Spring 2021: ECE 5960/5960-11: Advanced CMOS Technology

Instructor: Prof. Sriram Krishnamoorthy (sriram.krishnamoorthy@utah.edu)
Credit hours: 3.0

Mo We / 01:25PM-02:45PM/ IVC lecture via Zoom

Next Offering: Spring 2023

Pre-requisites
6960: Graduate Students in ECE, MSE, ChemE, Physics programs
ECE 6261 OR ECE 5201 OR MSE 5201 OR MSE 6050-004 (F 18)
OR Instructor Permission (Graduate students with equivalent courses from their previous institution)

5960: Undergraduate Students in ECE/ChemE
ECE 3200 OR ((ECE 5201 OR ECE 6261) OR Instructor Permission).

Course Objective: This course would provide an overview of the modern CMOS technology and device physics, device simulation and nanofabrication processes. Objective is to provide an in depth understanding of advanced electron devices and expose students to some of the current and emerging research directions towards next-generation low power switches for computation, communication, sensor networks (IoT) etc.

Some of the learning outcomes are:
1. Understand the challenges and solutions in modern CMOS device technology,
2. Learn CMOS unit processes and process flow in CMOS,
3. Perform device simulations in Synopsis Sentaurus to reinforce the concepts learned in class,
4. Special focus on research directions/trends for next-generation computation.

Contents covered in this class will be very beneficial to students planning for a career in the microelectronics/semiconductor industry (device/process research/development & circuit design)

Text Book/Reference Books: Lecture notes will be posted on Canvas. Contents covered will broadly follow topics from the following books. Notes will be provided for contents not covered in the text book. Text book purchase is recommended (Main text book).

Main Text Book: Yuan Taur & Tak. H. Ning - Fundamentals of Modern VLSI Devices (2nd edition);

Supplementary Books/Materials:
1. Yannis Tsividis, Colin McAndrew- The MOS Transistor
3. Tsu-Jae King Liu & Kelin Kuhn- CMOS and Beyond- Logic switches for Terascale Integrated Circuits
4. Jerry G. Fossum, Vishal P. Trivedi- Ultra-thin-body MOSFETs and FinFETs
5. Key journal publications, review articles (E.g., Intel IEDM publications/publications on technology nodes) will be posted on Canvas.
Course Evaluation Components:

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<tr>
<th>Component</th>
<th>Percentage</th>
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<tr>
<td>Sentaurus Device Simulation Assignments (Best 5/6)</td>
<td>50%</td>
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<tr>
<td>Homework (Best 5/6 HW sets)</td>
<td>25%</td>
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<tr>
<td>Final Exam (Take Home/Open Book/Open Notes)</td>
<td>25%</td>
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❖ Undergraduate (5960) and graduate students (6960) will be graded separately for the final grades
❖ Graduate students (6960) will have extra questions in the final exam.

Course Schedule/Topics

Week 1  Basic Device Physics Recap (Taur & Ning Chapter 2)- Recap of ECE 3200
Week 2  Long Channel MOSFETs (Taur & Ning Chapter 3)
Week 3  Sentaurus Device Simulations – Tutorial
Week 4  Short Channel MOSFETs, DIBL, Velocity Saturation/High Field Transport (Taur & Ning Chapter 3)
Week 5  Ballistic MOSFETs, Natori Model (Notes)
Week 6  CMOS Device Design (Scaling, Vt, channel length)- (Taur & Ning - Chapter 4)
Weeks 7, 8  CMOS circuit elements, parasitics, delays- (Taur & Ning - Chapter 5)
Week 9, 10, 11  FD/SOI CMOS, UTB MOSFETs (Taur & Ning - Chapter 10, Fossum Ref. Book), FinFETs, Nanowire FETs
Week 12, 13  CMOS Process Technology- I ; Unit Processes Overview (Campbell), CMOS Process Technology- II; Process Integration, Process flow (Campbell)
Week 14  Beyond CMOS- Tunnel FETs, Negative capacitance FETs, Phase transition FETs, Ferroelectric FETs (Notes)
Week 15  Beyond CMOS- Intro to neuromorphic computing, Quantum computing (Notes)