Abstract

This thesis focuses on studying heterostructures of GaN, Silicon and AlN. GaN nanostructures are grown on bare Si (111) with and without a GaN buffer layer and GaN film was grown on an AlN layer. Apart from the material characterization of the grown samples we have studied the carrier transport across GaN/Si and AlN/Si heterojunctions by means of the I-V-T curves from these junctions and we also studied the band alignment across GaN/AlN and AlN/Si heterojunctions by means of X-ray photoelectron spectroscopy.

The thesis is divided in 7 chapters. The first chapter deals with general introduction of the field, choice of the substrate, different growth techniques and an overview of nanostructures.

In the second chapter different experimental techniques used in the current study are briefly mentioned. These techniques include Growth by Plasma Assisted Molecular Beam Epitaxy (PAMBE), X-Ray Diffraction (XRD), Raman spectroscopy, Photoluminescence spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM) and X-ray photoelectron spectroscopy (XPS).

Then in the 3rd chapter the growth and characterization of GaN nanostructures on Silicon (111) is discussed. Attention has been paid to the effect of substrate temperature and V-III ratio on the morphology and optical quality of the grown structures when other growth parameters has been kept constant. However due to the complexity involved in forming proper electrical contacts from such rods and low yield of single nanowire-based devices, the need to grow compact nanorods was felt.

Hence in the fourth chapter compact GaN nanorods were grown on n-Si with a buffer layer for improved quality and elimination of any possibility of electrical short with the substrate during metallization. The main focus in this chapter is the electrical characterization of GaN nanorods/Si

(111) heterojunction. The temperature dependent current-voltage characteristics from GaN/n-Si (111) junctions are analyzed and explained as the result of a lateral inhomogeneity in barrier heights with Gaussian distribution and temperature dependent Gaussian parameters.

The importance of AlN as a buffer layer for many III-Nitride based devices and as an active layer in many electromechanical devices drew our attention towards band off-set studies of the GaN/AlN/Si heterojunction and electrical transport across the AlN/n-Si junction, in 5th and 6th chapter respectively. The 5th chapter starts with the structural and optical characterization of AlN/Si (111) templates and overgrown GaN thin film. The rest of the 5th chapter is dedicated to the band off sets studies on GaN/AlN and AlN/Si (111) heterojunctions with X-ray photoelectron spectroscopy (XPS). A band diagram of GaN/AlN and AlN/Si is suggested based on our studies.

In the 6th chapter, which happens to be the last work chapter, the temperature dependent electrical characterization of AlN/n-Si (111) heterojunction was carried out from 100K to 400K and the transport mechanism was explained with the help of the trap states at the interface. Finally, the thesis is concluded and insights for future work is presented in the seventh chapter.