EE 441 – Semiconductor Integrated Circuit Technology

Designation: EE elective course for electrical engineering majors.

University Bulletin Description: EE 441: (3) An overview of fundamentals of processes involved in silicon integrated circuit fabrication through class lectures and hands-on laboratory.
Prerequisites: EE 310, EE 397E or ESC 314.

Prerequisites by Topics:
1. Knowledge of the basic physics of semiconductor materials.
2. Knowledge of the physical principles of operation of key semiconductor devices both field-effect (MOS in particular) and bipolar (BJT in particular).
3. Understanding of the principles of digital and analog circuits.
4. Proficiency in the use of computational tools for the purpose of process modeling and simulation.
5. Proficiency in the use of basic equipment used in electrical characterization of semiconductor devices.

Textbook/Required Materials:
* Handouts
* Text book:R.C. Jeager, *Introduction to Microelectronic Fabrication,* 2nd Edition, Prentice Hall, 2002; Additional resource: S.A. Campbell, *The Science and Engineering of Microelectronic Fabrication,* 2nd Ed., Oxford University Press, 2001
* Web-based references

Learning Outcomes:
Educational objective of this course is to teach students through lectures, laboratory and homework assignments fundamentals of semiconductor integrated circuit technology with emphasis on ULSI silicon IC fabrication. Specific educational tasks that this course aims to accomplish include:
1. Become familiar with a process of developing a monolithic integrated circuit and with types of monolithic integrated circuits.
2. Learn what type of operations are involved in converting silicon wafer into a complex integrated circuit.
3. Learn in detail basics of all operations used to manufacture a silicon-based monolithic integrate circuit.
4. Gain experience in the modeling and simulation of semiconductor manufacturing processes.
5. Gain a hands-on experience in carrying out key operations needed to fabricate monolithic silicon-integrated circuit.
6. Become proficient in the measurements of key electrical parameters and characteristics of MOS capacitors and simple MOS integrated circuits

Topics:
1. Overview of processes in EE 441 laboratory
2. Introduction: Semiconductor integrated circuits, overview of microelectronic technology, basic processing steps in IC manufacturing
3. Fabrication of silicon wafers and Si-based engineered wafers
4. Wafer surface cleaning and engineering technology
5. Thin Layers of single crystal silicon; epitaxial deposition, SOI substrates
6. Dielectric materials in silicon device technology; advanced MOS gate technology; high-k dielectrics.
7. Pattern definition: lithography and etching
8. Selective doping techniques: diffusion and ion implantation
9. Contacts and interconnects; copper and low-k dielectrics.
10. Assembly and packaging

Class/laboratory schedule: Two 50-minute lectures and one 3-hour laboratory per week.

Computer usage:
1. Modeling and simulation of selected processes in an integrated circuit manufacturing.
2. Data collection and processing in laboratory projects as well preparation of formal technical report.

Laboratory Projects/Assignments:
During laboratory sessions in this course students fabricate an MOSFET Al-gate contact based chips containing both discreet MOS devices as well as simple integrated circuits. Laboratory experience is used to strengthen through hands-on experience the knowledge of concepts introduced and discussed in class, followed by measurements of electrical characteristics of fabricated devices. The following are the four parts of the laboratory project:
1. First, at least two laboratory sessions are devoted to the introduction of microelectronics laboratory procedures as well safety requirements.
2. Starting with bare silicon wafers, students manufacture, typically in the course of about seven laboratory sessions, a complete MOS microchip using set of four masks prepared ahead of time.
3. Wafers with processed devices and circuits are subjected to electrical testing during typically 2-3 laboratory sessions.
4. Students individually prepare formal report summarizing experimental procedures and results obtained.

Contribution to Meeting the Requirements of Criterion 5. Curriculum:
This course contributes to both the engineering topics and design components.
This course stresses manufacturing aspect in the area of electronic and photonic materials and devices.
The course is also taken by other than EE majors including materials science and engineering, physics, and engineering science and mechanics. It is a prerequisite to the follow up advanced semiconductor manufacturing graduate level course (EE 518).

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.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.5.1. Graduates will have good teamwork skills.
O.5.2. Graduates will possess good oral and written communication skills.
O.6. Graduates will appreciate their role as engineers in society.

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