Southern Illinois University at Carbondale
Spring 2014
ECE 550 (Nanoelectronic Devices)

Instructor:
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Course Total Credit Hours: 3

Lecture: 3, TTH 2:00–3:15 PM ENGR A-222
Office Hour: TTH 11 a.m.–1:45 p.m. (or by appointment)

Prerequisites: Basic semiconductor devices (equivalent to ECE 447) or Instructor consent.

Objectives:
(1) Give a general introduction to *different types* of conventional and novel nanoelectronic devices for different VLSI and ULSI applications. The target applications are digital switching, analog amplification, and DRAM and Flash memory storage.
(2) Understand the fundamental *physical processes* governing the operation of these devices.
(3) Understand various *figures-of-merit* widely used for efficient device design.
(4) Understand various *higher-order effects* (e.g. short channel effects, quantum effects, discrete dopants and process variation) that influence today's nanoscale MOS devices.
(5) Develop the SPICE and BSIM models for MOSFETs (that establish a bridge between the device engineers and circuit/system designers working in a semiconductor industry).
(6) Study the potential of *novel materials, devices, and architectures* for use in MOSFETs as means of sustaining the semiconductor industries' growth in the coming years.
(7) Students will be using *in-house (Synopsys Sentaurus TCAD) 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.
(8) Demonstrate how *computer programming* (Matlab or similar tools) can facilitate learning of nanoscale phenomena and device design.

Laboratory Fees: None
Laboratory safety equipment: None

Course Committee: Department of Electrical and Computer Engineering Faculty.

Books: The subject matter for this course will be heavily drawn from the research literature, and extensive references will be provided in the class notes. Three useful books:

(1) Y. Taur and T.H. Ning, *Fundamentals of Modern VLSI Devices*, 2nd Edition, Cambridge University Press, 2009.
(2) Yannis Tsividis and Colin McAndrew, *Operation and Modeling of the MOS Transistor*, 3rd ed. Oxford University Press, ISBN13: 9780195170153, 2010.
(3) Simon M. Sze, Kwok K. Ng, *Physics of Semiconductor Devices*, John Wiley and Sons Inc., 2006.

Topical Outline (Tentative, 'min': minutes):

Introduction: Evolution in semiconductor device technology	50 min	2.2%
Principles of semiconductor devices	250 min	11%
MOSFETs:		
Introduction, structure, operation	50 min	2.2%
MOS electrostatics: capacitance and threshold voltage	100 min	4.4%
MOSFET current-voltage characteristics	100 min	4.4%
Nanoscale Effects:		
Electrostatics effects (SCEs)	50 min	2.2%
Power dissipation and leakage	50 min	1.1%
Hot-carrier effects, Interconnects, and MOSFET reliability	50 min	1.1%
Non-stationary and ballistic transport	50 min	1.1%
Process variability and discrete impurity effects	50 min	2.2%
Quantum effects	50 min	2.2%
SPICE and BSIM models	50 min	2.2%
Advanced MOSFETs:		
Concept of *equivalent* scaling	50 min	2.2%
Silicon-on-Insulator (SOI) devices	50 min	4.4%
Advanced device architectures (Trigate, FinFET, Nanowire)	50 min	2.2%
Strained-Si and high-*k* gate dielectrics	50 min	2.2%
Hybrid-orientation technology (HOT)	50 min	2.2%
Alternative Channel Materials:		
III-V channel materials	50 min	2.2%
Carbon nanotubes, graphene ribbons, and 2D monolayers	100 min	4.4%
Unconventional Ultra Low-Power Devices:		
Negative-capacitance FETs	50 min	2.2%
Quantum mechanical devices: tunnel FETs and SETs	100 min	4.4%
Non-charge (spin) based devices	50 min	2.2%
Semiconductor memory devices	100 min	4.4%

Date and Time of Final Examination: Wednesday, May 7, 3:10-5:10p.m.

