

ECE 697MM - Special topics course: From nanoscience to terahertz technology.

Department of Electrical and Computer Engineering
University of Massachusetts at Amherst

Fall 2006

Day and Time: TuTh, 9:30 AM – 10:45 AM
Place: Lederle A205
Instructor: Prof. Sigfrid Yngvesson (Marston 142B)
Email: yngvesson@ecs.umass.edu
Office hours: M,W,F at 2:30 PM-3:30 PM

Course Goals:

To understand electronic transport in mesoscopic (for definition of ‘mesoscopic’ see the text book) solid state systems of different dimensionality (from three to zero).

To survey a number of different emerging devices most of which are of nanometer size.

To understand the limitations on the speed as well as the sensitivity of solid state devices, mostly analog ones.

To survey some of the technological progress that is occurring in the terahertz frequency range, especially that based on nano-scale devices.

Preliminary Course Outline:

1. Basics of Mesoscopic Transport. Material from Datta’s book, Chapters 1-3. Density of states in different dimensions. The concept of transverse modes in 2D. Transport in the linear (low E-field) regime. Landauer’s formula.
2. (Concurrently with 1.) Examples of 2-D semiconductor devices (HEMTs, for example). Basic operation and speed limitations. Examples of semiconductor 1-D devices (“Quantum point-contacts”). Examples of Quantum dots (0-D).
3. Energy bands of 1-D conductors, carbon nanotubes (CNTs) and quantum wires (QWs). Brief discussion of scattering processes in 1-D conductors.
4. Speed limitations for 2-D and 1-D devices: Quantum capacitance and kinetic inductance. Circuit models for 1-D conductors.
5. Some “high-speed” (terahertz or close to terahertz) devices. Negative resistance. Examples are Resonant tunneling diodes, single-electron transistors, quantum

- cascade lasers, detectors of different types, speed limitations for specific devices. Hot electron bolometers.
6. Noise processes that limit the sensitivity of terahertz detector devices: Thermal noise, shot noise, diffusion noise, temperature fluctuation noise, quantum noise.
 7. Some conclusions and outlook toward the future.
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Required text:

The course will be based on notes distributed in class and/or posted on the class web site. There is also a required text book: Supriyo. Datta, “*Electronic Transport in Mesoscopic Systems*” (Cambridge University Press, 1995). This book has been ordered through the UMass/Amherst text book annex. Other useful references will be given in class.

Grading:

Homework: 20%
Exam 1: 25%
Exam 2: 25%
Final term paper: 30%
