# MONTE CARLO SIMULATION OF SMALL SEMICONDUCTOR DEVICES INCLUDING BAND-STRUCTURE AND SPACE-CHARGE EFFECTS

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Electronic transport in Si and GaAs is investigated using a Monte Carlo technique which improves the 'state-of-the art' treatment of high-energy carrier dynamics: 1. The semiconductor is modeled beyond the effective-mass approximation using the band structure obtained from empirical-pseudopotential calculations. 2. The carrier-phonon, carrier-impurity, and carrier-carrier scattering rates are computed in a way consistent with the full band-structure of the solid, thus accounting for density-of-states and matrix-element effects more accurately than previous transport formulations. 3. The long-range carrier-carrier interaction and space-charge effects are included by coupling the Monte Carlo simulation to a self-consistent 2-dimensional Poisson solution updated at a frequency large enough to resolve the plasma oscillations in highly-doped regions.

The technique is employed to study experimental submicron n-channel Si field-effect-transistors with channel lengths as small as 60 nm operating at 77 and 300 K. Velocity overshoot and highly nonlocal, off-equilibrium phenomena are investigated together with the role of electron-electron interaction in these ultra-small structures. In the systems considered, the inclusion of the full band structure has the effect of reducing the amount of velocity overshoot via electron transfer to upper conduction valleys, particularly at large biases and low temperatures. The simulation of p-channel devices shows that highly non-equilibrium hole transport occurs below the 0.1-$\mu$m channel-length. At the 0.25-$\mu$m channel lengths, p-channel devices appear much slower than complementary n-MOSFETs. However, below 0.1-$\mu$m the behaviour of p-channel devices approaches that of the n-channel FETs, as reflected in similar transconductance values.