13:30-13:45 **[11]**

Hot Carriers in a LDD-MOSFET investigated with a Monte Carlo Simulator

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A 2D ensemble MC device simulator has been developed for Si devices to simulate hot carrier effects which play an important role in very small Si MOSFET's.

It solves the BTE self-consistent with the Poisson equation as previously reported /1,2/. As initial condition the particles are distributed over the device geometry according to the carrier densities achieved by the classical device simulator GALENE II /3/.

A nonuniform rectangular mesh with a modified cloud in cell method (CIC) for the charge assignment of the particles to the nodes allows the resolution of the carrier dynamics in regions of interest (e.g. inversion layer). Within each cell -defined by four grid points- the doping concentration and the electric field are assumed to be constant. In contrast to the approach in /4/, changes of these values are taken into account directly when a particle enters a new cell. This may become important for regions with strongly inhomogeneous fields and/or doping.

The bulk scattering mechanisms implemented in the program have already been described in detail elsewhere /5/. To reduce self scattering introduced by impurities, we use an 'internal MC simulator scheme' which was extended to inhomogeneous doping profiles /6/. The influence of the device boundaries is modeled by generation/recombination for contacts and reflection elsewhere. At Si/SiO2 interfaces the reflective boundary condition can be replaced by a diffusive one.

The program was applied to a LDD-MOSFET with 0.56 um channel length for VDS=VGS=3V using the reflective scattering process at the Si/SiO2 interface. The charge transport has been solved for 5 ps to reach steady state conditions (fig. 1). To extract device parameters 200 samples were averaged over the next 2ps (fig. 2-4). Contrary to the result of GALENE II applying the "thermal equilibrium approximation" the densities are pushed away from the surface near the drain. The same effect can be observed applying the "energy relaxation approximation" in GALENE /7,8/. The maximum temperature is about 7200 K and positioned at the Si/SiO2 interface. The mean drift velocity is about two times of the saturation value (1.E+7 cm/s) indicating velocity overshoot, and the mean energy is increased to about 0.8 eV.

For the diffusive scattering process at the Si/SiO2 boundary the drain current decreases from 2.3 A/cm to 0.5 A/cm. Compared with the result 1.23 A/cm for the drain current given by classical GALENE II simulation, the mobility of the carriers in the inversion layer seems to be overestimated using the reflective condition and underestimated through the diffusive one. This discrepancy requires a more accurate description of the carrier behavior in the inversion layer.

References:

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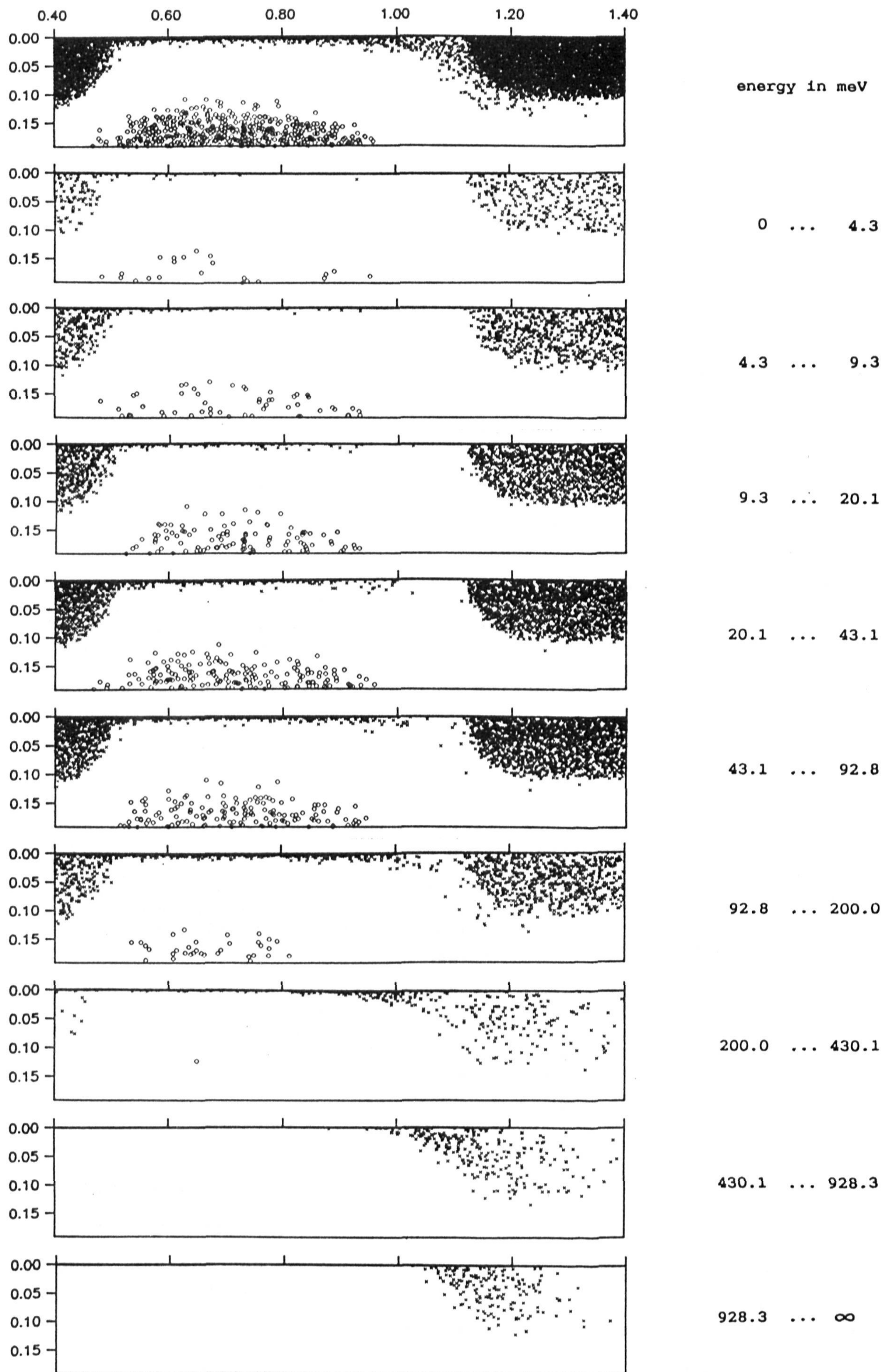

