

ECE 550 (Nanoelectronic Devices)

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Course Total Credit Hours: 3

Lecture: TTH 11:00 a.m. –12:15 p.m. Engineering, D Wing 0131

Office Hour: TTH 12:30 – 2:30 p.m., W 1:30 – 2:30 p.m. (or by appointment)

Prerequisites: ECE 345 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.

Textbook: Y. Taur and T.H. Ning, *Fundamentals of Modern VLSI Devices*, 2nd Edition, Cambridge University Press, 2009.

Another useful book: Yannis Tsividis and Colin McAndrew, *Operation and Modeling of the MOS Transistor*, 3rd ed. Oxford University Press, ISBN13: 9780195170153, 2010.

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

Introduction: Evolution of 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 <i>equivalent</i> 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- <i>k</i> 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%
Novel 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: Thursday, December 17, 2015, 10:15 a.m. -12:15 p.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

IMPORTANT DATES *

Semester Class Begins.....	08/24/2015
Last day to add a class (without instructor permission):.....	08/30/2015
Last day to withdraw completely and receive a 100% refund:.....	09/06/2015
Last day to drop a course using SalukiNet:.....	11/01/2015
Last day to file diploma application (for name to appear in Commencement program):.....	09/18/2015
Final examinations:.....	12/14–12/18/2015

Note: For outreach, internet, and short course drop/add dates, visit Registrar's Academic webpage <http://registrar.siu.edu/>

FALL SEMESTER HOLIDAYS

Labor Day Holiday 09/07/2015

Fall Break 10/10–10/13/2015

Veterans Day Holiday 11/11/2015

Thanksgiving Vacation 11/25–11/29/2015

WITHDRAWAL POLICY ~ Undergraduate only

Students who officially register for a session may not withdraw merely by the stopping of attendance. An official withdrawal form needs to be initiated by the student and processed by the University. For the proper procedures to follow when dropping courses and when withdrawing from the University, please visit <http://registrar.siu.edu/pdf/ugradcatalog1314.pdf>

INCOMPLETE POLICY~ Undergraduate only

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 one semester following 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, that is, by no later than the end of the semester following the term in which the course was taken, or graduation, whichever occurs first, the incomplete will be converted to a grade of *F* and the grade will be computed in the student's grade point average. For more information please visit: <http://registrar.siu.edu/grades/incomplete.html>

REPEAT POLICY

An undergraduate student may, for the purpose of raising a grade, enroll in a course for credit no more than two times (two total enrollments) unless otherwise noted in the course description. For students receiving a letter grade of A,B,C,D, or F, the course repetition must occur at Southern Illinois University Carbondale. Only the most recent (last) grade will be calculated in the overall GPA and count toward hours earned. See full policy at

<http://registrar.siu.edu/pdf/ugradcatalog1314.pdf>

GRADUATE POLICIES

Graduate policies often vary from Undergraduate policies. To view the applicable policies for graduate students, please visit

<http://gradschool.siu.edu/about-us/grad-catalog/index.html>

DISABILITY POLICY

Disability Support Services provides the required academic and programmatic support services to students with permanent and temporary disabilities. DSS provides centralized coordination and referral services. To utilize DSS services, students must come to the DSS to open cases. The process involves interviews, reviews of student-supplied documentation, and completion of Disability Accommodation Agreements.

<http://disabilityservices.siu.edu/>

PLAGIARISM CODE

http://pvcaa.siu.edu/_common/documents/Plagiarism/Guide%20to%20Preventing%20Plagiarism.pdf

MORRIS LIBRARY HOURS

<http://www.lib.siu.edu/about>

SAFETY AWARENESS FACTS AND EDUCATION

Title IX makes it clear that violence and harassment based on sex and gender is a Civil Rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, etc. If you or someone you know has been harassed or assaulted, you can find the appropriate resources here: <http://safe.siu.edu>

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. For Information on Saluki Cares: (618) 453-5714, or siucares@siu.edu,

<http://salukicare.siu.edu/index.html>

EMERGENCY PROCEDURES

Southern Illinois University Carbondale is committed to providing a safe and healthy environment for study and work. We ask that you become familiar with the SIU **Emergency Response Plan** and **Building Emergency Response Team (BERT)** programs. Please reference the **Building Emergency Response Protocols for Syllabus** attachments on the following pages. *It is important that you follow these instructions and stay with your instructor during an evacuation or sheltering emergency.*

INCLUSIVE EXCELLENCE

SIU contains people from all walks of life, from many different cultures and sub-cultures, and representing all strata of society, nationalities, ethnicities, lifestyles, and affiliations. Learning from and working with people who differ is an important part of education as well as an essential preparation for any career. For more information please visit: <http://www.inclusiveexcellence.siu.edu/>

LEARNING AND SUPPORT SERVICES

Help is within reach. Learning support services offers free tutoring on campus and math labs. To find more information please visit the Center for Learning and Support Services website:

Tutoring : <http://tutoring.siu.edu/>

Math Labs http://tutoring.siu.edu/math_tutoring/index.html

WRITING CENTER

The Writing Center offers free tutoring services to all SIU students and faculty. To find a Center or Schedule an appointment please visit <http://write.siu.edu/>

AFFIRMATIVE ACTION & EQUAL OPPORTUNITY

Our office's main focus is to ensure that the university complies with federal and state equity policies and handles reporting and investigating of discrimination cases. For more information visit:

<http://diversity.siu.edu/#>

Additional Resources Available:

SALUKINET: <https://salukinet.siu.edu/cp/home/displaylogin>

ADVISEMENT: <http://advisement.siu.edu/>

SIU ONLINE: <http://online.siu.edu/>