Steady State and Transient Study of The Electron Transport In N-Type GaSb Using Three Valley Monte Carlo Model

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Abstract

In this work, an investigation of the steady state and transient electron transport, at high electric field and high temperature, in n-type GaSb material was presented. We applied a Monte Carlo model considering the three valleys of the conduction band (Γ, L, X), isotropic and non-parabolic centered on the important symmetry point of the first Brillouin zone. This model provides a detailed description of the electronic dynamic and the electrons behavior at high electrical fields and high temperatures in these materials in each considered valleys. The calculation is made for different values of applied electrical field ranging from 50 to 600KV at different values of temperature. The scatterings rates taken into consideration are coulomb scattering acoustical and optical scattering, intra and inter-valleys scattering.

Keywords: *Gallium Antimonide, Electron Transport, Band Structure, Monte Carlo Method, Polar Scattering.*

1. Introduction

Over the last several years, the III-V binary compounds started showing considerable interest towards the study and use in microelectronic manufacturing [8, 19]. The Gallium Antimonide (GaSb) is one of these materials, with a direct bandgap that can be grown with high purity. The III–V ternaries and quaternaries (AlGaIn) (AsSb) lattice matched to GaSb seem to be the obvious choice and have turned out to be promising candidates for high speed electronic and long wavelength photonic devices [18].GaSb based structures are promising candidates for a variety of military and civil applications, notably for laser diodes with low threshold voltage, Photo-detectors, high frequency devices, and a promising material for optoelectronic semiconductor devices in the near infrared [4].

Because it's narrow bandgap (0.7ev), the GaSb-based structures are of great interest for application in mechanically stacked tandem solar cell, in thermo-photovoltaic [1] and in rechargeable lithium batteries [15]. As the unintentionally doped GaSb is invariably p-type in nature [14]. In our work we choose to study the n-type GaSb substrate. Recent investigations of the electron transport in the n-type GaSb are proposed in literature [4, 5, 16, 14]. In this work we investigate the steady state and transient electron transport properties, at high field and high temperature. It’s known that the electron transport at high fields and high temperatures has reached an important stage in the last years and is dominated by the complex conduction-band structure well above the lowest band edge [8]. For the n-type GaSb the transport properties are more complicated due to the contributions from *Γ*, *L* and *X* conduction bands [18]. However, the electronic transport and phonons scattering is always described by models based on the resolution of the Boltzmann transport equation (BTE) who characterizes the modification of the function distribution of particles, caused by various actions, in space and time. The most used models are: the drift diffusion models, Hydro-dynamical models and Monte Carlo Models. This last is computationally intensive in fact that we can simulate the trajectory of a large number of electrons in physical and momentum space. Nowadays the microscopic transport model based on the Monte Carlo method appears to be adequate for studying of electronic transports characteristic in bulk and semiconductor devices [20]. In what follows, we give, in section 2, a detailed description of our MC code which uses analytic descriptions for both the electron bands and the phonon dispersion, and the results of transient and steady-state transport simulations are discussed in the last section.