**ELEN 4430 : Physical Principles of Solid State Devices**

**Class Schedule**: 3 Credit course, meeting the equivalent of three 50 minute class periods per week.

**Course Coordinator**: Susan Schneider

**Course Materials**:

Required: B.G Streetman and S. Bannerjee, Solid State Electronic Devices, 6th Edition, Prentice Hall, 2006

**Course Description:** Fundamental physical principles of solid state devices are presented. Brief review of Quantum Mechanics. Applications of modern semiconductor devices that uses the Quantum Mechanics principles. The operation principle of modernsemiconductor devices is explained from Quantum Mechanics and these principles are used toextend the students’ knowledge of devices usedin electronic circuits.

**Prerequisites**: EECE 3010, ELEN 3110, and PHYS 1004 or PHYS 1014.

**Selected Elective** in the Electronic Devices and Systems area.

**Contribution to Professional Component**: Engineering Science 100%

**Course Goals**:

Develop a good understanding of basic semiconductor properties using the valence bond model.

Explain the origin of energy bands in solids. Understanding the basic Quantum Mechanics hypothesis and principles. Apply these hypothesis and principles to semiconductor devices including LED, laser, atomic clock, fluorescence light, SEM, thermocouple, and others. Develop equations that relate the energy band diagram to the doping and carrier concentrations in the material.

Carry out detailed analysis of a pn junction under thermal equilibrium and under an applied bias. Use the analysis to derive equations for important junction parameters such as depletion width, depletion capacitance, junction breakdown voltage, etc.

Describe the main properties of a metal oxide semiconductor system, first qualitatively and then quantitatively. Obtain equations that can be used to calculate surface charge conditions as a function of an applied gate bias.

If time permits, review basic operation of a bipolar junction transistor (BJT) and derive equations for emitter injection efficiency, base transport factor, short circuit current gain α, etc.

**Course Objectives**:

*By the end of this course, you should be able to ….*

1. Use valence bond model to derive equations relating carrier concentrations, conductivity, and doping levels in a semiconductor material. Apply these equations to calculate electrical properties of n and p type materials.

2. Use a simplified potential and boundary conditions to calculate energy levels of electron.

3. Use quantum mechanical hypothesis to calculate wavelength of electron.

4. Explain the basic concepts of energy band theory. Derive equations relating Fermi level to doping and carrier concentrations.

5. Analyze the operation of a pn junction under thermal equilibrium and under an applied bias. Calculate various junction parameters such as depletion width, depletion capacitance, electric field in the depletion region, breakdown voltage, etc.

6. Describe the various charge conditions such as accumulation, depletion, and inversion that can occur at the silicon – silicon dioxide interface in a metal oxide silicon (MOS) system. Be able to calculate the surface conditions in a MOS system as a function of the bias applied to the gate.

7. Calculate important parameters of a MOS transistor such as threshold voltage, oxide capacitance, charge stored in the semiconductor, etc.

**Contribution to Program Objectives**: partial fulfillment of Criterion 3 objectives A, E, G, K

**Course Topics**: in Text

Basic Semiconductor material properties Chap. 1

 Introduction to quantum mechanics Chap. 2

 Energy Bands and Charge Carriers in

 Semiconductors Chap. 3

 Properties of Semiconductors Chap. 4, sec. 4

 PN Junction diodes Chap. 5, sec. 1 - 6

 Field-Effect Transistors Chap. 6

 Integrated Circuits Chap. 9, sec. 1 – 3, 5

Bipolar Junction Transistors (If time permits) Chap. 7, sec. 1 – 4.