Calculation of High Field Electron Transport Properties in GaSb and GaAs

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Abstract— **Electron transport properties in GaSb and GaAs are calculated for different temperature, doping dependencies at high electric field applications. The calculations are performed using a three valleys ensemble Monte Carlo model that includes numerical formulations of the phonon scattering rates and ionized impurity scattering rates. For two materials, we find that electron velocity overshoot only occurs when the electric field in increased to a value above a certain critical field .This critical field is strongly dependent on the material parameters. Results from the two materials are finally compared. The agreement with the available experimental data is found to be satisfactory.**

Keywords-: *Monte Carlo method; ionized impurity scattering; overshoot velocity.*

I. INTRODUCTION

GaSb and GaAs semiconductors are becoming of increasing importance in many emerging optoelectronic and electronic device applications. Among these applications are ultraviolet photodetectors, blue and UV light emitters, and high frequency, high power electronic devices. As an aid to the device-related work, the transport coefficients of the materials need careful investigation. Transport properties of electrons in GaSb and GaN semiconductors can be conveniently derived by direct solution of the Boltzmann equation [1]. Previous applications of this technique were directed toward calculations of drift mobility in ideally pure semiconductors. There is also considerable interest in accurate descriptions of impure crystals, from both the experimental and the theoretical points of view. In the former case, foe example, one may take advantage of the sensitivity of mobility to ionized impurities in analyses of impurity content. In the latter case, highly doped materials allow one to probe regions of the conduction band in the neighborhood of the Fermi level, well above the band edge. Obviously, accurate calculations in conjunction with experimental data are helpful in exposing weaknesses of the theoretical model, particularly with regard to electron scattering by ionized impurities at low temperatures [2]. The purpose of the present paper is to calculate electron drift velocity for various temperatures and ionized-impurity concentrations. The formulation itself applies only to the central Γ valley conduction band and the two nearest valleys. We have also consider band nonparabolicity, admixture of p-type valence-band wave functions, degeneracy of the electron distribution to any arbitrary degree, and the screening effects of free carriers on the scattering probabilities [3]. All the relevant scattering mechanisms, including the two-mode nature of the polar optic phonon scattering, are taken into account [4].

In this communication, we present Monte Carlo calculations of steady-state electron transport conditions in GaSb and GaAs [5]. We demonstrate the effect of injection energy and electric field on the electron transport properties.

This paper is organized as follows. Details of the employed simulation model is presented in section 2 and the results of steady-state electron transport properties carried out on GaSb and GaAs structures are interpreted in section 3.

wavelength optical direction. Another advantage of GaSb is that it provides for type II band alignment in super lattices and quantum wells when used in conjunction with the InAs system. Such structures are being recognized as promising candidates for mid-infrared lasers due to the inherent suppression of internal electron-hole recombination. The Auger rates have also been shown to be greatly reduced in the GaSb based super lattices [18-19]. Furthermore, as the GaSb/InAs share no common cation or anion, one can fabricate either an InSb-like or a GaAs-like interface simply by changing the growth sequence. Different vibrational properties are expected to result [20], and the electronic properties of the confined carrier gas are correspondingly affected [21-23].

II. MODEL DETAILS

In order to calculate the electron drift velocity for large electric fields, consideration of conduction band satellite valleys is necessary. The first-principles band structure of zincblende GaSb and GaAs predicts a direct band gap located