Grading (Tentative):

Homework	25%
Midterm Exam(s)	25%
Final Exam	35%
Project	15%

Classroom Policies

A. Syllabus is subject to change at the instructor's discretion. Students are responsible for all announcements made in class and/or posted to D2L.
B. **Attendance Policy:** Attendance will be taken at random throughout the semester, and it may be counted toward the final grade.
C. **Late Homework/Missed Exams:** Late homework is not accepted. If an exam is missed for a *legitimate* reason, a grade will be assigned based on the remaining homework/exams.
D. **Mobile Technology Policy:** N/A

University Policies

A. Incomplete Grades: An INC is assigned when, for reasons beyond their control, students engaged in passing work are unable to complete all class assignments. An INC must be changed to a completed grade within a time period designated by the instructor but not to exceed one year from the close of the term in which the course was taken, or graduation, whichever occurs first. Should the student fail to complete the course within the time period designated, not to exceed one year, or graduation, whichever comes first, the incomplete will be converted to a grade of F and the grade will be computed in the student's grade point average. Students should not reregister for courses in which an INC has been assigned with the intent of changing the INC grade. Re-registration will not prevent the INC from being changed to an F.

B. Academic Integrity: You are expected to submit your original work and adhere to the academic policies as stated in the SIU Student Conduct Code: http://srr.siu.edu (listed under Additional Links). Any act of academic dishonesty, cheating, or plagiarism in any form, including anonymous internet sources used in student papers, will be reported. These acts are taken seriously and the consequences may range from failing as assignment to expulsion from the university.

C. SIU Email: Your SIU email account is an official form of University communication. Your instructor will use SIU email as a primary means of electronic communication with students. Please make sure that you maintain a valid password and acquire the habit of regularly checking your SIU email account for important instructor and University announcements. You may view the official SIU Student Email Policy at: http://policies.siu.edu/policies/email.html.

D. Emergency Procedures: SIU is committed to providing a safe and healthy environment for study and work. Because some health and safety circumstances are beyond our control, we ask that you become familiar with SIU Emergency response Plan and building Emergency Response Team (BERT) program. Emergency response information is available on posters in buildings on campus, available on BERT's website at http://www.bert.siu.edu/, the SIU Department of Public Safety's website www.dps.siu.edu (disaster dropdown and video, "Shots Fired"), and in the Emergency Response Guideline pamphlet. Know how to respond to each type of emergency. Instructors will provide guidance and direction to students in the classroom in the event of an emergency affecting your location. It is important that you follow these instructions and stay with your instructor during an evacuation or sheltering emergency. The Building Emergency Response Team will provide assistance to your instructor in evacuating the building or sheltering within the facility.

E. Supplementary Assistance: SIU is committed to assisting students with disabilities. With the cooperation of SIU's Disability Support Services (DSS), each student who qualifies for reasonable supplementary assistance has the right to receive it. Students requesting supplementary assistance must first register with DSS in Woody Hall, B-150, 618-453-5738 or 618-453-2293 (TTY), by email DSS@siu.edu, or http://disabilityservices.siu.edu/. Notice: If you have any type of special need(s) or disability for which you require accommodations to promote your learning in class, please contact me as soon as possible. The Office of Disability Support Services (DSS) offers various support services and can help you with special accommodations. You may wish to contact DSS to verify your eligibility and options for accommodations related to your special need(s) or disability.

Student Services

A. Learning Support Services: The Center for Learning Support Services (CLSS) assists students of all cultures, abilities, backgrounds and identities with enhancing their self-management and interdependent learning skills. Programs offered by CLSS include: group study sessions; math tutoring; academic coaching; early intervention program; and study skills seminars. For additional information please contact CLSS in Woody Hall, Room A-313, 618-453-2925, or www.tutoring.siu.edu.

B. Writing Center: The Writing Center offers free tutoring services and assistance with improving writing skills to all SIU undergraduate students and faculty. For center locations and hours, to schedule an appointment online, and to view information regarding the Online Writing Lab (OWL) contact the Writing Center at 618-453-1231 (Morris Library location); 618-453-2927 (Trueblood location), or www.write.siu.edu.

C. Saluki Cares: The purpose of Saluki Cares is to develop, facilitate and coordinate a university-wide program of care and support for students in any type of distress-physical, emotional, financial or personal. By working closely with faculty, staff, students and their families, SIU will continue to display a culture of care and demonstrate to our students and their families that they are an important part of the community. To make a referral to Saluki Cares click, call or send: http://salukicares.siu.edu/index.html; 618-453-5714, or siucares@siu.edu.