fig. 1: snapshot of the particles near the drain at 5ps, separated for different energy ranges (x refers to electrons, o refers to holes)

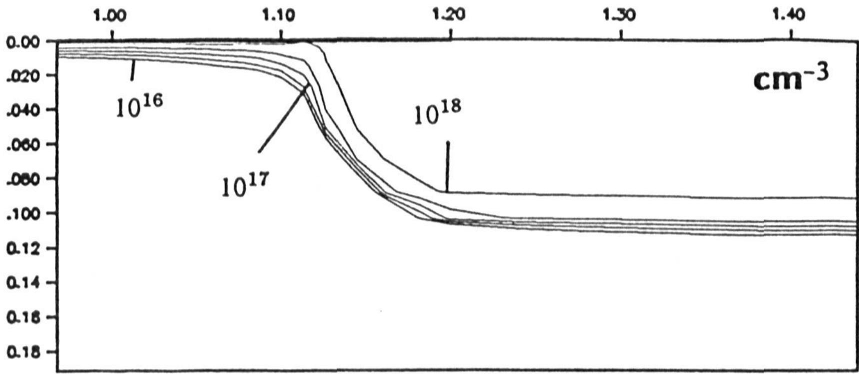

fig. 2a: electron density (GALENE II)

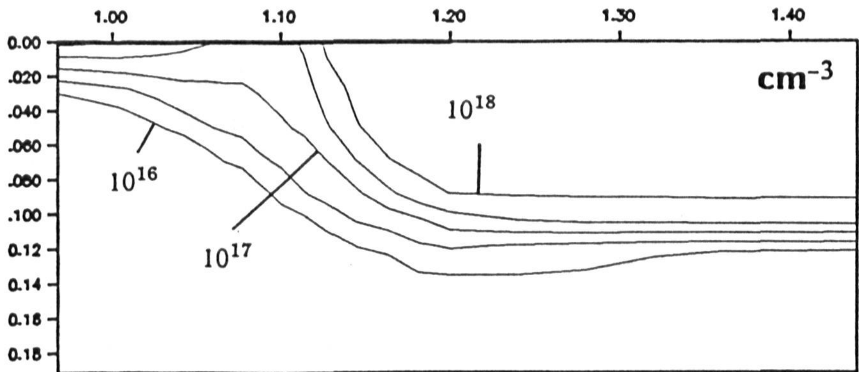

fig. 2b: electron density (MC)

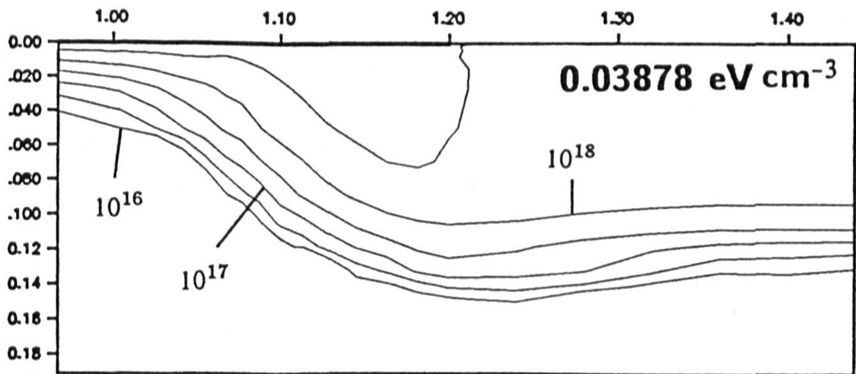

fig. 3: electron energy density (MC)

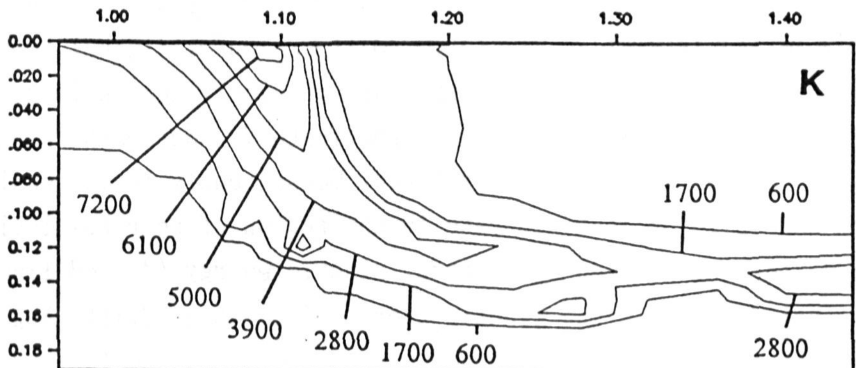

fig. 4: equivalent electron temperature (MC)