Physics 5336: Device Physics
Spring 2013

Instructor: R.L. Lichti **Office**: Rm 101 Sc **Hours**: 10:00-12:00 TR
roger.lichti@ttu.edu 742-3767 Open Door in general

Meeting Time: 9:00-9:50 TTh Rm: 204 Sc

Main Text: Y Taur & TH Ning, "Fundamentals of Modern VLSI Devices" 2nd Ed. (Cambridge, 2009).

Course Goals: This course is designed to provide the student with an understanding of fundamental device structures and the physical and electrical processes underlying the operation of the primary components on which modern semiconductor devices and IC's are based.

Learning Goals: By performing the regularly assigned work in this course students will

1) Explore the structures making up the basic components of modern semiconductor devices.
2) Model the charge separation and electric fields which result from these basic device structures.
3) Describe the motion of the fundamental charge carriers through these basic structures.
4) Explore details of the electrical function of simple transistors constructed from these structures.
5) Become familiar with the standard 'effective circuit' models for simple device components.

Assessment: Student progress toward understanding of the basic principles involved for each goal is evaluated from qualitative aspects of selected assignment and exam questions. Detailed technical and modeling aspects of assignments and major project assess preparation to contribute at a level required by the semiconductor industry and to effectively communicate the relevant fundamental ideas.

Comments: This course covers the basic physics underlying operation of modern semiconductor devices. The primary emphasis is on a few basic structures for roughly 3/4 of the course. The later part focuses on non-ideal aspects and design considerations related to the short distances and large fields that are present in the current technology.

Regular assignments will consist of a mix of problems and short presentations, and may include computer modeling and graphs of important results. Some portion of class time will be devoted to discussion of problem results, with student presentations on pre-selected topics. It is important that you come to these sessions well prepared, ready to discuss all of the topics or problems to be covered, not just your own assigned topic. Presentations should focus on the physics, not just math and results.

A major project, with a written report and related presentation, will be due near the end of the course and is intended to allow each student to pursue a selected topic in greater depth. This may include computer modeling of a specific device, results taken from the literature on a more advanced topic. Select topics and start work early so these projects can go beyond a simple survey of the basics.

Expect to have one or two (equally weighted) exams, which concentrate on qualitative understanding.

Finally, I would like plenty of feedback regarding what you understand, and more importantly where you are encountering difficulties, so that the discussions can be adjusted to the appropriate level and focus on topics that are not already well understood.

Course Grades are to be determined with the following weighting scheme:

Regular assignments	40 %
Major Project	30 %
Exams	30 %

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Topic Outline

I. Review of semiconductor properties & carrier statistics

II. Basic Processes related to carrier action

III. Basic p/n junctions – dc characteristics

IV. p/n Diodes – steady state, small signal, & transient responses

V. Basics of MIS capacitance structures

VI. MOSFET – basic model

VII. Non-Ideal MOS features

VIII. Bipolar Transistors

IX. Design considerations – selected topics

Other Sources: Partial list, see also the references listed in these texts.

M Shur, "Physics of Semiconductor Devices" (Prentice Hall) 1990.
JS Yuan & JJ Liou, "Semiconductor Device Physics and Simulation" (Plenum) 1998.
Fjeldly, Ytterdal, & Shur, "… Device Modeling and Circuit Simulation" (Wiley) 1998.
K-S Yeo, SS Rofail, & W-L Goh, "CMOS/BiCMOS ULSI" (Prentice Hall) 2002.
SM Sze, "Semiconductor Physics and Technology" (Wiley) 1985, or later Ed.
BG Streetman, "Solid State Electronic Devices" (Prentice Hall), any recent edition.

Due Dates and Other Policies:

Much of this course will be structured as a lecture, but with discussion and student presentations of some topics. Each student is expected to come to class prepared to talk about any assigned topic, with explanations ready, and most importantly, with questions regarding what they have not yet understood. We will try to spend most of the time on the basic physics underlying the device structures and how they function, rather than details of development of the mathematical descriptions; although, questions related to the math may be necessary at times.

Typical time allowed for standard problem assignments will be 10 days to two weeks. Assignments will usually be made after initial discussion of the related material. Short presentation topics will be assigned with at least one class meeting between the assignment and presentation. Except for mutually agreed extensions, late work will receive a deduction of 20% if more than one class meeting past due.

Major project target dates: basic topic area selected by late February, with a narrowed project outline due by mid March, before spring break. The final project paper will be due near the end of the course, with presentations scheduled for the final class meeting(s). Copies of the papers are to be given to the full class. Format guidelines will be provided well in advance of the due date. Detailed feedback can be provided if a draft is turned in at least a week prior to the deadline. It is critical to start this project early and go beyond the general ideas.

Expect to meet time for the project presentations at the scheduled Final Exam time as in University schedule for this class meeting time, unless my travel schedule creates a conflict.

Any student who, because of a disabling condition, may require some special arrangement to meet the course requirements should contact the instructor as soon as possible so that the appropriate accommodations can be made. Proper documentation must be presented from the Dean of Students Office.