Abstract

Si_xGe_{1-x}, GaAs, InGaAs and GaN are very promising materials for high speed, high frequency, and high power electronic and optoelectronic device applications because of their unique material properties. The significant problem that prevented the wide spread device application of these materials is their native oxide, which is easily grown on the surface upon air exposure and pins the Fermi level. In this thesis, this problem has been addressed using various passivation techniques, well adequate to these materials from processing point of view. Their surface properties prior and after passivation have been studied in detail.

Our studies of the rare earth oxides Ga_2O_3, Gd_2O_3, $Ga_2O_3(Gd_2O_3)$, and Y_2O_3 films on strained Si_xGe_{1-x} have demonstrated that all the oxides except pure Ga_2O_3 exhibit good dielectric properties and are capable of passivating SiGe surface. Among all the oxides used in the present study, $Ga_2O_3(Gd_2O_3)$ has exhibited the best result from the point of view of surface passivation giving a minimum interface state density of 4.8×10^{11} $eV^{-1}cm^{-2}$.

The effect of NH_3 plasma pretreatment on n-GaAs surface and effect of NH_3 / SiH_4 ratio on PECVD deposited Si_xN_y films has been studied. Moderately lower values of interface state density (1.1×10^{11} eV^{-1} cm^{-2}) and fixed charge density (1.57×10^{12} cm^{-2}) have been achieved upon optimized post-deposition annealing.

The growth of $In_{0.53}Ga_{0.47}As$ epilayers on InP substrate using MOVPE technique and their characteristics have been presented. Surface passivation using different phosphidization techniques has been experimented. The incorporation of phosphorous and the removal of arsenic oxides upon P-treatment of the surface have been observed by X-ray photoelectron spectroscopy. A minimum interface state density of 2.90×10^{11} eV^{-1} cm^{-2} has been obtained for $Au/Ga_2O_3(Gd_2O_3)/$ GaP/InGaAs structure.

Microwave plasma oxidation of GaN epilayer has been studied in detail. The SIMS data has shown that the oxide layer grows monotonically with time in the initial stage, while after about a thickness of 10 nm the growth rate saturates. The chemical shift of the binding energy of Ga 2p and 3d electrons has indicated the formation of Ga-oxide on GaN surface.