EE 442 – Solid State Devices

Designation: EE elective course for electrical engineering majors.

University Bulletin Description: EE 442: (3) The physics of semiconductors as related to the characteristics and design of solid-state electronic devices.
Prerequisites: EE 310, EE 397E or ESC 314.

Prerequisites by Topics:
1. Understanding of solid-state device physics at an introductory level (ESci 314).
2. Understanding of basic circuit uses of solid-state devices (EE 310).
3. Proficiency in the use of PSPICE.
4. Proficiency in a computer programming language.

Textbook/Required Materials:
Devices for Integrated Circuits: Silicon and III-V Compound Semiconductors, H. Craig Casey, John Wiley & Sons, Inc., 1999.

Learning Outcomes:
This course provides a senior level introduction to solid-state device physics. Through lectures and out-of-class problem, design and computer assignments students are provided learning experiences that enable them to:
1. Understand the basic physics of electrons in solids and carriers and carrier transport in semiconductors.
2. Understand the physics and design elements of p-n junctions.
3. Understand the physics of and design elements of silicon MOSFETs.
4. Understand the physics and design elements of homojunction bipolar transistors.
5. Understand and utilize physics-based devices models (for example, PSPICE) for device and circuit analysis.

Topics:
1. Electrons in solids (4 lectures)
2. Carrier transport (4 lectures)
3. Recombination (2 lectures)
4. p-n junction I-V electrostatics (3 lectures)
5. p-n junction forward I-V (3 lectures)
6. p-n junction reverse I-V and breakdown (1 lecture)
7. p-n junction capacitance and small signal characteristics (2 lectures)
8. Schottky-barrier diodes and MESFETs (3 lectures)
9. MOS capacitors (3 lectures)
10. MOSFET DC characteristics (4 lectures)
11. MOSFET scaling (2 lectures)
12. MOSFET small signal characteristics (2 lectures)
13. MOSFET circuit models (2 lectures)
14. Homojuction bipolar transistor DC characteristics (5 lectures)
15. Homojuction bipolar transistor small signal characteristics (2 lectures)

Class schedule: Three 50-minute lectures per week.

Computer Usage:
1. Students write programs to calculate junction depletion and capacitance for a p-n junction with arbitrary doping and C-V behavior for an MOS capacitor.

2. Students learn to manipulate physics-based circuit element models and use PSPICE to examine and/or design p-n junction diodes, MOSFETs, and BJTs.

Contribution to Meeting the Requirements of Criterion 5. Curriculum:
This course contributes to both the engineering topics and design components.
This course provides a design emphasis in the area of solid-state devices. It provides a senior-level introduction to device physics, an introduction to the physics dependence of devices for integrated circuits, a foundation for the use of device models in circuit analysis and design tools, and motivation for life-long learning.

Relationship to Program Outcomes:
O.1.1. Graduates will possess mathematics skills necessary for electrical engineering.
O.1.2. Graduates will have a theoretical and practical background in both physics and chemistry.
O.1.3. Graduates will have attained computer proficiency.
O.2.2. Graduates will understand electronic devices.
O.3.1. Graduates will have in-depth technical knowledge in one or more areas of specialization.
O.3.2. Graduates will have practical understanding of the major electrical engineering concepts and demonstrate application of their theoretical knowledge of the concepts.
O.4.1. Graduates will interact with industry both within and outside of a classroom setting.
O.4.2. Graduates will develop an appreciation of continuing educational and professional development.
O.6. Graduates will appreciate their role as engineers in society.

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