Abstract

Studies on Some Striking Features of III-V Nanostructures through Advanced Numerical Methods

The electronic and optical properties of nanostructures of III-V compound semiconductors are high priority research areas and have led to a lot of open research problems. In this thesis we have elucidated some of such unexplored problems using quantum mechanical computations, namely self-consistent solutions of the Schrödinger and Poisson equation, in the numerical regime.

We have investigated the behavior of the low dimensional structures like quantum wells (QWs) on the capacitance-voltage (C-V) measurements. For proper measurements we have set up guidelines for the design of the QW structures. The inconsistent temperature dependence of the C-V carrier peak of the QW structures has been explained.

Further, we have explained the inconsistency between the C-V carrier profiles in normal and inverted type heterojunctions. The effects of different parameters on the errors in the C-V profiling of heterojunctions have been discussed elaborately. A new technique to obtain more accurate results from the measured C-V data has been presented.

We have elucidated the effects of different fundamental parameters on the emission energy of the In$_x$Ga$_{1-x}$N/GaN QW light emitting diodes. The built-in electric field strongly depends on these fundamental parameters and causes large change in the emission wavelength, as the operating current changes. Our study reveals the ways to minimize instability in the emission energy and to maximize transition probability.

We have comprehensively discussed the effect of the built-in field on the photoluminescence (PL) measurements of InGaN/GaN QWs. The broadening of the PL spectrum due to the fluctuations in the In composition and well width, is enhanced further by the large built-in field and makes the characterization ambiguous.

We have reported for the first time that the InGaN/GaN QW LEDs has immense potentiality to achieve tunable LED which should be of very high impact in device applications.

We have presented a new formulation of the absorption spectrum of elongated InAs/GaAs semiconductor quantum dot (QD) system with dot height distribution described by a Gaussian function. The methodology is also applicable for short quantum wires. Finally, we conclude with some propositions for future work as an extension of the work, described in the thesis.