ECE 585

MOS Device Modeling and Design

Professor E. Rosenbaum Spring Semester 2022

Semester Overview

We will start by deriving the Q(V) relation of a MOS capacitor, and we will use that result to derive a general equation for the MOSFET drain current under static conditions. We will proceed to develop approximate (compact) versions of the I(V) equation that are computationally efficient and that include empirical enhancements to capture non-equilibrium effects such as velocity saturation. Experimental techniques for measuring critical parameters such as inversion charge density, channel mobility and effective channel length will be introduced at the appropriate times. After we establish a static model, transient and RF modeling will be examined.

In the latter part of the semester, our focus 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, UTB-SOI, and nano-sheet transistors). 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, 2017 ECEB

Important Dates

Midterm Exam: Tuesday, March 8
Oral presentations: April 26, April 28 and May 3
Project reports due: 8:00 AM, Monday, May 9
Final Exam: 1:30 PM, Thursday, May 12

Grading

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

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

Teaching Assistant

Shudong Huang (shudong3@illinois.edu)

Office Hours

(Professor) Monday 4:00-5:00 PM
(Professor) Wednesday 11:00 AM - 12:00 PM

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."

(TA) Monday 1:00-2:00 PM

Professor and TA office hours will be held on zoom until you are informed otherwise; use the same link as for the class lectures.

Textbook

Y. Taur and T. Ning, *Fundamentals of Modern VLSI Devices, 3rd edition*, Cambridge University Press, 2021

The 3rd edition is scheduled to be first available as an e-book in January 2022. Until it is available for purchase, enrolled students will be able to read select chapters on a password-protected website.

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 9:30 AM 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 Piazza

https://courses.grainger.illinois.edu/ece585/sp2022/ (*under construction, check after classes begin*)

Homework and exam solutions will be posted on the class website, as will copies of any slides shown in class. Piazza is the primary medium for communication outside of class and office hours; email should be reserved for matters of a personal nature. Piazza is an extremely useful forum for posting homework questions; class members are encouraged to answer each other's questions. (The TA and the professor will check Piazza daily and will clarify or correct an answer if needed.) Also, students can use Piazza to post links to articles or presentations they believe their peers will find relevant, useful, and interesting. We will enroll registered students in the class Piazza forum; if you don't have access by the time classes start, please contact the class instructional staff.