

ECE 585
MOS Device Modeling and Design

Professor E. Rosenbaum

Spring Semester 2018

Semester Overview

Initially, we will use Poisson's equation to derive the $Q(V)$ relation of a MOS device. We will derive a general equation for the MOSFET drain current under static conditions and then develop approximate (compact) versions that are computationally efficient and that include empirical enhancements to capture non-equilibrium effects such as velocity saturation. The modeling approach will be similar to that of BSIM, which is the SPICE Level 49 (BSIM3) or Level 54 (BSIM4) MOS model. Experimental techniques for measuring critical parameters such as inversion charge density, channel mobility and effective channel length will be briefly introduced at the appropriate times. After establishing a static model, transient and RF modeling will be examined. In the latter part of the semester, our attention will turn to device design. Channel and drain engineering, i.e., non-uniform doping, will be described, as will more recent innovations, including strained silicon, high-k gate dielectric and ultra-thin body devices (includes FinFET and UTBB). The relations between device design and device behavior will be explored, with a special emphasis on short channel effects such as V_T roll-off and off-state leakage current.

Lectures

Tuesdays and Thursdays, 9:30 AM – 10:50 AM, 4070 ECEB

Important Dates

Midterm Exam: Tuesday, March 13

Oral presentations: April 23 – May 1

Prof Rosenbaum's final lecture will be on Thur. Apr. 19. Term project presentations will be given by students at mutually agreed upon times during the following 1.5 weeks, including the regularly scheduled class time on Apr. 26 and May 1.

Project reports due: Tuesday May 8, 3 PM

Final Exam: Friday May 11, 8 AM

Grading

Homework	25%
Midterm Exam	20%
Term Project	35%
Final Exam	20%

Each student's lowest homework score will be dropped before the semester grade is calculated.

Instructor Office Hours

Monday 10:30-11:30 AM, 407 CSL

Thursday 3:00-4:00 PM, 407 CSL

I occasionally need to shift my office hours to accommodate prelim exams, travel, etc., so always check the class webpage before coming to office hour on any given day. Any changes to my office hours will be listed under "Announcements."

Teaching Assistant

Zaichen Chen (zchen19@illinois.edu)

Office Hours: 5:00-6:00 PM, Monday and Wednesday, 2036 ECEB

Textbook

Y. Taur and T. Ning, *Fundamentals of Modern VLSI Devices*, 2nd edition, Cambridge University Press, 2009

- Journal papers will supplement the textbook.

Other Useful Texts (on reserve at Grainger Library):

Y. Tsividis and C. McAndrew, *Operation and Modeling of the MOS Transistor*, 3rd edition, Oxford University Press, 2001.

E. Nicollian and J. Brews, *MOS (Metal Oxide Semiconductor) Physics and Technology*, John Wiley and Sons, 1982.

Term Project

Students may select their own topic or may choose one from a list provided by the instructor. The project may consist of a detailed literature review on a specific topic; such projects must be done individually unless the literature review will be substantively augmented by the students' own analysis. Alternatively, an original research project may be selected. Original research may be done individually or in groups of two. An original research project might consist of analysis (i.e., derivation of equations), device simulation, or device measurement with subsequent data analysis. Students will give an oral presentation on their work at the end of the semester. Detailed instructions for carrying out the term projects will be provided immediately following the midterm exam.

Homework Policy

Homework assignments are due at irregular intervals, ranging from 2 days to 2 weeks. (After Spring Break, the homework assignments will contain fewer problems so that students may focus on their term projects.) Homework is due at the beginning of the class period, on the date indicated. Late homework will not be accepted unless agreement has been obtained from the instructor prior to the due date. Students may discuss homework problems with one another (and are **encouraged** to do so) but are ultimately responsible for writing out their own solutions to the problems. I recycle certain "classic" homework problems from previous years. Copying the solution provided in a previous semester constitutes cheating, is dishonorable, and will result in disciplinary action. Don't do it.

Class Website and Web-board

<https://courses.engr.illinois.edu/ece585/>

Homework and exam solutions will be posted on the class website, as will copies of any slides shown in class. The web-board is the primary means for student-staff communication outside class and office hours. Do not email the instructor with questions regarding the homework or exams; post such questions on the web-board. Email is reserved for matters of a personal nature. The web-board will be checked on a daily basis. Students are encouraged to augment the instructor's answers or to propose answers of their own. It is also a forum where students can post links to articles or presentations they believe their peers will find relevant, useful and interesting.