ABSTRACT

Since the discovery of high brightness blue Quantum Well Light Emitting Diodes (QW-LEDs), III-Nitride QW LEDs have become extremely popular research area. GaN based QW LEDs have achieved wonderful improvements in the field of solid state lighting (SSL). In this high priority research area of III-Nitride LEDs for solid state lighting, various unresolved research challenges exist. In this thesis we have addressed some of such unexplored problems, providing avenues for improvement of the GaN based QW LEDs, through the software simulation approach to find the solutions of the Schrödinger and Poisson equations, by using Technology Computer-Aided Design (TCAD) software like SILVACO© ATLAS©. GaN based QW LEDs are quite efficient in the Ultraviolet and blue range of light spectrum, but the efficiency of these devices reduces at higher current levels. We have investigated the InGaN/GaN and AlGaN/GaN QW LEDs, with different indium and Aluminium compositions in the barriers and quantum wells. From the results we observed that the effective confinement of electron and holes in the quantum wells of the LEDs and reduction in band bending effect improves the performance of these LEDs.

We studied and simulated different types of GaN based QW-LEDs having emitting wavelength range from deep UV to Visible. We calibrated our simulation software to match the results with the experimental data available in the literature. Hot electron overflow, higher non radiative recombination and asymmetrical electron/hole injection were found to be the dominant reasons for efficiency degradation in nitride LEDs at high injection currents. Our comprehensive studies yield that the use of graded quantum layers is more beneficial to attain symmetrical electron/hole concentration. Thickness of barrier and quantum wells also plays an important role in the performance of QW-LEDs. Based on these observations, we have optimized the device structure of near UV-LED and have also proposed various new device structures to improve the efficiency of GaN based UV, blue, green and yellow QW-LEDs. Since the properties of the material varies significantly with the variation of Aluminium and Indium content in the AlGaN and InGaN layers, the technique used to improve one type of LED does not necessarily works on the other types. That's why, for each type of LED different parameters and techniques have to be used to improve the performance and efficiency droop behaviour of the device.

Finally, the thesis is completed with a suitable conclusion and with some suggestions for future work, related to the thesis.