Southern Illinois University at Carbondale

Spring 2012

ECE 550 Nanoelectronic Devices

Catalog Description: (A) **NanoTransistor**: Charge-based devices—MOSFETs, Advanced MOSFETs: Trigate FETs, FinFETs, SOI, SiGe, Ge and III-Vs, carbon nanotubes and Graphene ribbons, nanowires. Quantum Devices—single electron transfer devices (SETs), resonant tunnel diodes, tunnel FETs, quantum interference transistors (QITs), quantum dot cellular automata (QCAs), quantum bits (qubits). Non-charge based devices—spinFET; (B) **NanoMemory**: Flash, PCM, Electrolyte, M/F RAM, Spin torque devices, DRAM, ZRAM; (C) **Energy-Related Devices**: Solar cells, LEDs/SSLs, thermoelectric devices, supercapacitors; (D) **NanoBio Devices**: Biosensors.

Course Total Credit Hours: 3
Lecture: 3  MWF 4:00 – 4:50 PM  EGRA 0208  Office Hour: MW 1:00–3:00 PM and by appointment
Prerequisites: Basic semiconductor devices, ECE 375 and ECE 447, or Instructor consent.

Objectives:

- Give a general introduction to different types of conventional and novel nanoelectronic devices for different applications. The target applications are switching, memory, energy conversion/storage, and bionanoelectronics.
- Understand the underlying physical processes governing the operation of these devices. Understanding of these processes would build on earlier semiconductor device courses, which introduced the student to the basic device concepts.
- Various figures of merit widely used for efficient device design and performance study will be addressed.
- Understand various higher order effects (e.g. short channel effects, quantum effects, discrete dopants and process variation) that influence today’s nanoscale devices.
- Various problems/challenges and technological bottlenecks in the realization of nanoelectronic devices with desired and optimum performance will be discussed.
- Study different novel and exploratory devices and alternative technologies (non-charge based and fully quantum computation and information processing) as means of sustaining the semiconductor industries’ growth in the coming years.
- Students will be using in-house and freely available software tools to study and analyze various aspects of nanoelectronic devices and expected to generate novel design ideas and find solutions to these technological problems.
- Communicate efficiently with the circuit/system designers and the science persons and give them essential feedback from device point of view.
- Demonstrate how computer programming (Matlab/Fortran/C/others) can facilitate learning of nanoscale phenomena and device design.

Laboratory Fees: None

Laboratory safety equipment: None
Instructor: Dr. Shaikh S. Ahmed, Associate Professor, ECE Department, SIUC.
Course Committee: Department of Electrical and Computer Engineering Faculty.

Text Book: The subject matter for this course will be heavily drawn from the research literature, and extensive references will be provided in the class notes. A useful book:


References:

• S. M. Sze, Kwok K. Ng, *Physics of Semiconductor Devices*, Publisher: John Wiley and Sons Inc., 2006

**Topical Outline (Tentative):**

Introduction: Evolution in CMOS technology 1 lectures (2.2%)
 Fundamental principles of electronic devices 5 lectures (11%)
 MOS capacitor 2 lectures (4.4%)
 MOS threshold voltage 2 lectures (4.4%)
 MOSFET current-voltage 2 lectures (4.4%)
 Short channel effects 2 lectures (4.4%)
 Quantum effects 2 lectures (4.4%)
 Discrete impurity effects 1 lectures (2.2%)
 Silicon-On-Insulator (SOI) devices 2 lectures (4.4%)
 Advanced device architectures (DGFETs, FinFETs) 1 lectures (2.2%)
 Alternative materials: SiGe 1 lectures (2.2%)
 Alternative materials: Carbon nanotubes and Graphene ribbons 2 lectures (4.4%)
 Alternative materials: Nanowires 1 lectures (2.2%)
 Alternative materials: III-Vs 1 lectures (2.2%)
 Fully quantum mechanical devices 3 lectures (6.7%)
 Non-charge (Spin) based devices 1 lectures (2.2%)
 Semiconductor memory devices 4 lectures (8.9%)
 Energy-related devices 4 lectures (8.9%)
 NanoBio devices 2 lectures (4.4%)

**Grading:**

Homework 20%
6 short tests (~30 minutes each) 60%
Final Project/Paper 20%

Letter grade: **A**: 90-100 **B**: 80-89 **C**: 70-79 **D**: 60-69 **F**: <60