperatures.

Most of the studies on this defect have been carried out on the $Ga_xAl_{1-x}As$ material system. However, to date there is significantly less work on DX centers in $In_xAl_{1-x}As$ compounds. This is partly due to difficulties associated with the growth of

defect free materials other than lattice matched $In_{0.52}Al_{0.48}As$ on InP and partly because the energy level of the DX center is in resonance with the conduction band in $In_{0.52}Al_{0.48}As$. The purpose of this dissertation is to extend the DX center investigation to InAlAs compounds, primarily in the indirect portion of the InAlAs bandgap.

In this work the indium composition dependence of the DX centers in $In_xAl_{1-x}As/In_yGa_{1-y}As$-based heterostructure is studied experimentally. Different $In_xAl_{1-x}As$ epitaxial layers with x=0.10, x=0.15, x=0.20, and x=0.34 in a MODFET-like heterostructure were grown by Molecular Beam Epitaxy (MBE) on (001) GaAs substrates. In order to compensate the lattice mismatch between epitaxial layers and their substrates, step-graded buffer layers with indium composition increments of x=0.10, every 2000 Å, were used.

For the samples grown with different indium contents Hall measurements as a function of both temperature and different cooling biases were performed in order to determine their carrier concentrations. A self consistent Poisson-Schrödinger numerical software is used to model the heterostructures. With the help of this numerical model and the grand canonical ensemble (GCE) the energy levels of the DX centers relative to the conduction band edge were estimated.

The optical properties of the DX centers were also investigated using a 1.0 μm thick, Si-doped bulk-like GaAlAs epitaxial layer grown by MBE on a GaAs substrate. A conductivity modulation experiment using a stripe-patterned mask has been performed at 77 ^{o}K. A conductivity difference, up to 10^4 along parallel and perpendicular directions relative to the stripes, has been measured. The difference in conductivity is a result of the large PPC effect of the DX centers and clearly indicates the localized nature of these deep levels.