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DEVICE SIMULATION FOR 0.1 MICRON MOSFETS - *Performance and Reliability*

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The Energy Transport (ET) method for solution of the Boltzmann Transport Equation is an efficient and economical approach to the simulation of the performance and reliability of devices with active lengths down to only hundreds of Angstroms. This method is rapid enough, even with accuracy-enhancing measures taken, and when applied to two-dimensional problems, to be used at an individual engineer's workstation.

While original ET device simulations were confined to use of a symmetrical distribution function, current simulations using this method either add an additional moment equation, to account for heat flow; or approximate the distribution function with physically reasonable functions. We have adopted the latter approach, and incorporated the method into our two-dimensional device simulation program UMDFET.[1] The distribution function we use is an expansion in Legendre polynomials, to account for a spherically symmetrical and an asymmetrical component, and yields energy distribution function results very close to those obtained by MC simulations--at a very small fraction of the cost. In addition, use of this expansion allows the ET moment equations to be expressed in very simple and easily calculable form.

We have used these methods in our two-dimensional ET program to study n-channel silicon MOSFET's with gate lengths between 0.05 and 0.25 microns. With constant-field scaling, maximum electron temperature in these devices decreases significantly as channel length decreases, for channel lengths less than 0.18 microns. This phenomenon, which is a result of the decreased ratio of electron transit time to energy relaxation time as gate lengths are shortened, indicates that short-channel devices can be more reliable than similar long channel devices, as indicated also by recent experiments.[2]

Our short-channel ET simulations, which require only SUN-level workstations, show that hot-electron related MOSFET reliability problems should become less threatening for silicon MOSFET's with very short channel lengths. These simulations will be equally useful for predicting basic device performance factors, as well--if suitable process-related constants can be obtained--as for predicting device reliability.

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[1] Z. Peng, "UMDFET A Two-dimensional General Device Simulator and its Application in EPROM Analysis", Master's Thesis of 1989, in the University of Maryland.

[2] G.G. Shahidi, D.A. Antoniadis, and H.I. Smith, "Reduction of Channel Hot-Electron-Generated Substrate Current in Sub-150nm Channel Length Si MOSFET", IEEE Electron Device Letters, vol. 9, no. 10, p.497,1988

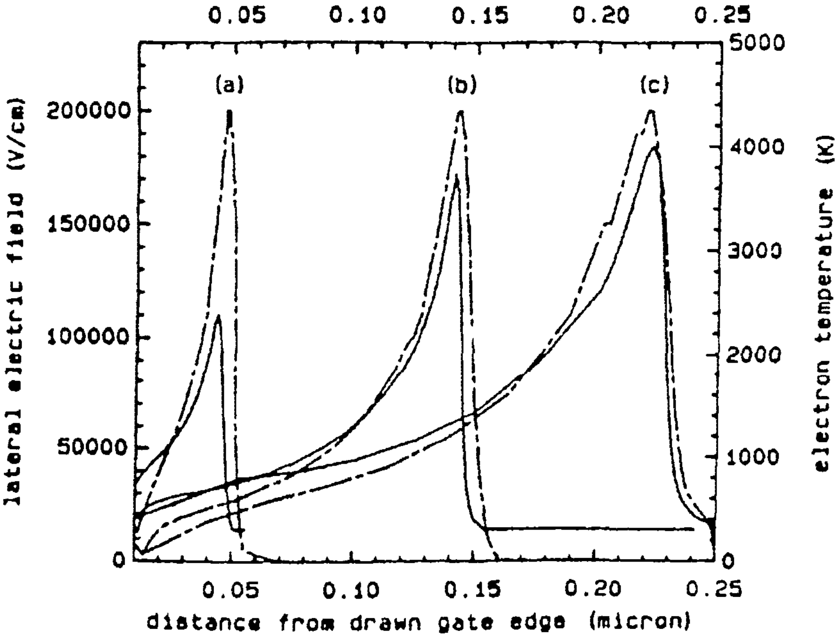

Figure 1.
Lateral electric field at the surface, and temperature of electrons at the surface, for MOSFETs with gate lengths of 0.05, 0.15, and 0.25 microns. Doping levels were adjusted so peak fields were the same. Drain and gate voltages were: (.05u)0.32V,0.30V; (.15u)0.83V, 0.90V; (.25u)1.45V, 1.50V.

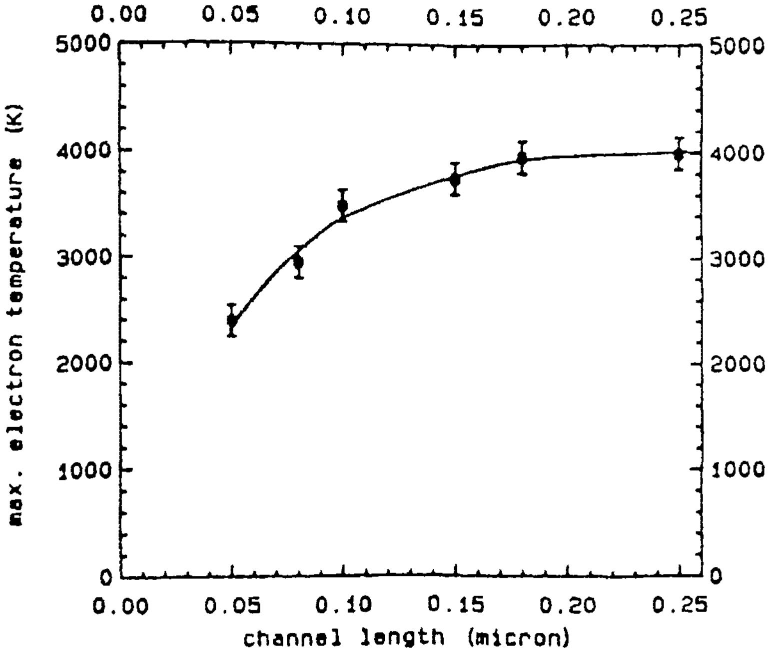

Figure 2.
Maximum temperature of electrons under the gate in Si MOSFETs designed for constant-field scaling.