A NEW MONTE CARLO SIMULATOR OF SI MOSFET'S

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With the reduction of device size, various effects of nonequilibrium transport become more important in device characteristics which cannot be simulated by classical hydrodynamic device simulators. To analyze these effects, relaxation time approximation or Monte Carlo method has been vigorously studied by many workers. We have developed a new practical Monte Carlo device simulator to analyze Si MOSFET's in microscopic view.

The main problem in applying this method to MOSFET's is the abrupt change of impurity concentration in junction regions. We have treated this by the next 3 methods.
(1) The error of ionized impurity scattering model in high concentration region is corrected by some published models/1/. Mobility value calculated by this model shows good agreement with conventional model used in classical simulator.
(2) The results of a classical simulator are used for the initial condition of majority carrier concentration. They are also used in low concentration region where no particle exists.
(3) Since the carrier concentration varies over a wide range, nonuniform rectangular grid system is adopted to calculate Poisson equation. We can calculate potential profile of MOSFET's as stable as classical simulators with (2),(3) methods.

To evaluate the simulator, I-V characteristics of Si MOSFET's with Leff of 0.7 and 0.2 um simulated by M.C. have been compared with those by conventional simulator. For the 0.7um device, both I-V curves show a good agreement(fig.1). This fact shows that our ionized impurity scattering model is reasonable in high concentration region. For the 0.2um device, currents by M.C. method are larger than those by the classical simulator(fig.2). Fig.3 shows electron energy distribution in channel region of those device. The electron energy is largerfor 0.2um case.

We have also simulated the impact ionization for 0.7um device at Vd=7v and Vg=3.5v. The distribution of generated carriers are compared in Fig.4. By the M.C. method, the position where carrier generation is occured is nearer the drain than by the conventional simulation. The conventional model of ionization rate which is the function of the local electric field cannot be used in these cases. We must adopt carrier energy model in impact ionization in submicron devices.

/1/ D.Chattopadhyay, H.J.Queisser, Rev.Mod.Phys., p.745(1981)

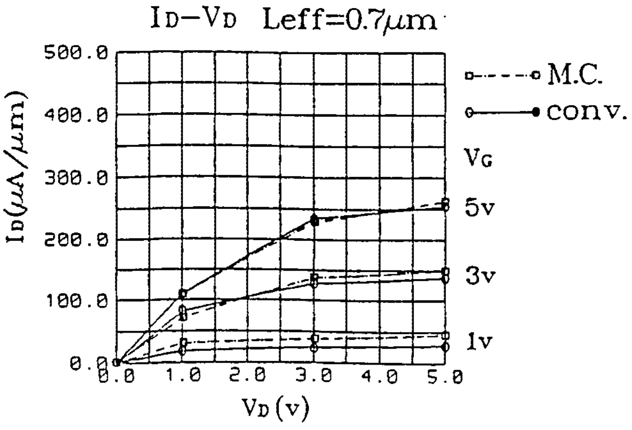

Fig.1: I-V Curve of 0.7um Device.

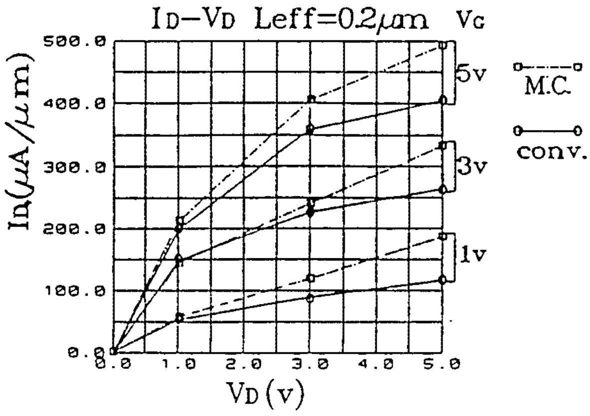

Fig.2: I-V Curve of 0.2um Device.

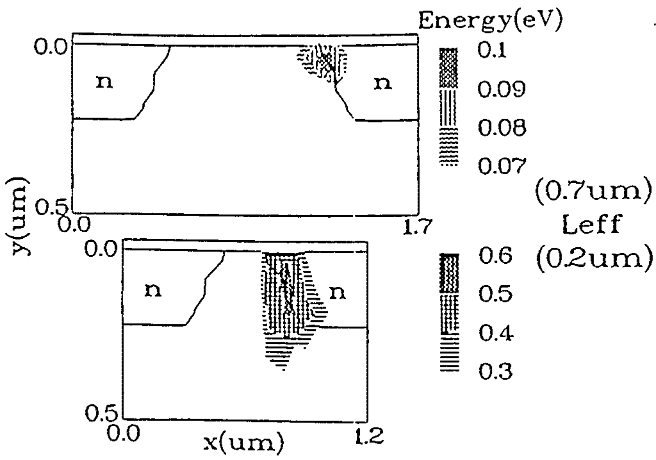

Fig.3: Electron Energy in Channel Region.

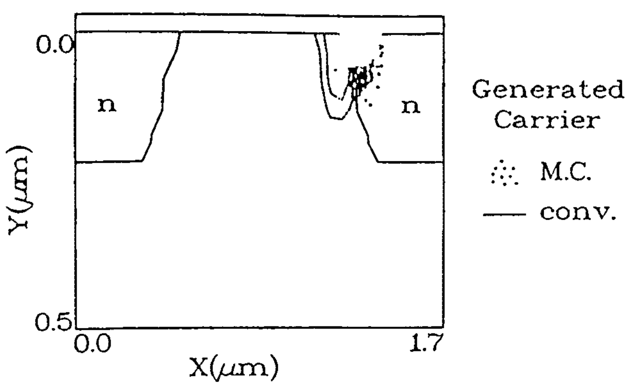

Fig.4: Generated Carrier Distribution.