Abstract

The work presents in-depth study of Plasma Assisted Molecular Beam Epitaxy (PAMBE) growth, structural, optical and electrophysical characterizations, and analysis of strained III-N heterostructures. A universal method for band gap determination of semiconductors has been developed. Different effects are incorporated in the band gap determination method. The numerical method has been compared with existing models and validated by the experimentally obtained results of GaN, GaAs and Si semiconductors. Low GaN buffer thickness based different AlGaN/GaN heterostructures have been grown by PAMBE for comparative analysis. Thick InAlN epitaxial layers and strained InAlN/GaN quantum well heterostructures have been grown by PAMBE. The detail investigation of InAlN growth with different growth conditions has also been carried out. It has been found that at 500° C growth temperatures, with shutter modulation scheme followed by annealing at 520°C temperature, the InN segregation can be avoided.

The crystalline quality of the MBE grown samples has been scrutinized through various epitaxial measurement techniques. They are High Resolution Transmission Electron Microscopy (HRTEM), Field Emission Scanning Electron Microscopy (FESEM), Atomic Force Microscopy (AFM), High Resolution X-ray Diffraction (HRXRD), Room Temperature Raman Spectroscopy (RTRS) and Room Temperature Photoluminescence (RTPL). The HRXRD scan is performed to determine the Al mole fraction and strain in AlGaN and InAlN layers of AlGaN/GaN and InAlN structures on silicon substrate respectively. RADS simulation has been used as an alternative way to determine the thickness of the layers. A novel method has been proposed to determine lattice constant from Raman spectroscopy measurement technique. Band gaps were measured by Photoluminescence measurement. ECV measurement has confirmed the 2DEG formation at InAlN/GaN heterointerface and Hall measurement gives the 2DEG sheet carrier concentration of 5.1×10^{13} cm^{-2}.