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Carrier Transport Simulator using Distribution Function

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1. Introduction

In recent years, microfabrication technology of semiconductor devices has made rapid progress. In order to obtain the carrier behavior in non-equilibrium transport conditions, it is necessary to take into account rigorous physical models. Although Monte Carlo method is well-known for its accuracy, the feature of distribution function in high energy region is rugged. We have developed a new method which directly calculates the distribution using the Boltzmann transport equation. This method provides accurate solutions of the transport of electrons to the extent of high energy region.

2. Method of computation

The momentum space is divided into a number of small cells with node spacing Δk and $\Delta\theta$. The electrons are distributed in each cell before free flight. They undergo free flight in the electric field from each state to others for given time interval and are distributed over the array. Then, they are scattered by scattering mechanisms using the relative probability which is stored in a table for various wave number ranges and are distributed over the array before free flight. These procedures are iterated until the distribution becomes steady. We performed this method in a uniform electric field applied parallel to <111> direction for Si at 300K. We took into account the ellipsoidal and nonparabolic band structure, acoustic intravalley, and several f and g intervalley scattering mechanisms.

3. Results

We show in Figure 1 the field dependence of the electron mean energy. This result is in excellent agreement with Monte Carlo result. Figure 2 shows the distribution function. In the relaxation time approximation, the Maxwell distribution function is assumed. However, the distribution function is not Maxwellian. It should be noted that Maxwell distribution function overestimates the number of high energy electrons and has its limit for high electric field.

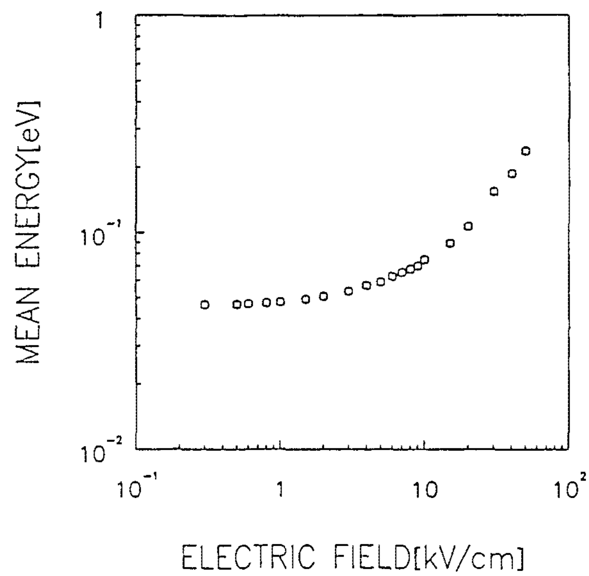

Fig. 1. Steady state electron mean energy as a function of electric field applied parallel to <111>.

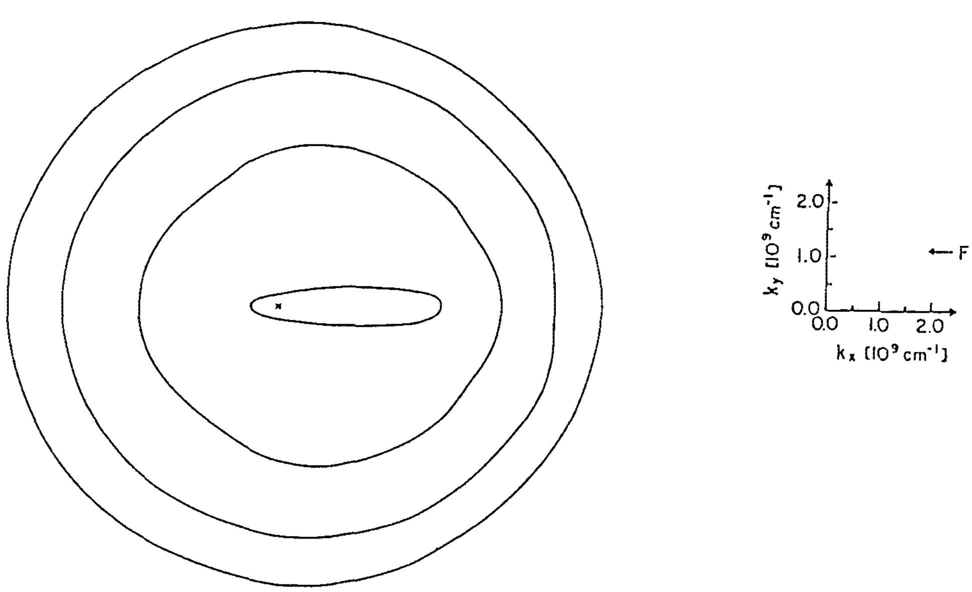

FIg. 2. Steady state momentum distribution of electrons in the plane of electric field of F=50kV/cm.