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, M and F 2-3pm and W 11:15-12:15

Webpage: http://blogs.umass.edu/eceng614-zlatana/

Description: Starting with the simplest semiclassical approaches and ending with the description of complex fully quantum-mechanical methods for quantum transport analysis of state-of-the-art devices, this course provides a comprehensive overview of the essential techniques and methods for effectively analyzing transport in semiconductor devices. The course introduces advanced simulation methods for proper modeling of state-of-the-art nanoscale devices and explores both semi-classical and quantum transport modeling.

Suggested Textbook: *Computational Electronics* by D. Vasileska, S. Goodnick, and G. Klimeck
(CRC Press, http://www.crcpress.com/product/isbn/9781420064834)

Course Topics:

1. Introduction to Computational Electronics
    a. Semiconductor Bandstructure
    b. Electronic Bandstructure Calculation Methods
    c. Density of States calculations and Spectral Methods
    d. Poisson Equation and Numerical Techniques
2. Semiclassical Transport Theory
    a. Displaced Maxwellian distribution function
    b. Relaxation Time Approximation for the Boltzmann Equation
    c. Scattering Mechanisms
    d. Rode's and other Iterative Methods for the BTE

3. Drift-Diffusion Equations and Their Numerical Solution
    a. Scharfetter-Gummel Discretization
    b. Newton's Method
    c. Generation and Recombination
    d. Hydrodynamic Modeling
4. Particle-based Simulation Methods
    a. Monte Carlo method
    b. Multi-carrier Effects, exclusion and carrier-carrier interaction
    c. Device Simulation
    d. Thermal modeling and phonon generation/transport
    e. Quantum Corrections to semi-classical models
5. Quantum Transport in Semiconductors
    a. Schroedinger Equation Solvers, coupled Schroedinger-Poisson
    b. Transfer Matrix approach
    c. Landauer Formalism and the Usuki Iterative Method
    d. Master Equation Method
    e. Wigner Equation and Wigner Monte Carlo
    f. Non-equilibrium Green's Functions

Assignments: 4 homeworks (machine problems) and a final project.

- 4 homeworks assigned on a (roughly) bi-weekly schedule
- Each homework will consist of a mix of conceptual problems and machine problems implementing the methods covered in class in Matlab/C/C++/Python/Fortran code and plotting the results

Final Project:

- Project will be computational in nature
- Develop a Matlab/C/C++/Python/Fortran code to simulate a physical process or implement a calculation based on a reading assignment
- Project done in teams of 2 (exceptions allowed in special cases)
- All presentations are 15 min plus 5 min for questions
- Project can be selected to enhance your own research project
- Final presentation is worth 15% and project report is 25% of the grade
- Presentation grade will be based on class feedback