Southern Illinois University at Carbondale

Fall 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 (QUITs), 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 2:00 – 2:50 PM EGRA 0210 Office Hour: TBD 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:


Topical Outline (*Tentative*):

Introduction: Evolution in semiconductor device technology
Fundamental principles of electronic devices
MOS electrostatics: capacitance and threshold voltage
MOSFET current-voltage characteristics
Short channel and nanoscale effects
Quantum effects
Discrete impurity effects
Power dissipation and leakage
Silicon-On-Insulator (SOI) devices
Advanced device architectures (Trigates, FinFETs, Nanowires)
Alternative materials: SiGe
Alternative materials: III-Vs
Alternative materials: carbon nanotubes, graphene ribbons, and 2D monolayers
Non-charge (Spin) based devices
Quantum mechanical devices: tunnel FETs and SETs
Semiconductor memory devices
Energy-related (solar cells, solid-state lighting, thermoelectricity, supercapacitors)
NanoBio devices (tentative)

Grading:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
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<tr>
<td>4 short tests (~30 minutes each)</td>
<td>40%</td>
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<tr>
<td>Final Exam</td>
<td>20%</td>
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<tr>
<td>Project</td>
<td>20%</td>
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Letter grade: **A**: 90-100 **B**: 80-89 **C**: 70-79 **D**: 60-69 **F**: <60