EE 397E Introduction to Nanoelectronics
Spring 2012 Syllabus

Professor:
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Office Hours: W, F 11 AM – noon;

Course Web Site: http://angel.psu.edu
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Meeting time: 2 hours every week (Location: TBD)

1. Meeting Times

Section 1 (Datta)	Lecture	M W F	1:25 PM – 2:15 PM	067 Willard

2. Introduction

In this course, we learn the relevant concepts in quantum mechanics and statistical mechanics pertaining to understanding the key physical mechanisms that govern the electrical and optical behavior of semiconductor materials and devices. This course explicitly deals with the physics of operation of electronic and optoelectronic devices, and expounds on the practical aspects of device design given the inherently non-ideal nature of semiconductor devices in real life.

Nanoelectronics today is a very broad discipline that extends the traditional solid-state devices such as transistors, diodes, resistors, capacitors, photodetectors, laser diodes commonly found in electronic and optoelectronic integrated circuits to a variety of emerging technologies such as large area flexible electronics, energy conversion devices, chemical and biological sensors, microelectromechanical devices. A continuous trend of fundamental breakthroughs at the materials and device architecture level keeps this field exciting and opens up new application space hitherto unexplored. The opportunity exists for you to get introduced at a broad level to each of these areas. This course will serve as a cornerstone of your electronics education whether you join the 275 billion dollar global semiconductor industry or you prudently decide to pursue graduate education in the area of advanced materials and devices.

3. Prerequisite:

You must have completed EE 210, or PHYS 214 with a grade of “C” or better for admission into this course.

4. Textbook

Required: Dimitrijev, Sima, Principles of Semiconductor Devices, 2nd edition, Oxford University Press, ISBN 978-0-19-538803-9 (hardback)

5. Educational Objectives:

The lecture sessions provides learning opportunities that should enable you to do the following upon completion of this course:

A. Develop a basic understanding on the following key concepts in quantum and statistical mechanics relevant to physical properties of electronic materials and their device applications:

i. *Quantum Mechanics:*
Crystal structure of solids; space lattices; wave particle duality; Schrodinger's wave equation; particle trapped in a box; particle tunneling through a barrier; allowed and forbidden energy bands; propagating electron wave in a periodic lattice; effective mass; density of states; quantization effects in nanoscale devices

ii. *Statistical Mechanics:*
The Fermi-Dirac and Maxwell-Boltzmann probability distribution function; the Fermi energy;

iii. *Equilibrium vs non-equilbrium properties:*
Carrier distribution at equilibrium; doped semiconductors; compensated semiconductor; carrier transport phenomena; hall effect; excess carriers in semiconductors; continuity equation; Poisson's equation

iv. *p-n junction:*
Carrier distribution and field profile at a p-n junction; diode I-V characteristics and non-idealities, diode capacitance; small-signal AC model of diodes

v. *MOS capacitors and field effect transistors:*
Understand and interpret C-V characteristics; understand the physical structure and detailed operation of Metal-Oxide Semiconductor Field-Effect Transistors (MOSFETs); understand the terminal I-V characteristics of MOSFETs and their associated non-idealities due to scaling, under the AC small-signal model of FETs to analyze frequency limitation of state-of-the-art FETs; high electron mobility transistors; organic thin-film FETs for flexible large area electronics applications;

vi. *Solar Cells:*
Understand the physical operation of solar cell and its efficiency limits; heterojunctions to improve efficiency; potential impact on global energy consumption and greenhouse effects

vii. *Photodetectors and light emitting diodes:*
Understand the physical operation of detectors and LEDs; figure of merits estimation; laser diode operation and device architecture;

B. Become proficient with the fundamental device physics concepts

C. Learn to analyze device characteristics in detail and brainstorm ways towards improving them or adapting them to new applications

6. Grading Policy:

Lecture Related:	Homework	15%
	Quiz 1	25%
	Quiz 2	25%
	Final Exam	35%
	Totals:	100%

7. Attendance:

Attendance at all lecture classes is expected. If you have a conflict with a scheduled exam or with the submission of any in-class assignments, you must make arrangements with your instructor well in advance so that alternate times can be scheduled.

8. Homework:

Homework will be collected in class on most Fridays. For a specific list of homework assignments and due dates, see the course calendar on ANGEL. You may consult with other students and with your instructor while you are working on assigned problems but your goal in consulting should be limited to exploring options and approaches rather than avoiding work. The ability to solve problems develops through disciplined effort and the exams will require you to be able to solve problems. To obtain full credit for a homework assignment you must submit it to your instructor in class on the due date as described in the homework policy posted on ANGEL.

9. Academic Integrity

Most students are honest and work hard for their grades. There should not be an alternate route to a passing grade and a diploma. We expect that all graded work will be done without assistance from anyone else, unless the instructor has explicitly indicated otherwise. Incidents of academic dishonesty will be dealt with according to University policy. The current policy may be found at http://www.psu.edu/dept/oue/aappm/G-9.html