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We investigated transport properties of InSb and GaSb. We implemented an algorithm for electron-electron scattering in the Monte Carlo simulator, and used this simulator to study the effect of electron-electron scattering at relatively low electric fields. We also developed a program for the calculation of the electron velocity and electron temperature as functions of an electric field . This calculation was based on the moment and energy balance equations. We applied this program to study the heating and drift velocity of electrons in InSb. This method is less time-consuming than the Monte Carlo method and more suitable for the implementation in device simulators. We have also calculated numerically the low-field mobility due to acoustic and optical phonons, obtaining excellent agreement with our Monte Carlo simulations. Based on these studies, we wrote a program for the calculation of mobilities in all cubic semiconductors and their alloys. The program assumes spherical bands, but accounts for carrier degeneracy, non-parabolicity, and varying screening length. (It can be easily modified to account for non-parabolicity.)

The program calculates mobility for the following scattering mechanisms:

A) Γ-valley electrons:
1) polar optical scattering
2) acoustic (deformation potential) scattering
3) piezoelectric scattering
4) ionized impurity scattering, with and without Ridley modification
5) alloy scattering
6) intervalley scattering to L-valley

B) L-valley electrons:
1) polar optical scattering
2) acoustic (deformation potential) scattering
3) piezoelectric scattering
4) ionized impurity scattering, with and without Ridley modification
5) alloy scattering
6) intervalley scattering between L-valleys
6) intervalley scattering to Γ-valley

We calculated mobilities for the temperature range 20 K to 80 K and drift velocity versus electric field for electrons in InSb at 77 K. For this compound, the calculations were limited to the values of electric field such that the carriers are confined to the central Γ-valley and no impact ionization occurs. The optical phonon scattering calculation at 77 K was based on a new approach valid for thermal energy smaller than the polar phonon energy. We first developed this approach for wide band gap semiconductors and then we modified it for narrow gap materials taking into account non-parabolicity of the electron dispersion law.

This calculation does not assume a displaced Maxwellian distribution function, and the result is in excellent agreement with our Monte Carlo simulations.

We also considered the theory of polar optical mobility in two-dimensional electron gas and derived equations which allowed us to calculate this mobility in the case when intersubband transitions are negligible.

In GaSb intervalley scattering from the Γ-valley to L-valley as well as between the equivalent L-valleys has to be taken into account in the calculation of the low-field mobility. We also developed a similar approach for intervalley scattering between both equivalent and nonequivalent valleys. We obtained a good agreement with experimental data.

Submitted for publication:

B. Gelmont, M. Shur, and M. Stroscio, "Polar Optical Phonon Scattering in Three and Two Dimensional Electron Gases", submitted to J. Appl. Phys.

B. Gelmont, B. Lund, and M. Shur, "Analytical Theory of Low Field Transport in GaSb", in preparation