

Reactive sputtering of gallium nitride
thin films and the electrical characterisation
of GaN/GaAs metal insulator semiconductor
diode structures.

Thesis submitted in partial fulfillment of the requirement
of the degree of

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CERTIFICATE

This is to certify that the dissertation entitled "Reactive sputtering of gallium nitride thin films and the electrical characterisation of GaN/GaAs metal insulator semiconductor diode structures", which is being submitted by Mrs. Lakshmi Enjeti to the Indian Institute of Technology, Delhi, is a record of bonafide research work carried out by her under my guidance and supervision.

In my opinion this dissertation has reached the standard fulfilling the requirements of all the regulations relating to the degree. The results contained in it have not been submitted in part or in full to any other University or Institute for the award of any degree or diploma.

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ABSTRACTReactive sputtering of gallium nitride films and the electrical characteristics of the gallium nitride gallium arsenide MIS diode structures

This work aims at conducting an investigation into the fabrication and characterization of the gallium nitride-gallium arsenide metal insulator semiconductor diode structure.

Gallium nitride thin films were grown by the reactive sputtering of pure gallium in a nitrogen argon atmosphere. By suitable optimization of the various sputtering conditions in an r.f. sputtering chamber, stoichiometric gallium nitride films were deposited having an as deposited resistivity of 10^{13} - 10^{14} ohm cm.

The insulator characteristics were determined from the detailed study of the gallium nitride silicon MIS capacitor. The properties studied include etch rate, dielectric constant and its frequency dependence, the d.c. and a.c. insulator loss resistances, and the dielectric breakdown field strength.

Detailed study of the capacitance voltage and conductance voltage characteristics of the GaN/GaAs MIS structure in the frequency range from 10 hz to 1 Mhz revealed a significant dependence of the same on the growth conditions of gallium nitride films and post growth annealing treatments. Best results were obtained when GaN is deposited at 350°C

and N_2 annealed for 1/2 hr at 450°C . H.f. Terman's method and the conductance technique were used to determine interface state density, its distribution in the band gap and their capture cross section.

The interface state density distribution was found to be a two peaked one with a small peak at 0.35eV below the conduction band edge and a much more pronounced one at 0.5eV above the valence band edge. The minimum interface state density was $8 \times 10^{10}/\text{cm}^2\text{eV}$. The capture cross section, of the interface states determined over a small portion of the band gap was found to be in the range of 10^{-12} cm^2 .

The indepth Auger electron analysis of the GaN/GaAs MIS structures showed that the significant improvement in the interface state characteristics on N_2 annealing was due to the fact that the latter was found to be effective in reducing the oxygen content of the interface, while simultaneously increasing its nitrogen content.

The minority carrier lifetime in GaAs was determined from the transient capacitance plots of the GaN/p GaAs MIS structure. Zerbst's technique has been modified to include the effect of finite leakage currents through the insulator. It was found that these leakage currents produce significant changes in the slope and shape of the resultant Zerbst plots. The effect of various other modifications to the Zerbst analysis, as developed over silicon, namely surface state effect, lateral edge effect and the effect of using a modified value of the generation width, over GaAs MIS structure have also been discussed.

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