ENEE 694 (Formally 648W)
Physics and Simulation of Semiconductor Devices
Fall 2000

Professor: Neil Goldsman; Office: 2457 AVWII; Phone: 405-3648
Office Hours: Tuesday 4:00-5:00, Friday 10:30-12:00

TA: Zeynep Dilli

Contents: Course will cover the physics of electron transport in semiconductor devices. Numerical methods for attaining solutions to transport equations will be explored. Students will also learn how to use CAD tools for semiconductor device design.

Prerequisite: The class is self-contained, so there are no formal prerequisites. A basic understanding of semiconductor devices as well as a little exposure to solid state physics and quantum mechanics will be helpful.

Recommended Text: There is no required text for this course. The following texts are recommended:

M. Lundstrom, *Fundamentals of Carrier Transport*, Modular Series on Solid State Devices, New York: Addison-Wesley, 1990.

S. Selberherr, *Analysis and Simulation of Semiconductor Devices*, Wein-New York: Springer-Verlag, 1984.

R. Muller and T. Kamins, *Device Electronics for Integrated Circuits*. New York: John Wiley & Sons, 1986.

In addition, periodically I will give references and provide notes.

Grading: Your grade will be depend on computer projects and homework; there will be no exams.

Course Outline:

1. Electrons in Semiconductors: Basic review of solid state physics which is important for modeling electron transport in semiconductor devices. This will provide the physics underlying the effective mass concept.

2. Collision Processes in Semiconductors: Electron scattering by phonons, ionized impurities, impact ionization, and other electrons will be described in terms of quantum perturbation theory, using Fermi's Golden Rule. Scattering and effective mass determine mobility which is fundamental to semiconductor device operation.

3. The Monte Carlo method uses a computer and random numbers to mimic how an electron moves within a device. The method is excellent for obtaining an appreciation of the underlying physics of device operation on a microscopic level. Students will learn how to apply the Monte Carlo technique to semiconductors.

4. The Boltzmann Transport Equation, which is the most fundamental equation describing electron transport, will be presented. The equation describes how to obtain the electron distribution function during non-equilibrium conditions (when Maxwell-Boltzmann and Fermi-Dirac are not applicable). The textbook models for device operation can be derived from the BTE.

5. Device Simulation Using the Drift-Diffusion Model: Numerical methods will be described for solving the textbook drift-diffusion equations in semiconductor devices. Students will learn to use state-of-the art device simulators. Learning these skills will be useful for both employment opportunities and research.

6. CAD of Short-Channel Devices: Students will use the CAD tools to predict short channel effects such as pinch-off, punch-through, and hot-carrier reliability issues.