Comparison of Electron Scattering Mechanisims and Electron Mobility in AlN and GaN at Low Electric Field Application

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Abstract-- **Iterative technique is used to solve Boltzmann transport equation in bulk wurtzite phase GaN and AlN at central valley conduction band. The electron mobility is calculated as a function of temperature and ionized-impurity in the ranges of 100 K to 600 K and 10^{16} to 10^{18} cm^{-3}. The theoretical maximum motilities in GaN and AlN at 300 K are about 1100 and 380 $cm^2.V^{-1}s^{-1}$. We compare the results with experimental data and find reasonable correlation.**

Keywords-*: Iteration Model; ionized impurity scattering; electron mobilities.*

I. INTRODUCTION

Gallium nitride (GaN) and aluminum nitride (AlN) are two of the most promising III-V semiconductors for short – wavelength optoelectronic devices [1]. Due to the wide band gap of AlN and GaN, these are the potential materials for fabrication of UV emitters and detectors. UV-emitters can be used for curing, material identification, forensic location, disinfection and material processing applications. V-detectors based on III-nitrides are useful in UV sensing applications such as high temperature flame sensing, automobile engine combustion sensing, burner monitoring in gas turbines, environmental monitoring, solar blind detectors, remote sensing of earth resources and missile plume detection for military use [2]. The low-field electron mobility is one of the most important parameters that determine the performance of a field-effect transistor. The purpose of the present paper is to calculate electron mobility for various temperatures and ionized-impurity concentrations. The formulation itself applies only to the central Γ valley conduction band. We have also consider band non-parabolicity and the screening effects of free carriers on the scattering probabilities All the relevant scattering mechanisms, including polar optic phonons, deformation potential, piezoelectric, acoustic phonons and ionized impurity scattering are included in the calculation. The Boltzmann equation is solved iteratively for our purpose, jointly incorporating the effects of all the scattering mechanisms. This paper is organized as follows. Details of the iterative model is presented in section II and the results of iterative calculations carried out on AlN and GaN structures are interpreted in section III.

II. MODEL DETAILS

To calculate mobility, we have to solve the Boltzmann equation to get the modified probability distribution function under the action of a steady electric field. Here we have adopted the iterative technique for solving the Boltzmann transport equation. Under the action of a steady field, the Boltzmann equation for the distribution function can be written as [3]

$$\frac{\partial f}{\partial t} + v.\nabla_r f + \frac{eF}{\hbar}.\nabla_k f = (\frac{\partial f}{\partial t})_{coll} \qquad (1)$$

Where $(\partial f / \partial t)_{coll}$ represents the change of distribution function due to the electron scattering. In the steady-state and under application of a uniform electric field the Boltzmann equation can be written as [3]

$$\frac{eF}{\hbar}.\nabla_k f = (\frac{\partial f}{\partial t})_{coll} \qquad (2)$$

Consider electrons in an isotropic, non-parabolic conduction band whose equilibrium Fermi distribution function is $f_0(k)$ in the absence of electric field. Note the equilibrium distribution $f_0(k)$ is isotropic in k space but is perturbed when an electric field is applied. If the electric field is small, we can treat the change from the equilibrium distribution function as a