Course: ECE 614 Numerical Semiconductor Device Modeling
Instructor: Zlatan Aksamija (zlatana@engin.umass.edu)
Meeting Times: MWF 10:10-11:00 in ELab 327
Office Hours: 201B Marcus Hall, MF 2-3pm and W 11:15-12:15
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Final Project: Project proposal due Friday April 24th.
[more information about the proposal at the end of this document.]
Presented in class on April 27 and 29. Presentations are peer graded.
Final Report due May 8th.

The goal of this homework project is to develop a simulation code of your choice in Matlab (or another programming language of your choice) or use an existing code to perform some interesting numerical simulation of semiconductor materials or devices.

Here are a few options which build on the existing work in HW2-4:

1) Use Rode’s method (HW2) to calculate the thermoelectric Seebeck coefficient in Si, SiGe alloys (with the addition of alloy potential scattering), or GaAs as a function of temperature and doping. The Seebeck coefficient can be obtained from the solution g(k) by integration in a way similar to mobility but with the addition of a (E-E_F) term inside the integral to capture the average electron energy.

2) Expand the Monte Carlo code in HW4 to either Si (by adding 6 equivalent X valleys with f-type and g-type intervalley scattering) or GaAs (by adding polar optical phonon and piezoelectric scattering). Compare your results to those obtained by Rode’s method to see how far with electric field Rode’s method holds up.

3) Develop a 1-dimensional coupled Poisson-Schroedinger solver for quantum electrostatics. Use the Poisson solver from HW3 and add a 1-dimensional time-independent Schroedinger equation based on the Matlab eigenvalue solver. Use an iteration procedure similar to the Scharfetter-Gummel iteration to reach self-consistency. Apply your code to the MOS system with a gate voltage on one side and semiconductor on the other, separated by an oxide having a large barrier. Show the dependence of the solution energy levels and densities (given by the wavefunctions) on the gate voltage.

4) Use a commercial 3-dimensional drift-diffusion device simulation software (often called TCAD for technology computer aided design) such as the free (for 30 days) TiberCAD from TiberLAB (http://www.tiberlab.com/). Simulate a simple device such as a MOSFET or BJT and show the basic device operation.

5) Expand the 1-d drift-diffusion solver from HW3 to simulate the operation of a solar cell by adding in electron and hole generation through the optical absorption.

6) Expand the drift-diffusion code from HW3 to capture time dependent phenomena by solving the time-dependent drift-diffusion equations instead of the steady-state current continuity equation as described in the course textbook. Simulate the high frequency response of a diode or another 1-dimensional system of interest.
7) Add in a density gradient quantum correction to the drift-diffusion code in HW3 to simulate the tunneling of electrons through the barrier in a n+i n+ diode with a narrow intrinsic region (or having a thin oxide barrier) between the two highly doped regions.

8) Solve the 1-dimensional time-dependent Boltzmann transport equation in the relaxation time approximation by discretizing it using the upwind method described in class. Use the code to simulate the response to a transient voltage.

9) Solve the 1-dimensional time-dependent Schrödinger equation for a potential barrier and show the dynamics of an electron wavepacket tunneling through the barrier. You can use explicit time-stepping and the upwind method or implicit time-stepping and the triad.m tridiagonal solver from HW3.

10) Solve the discretized Wigner equation by using the finite difference discretization and the Wigner transform for the quantum potential. Use the relaxation time approximation for the scattering term. Show the dynamics of an electron in response to a single or a series of potential barriers, such as in a resonant tunneling diode (RTD) structure, leading to negative differential resistance.

For your project proposal, submit a single page document stating the following:

1) Title/topic of the project.
2) What is the project related to (one of the homeworks, an idea you have, research interest)
3) Describe the motivation for choosing that particular topic. What do you hope to achieve?
4) What are the specific steps you plan to take to complete your project?
5) What are the deliverables of the project—what will you produce and present at the end?