EEE 5324 Silicon Integrated Circuit Fabrication

Credits: 3 credits

Textbook, title, author, and year: Silicon Processing for the VLSI Era, Volume 1 - Process Technology, Second Edition, By: S. Wolf and R. N. Tauber. ISBN: 0-9616721-6-1.

Reference materials: Research papers will be given at the end of lectures to read and understand

Specific course information:

Catalog description:

The aim is to provide an introduction to the basic steps and processes of fabricating integrated circuit semiconductor devices. Fundamental semiconductor physics concepts will also be covered. Concepts and processes related to BioMEMS and microfluidics will also be explained.

Prerequisites: Circuits I and Electronics I are prerequisite for this course. Students from other departments can also take this course with instructor's permission.

Specific goals for the course:

To introduce the students to the concepts of silicon integrated circuit fabrication processes and modules. The students will be able to understand the standard device fabrication processes and design the methods to fabricate and test Nano-devices using fabrication processes. Students will be able to analyze data and interpret results obtained from fabrication processes.

Students will be able to function on multidisciplinary teams to design and solve challenges related to nanotechnology and device fabrication. Students will be able to communicate effectively after the end of this course**.**

Brief list of topics to be covered:

1. Semiconductors and Insulators: Definition, crystal structures, physical properties.
2. Wafer Fabrication: Czochralski (CZ), Float Zone (FZ), Molecular Beam Epitaxy
3. Crystal Defects: Monovacancy, Divacancy, Microvoids, Voids, Antisites, Interstitials, Dislocation, Stacking fault, Grain Boundaries, Precipitates.
4. Diffusion:
   - Fick's first and second law and their solutions
   - Mechanism of diffusion
   - Profile and Junction Depth and techniques of their determination
   - Effect of electric field on diffusion process
   - Impurity diffusion in IC fabrication (Boron, Phosphorus, Ar).
   - Principles of SUPREM process simulation
   - Diffusion Systems [equipment, sources (gas, liquid, solid)]
   - Measurement techniques.
5. Thermal Oxidation and Nitridation of Silicon
   - Oxidation kinetics (general solution, Parabolic and linear growth and empirical modifications to the growth rate of SiO_2 and its kinetics)
   - Thermal Nitridation
   - Factors in oxidation
   - Applications of oxide and nitride layers in IC fabrication.
   - SiO_2/Si interface, charge traps and impurities redistribution at the interface.
   - Oxidation systems.

Measurement techniques

6. Ion Implantation:
   Dose, Beam Current, Range and Projected Range
   Projected and Lateral Straggle
   Ion Stopping (nuclear and electronic energy loss mechanism)
   Implantation in amorphous and single crystal (channeling effect)
   Ion implantation damage
   Electrical activation and implantation damage recovery (Annealing and RTP)
   Ion Implantation equipment
   Masking layers
   Shallow Junction
   Measurement techniques
7. Photolithography:
   Photolithography steps (Coat, Soft bake, Patterning and Exposure, Post Exposure Bake, Develop, Inspection)
   Photoresists (positive and negative)
   Resist chemistry (Photo sensitive and base)
   Physical properties (Sensitivity, Photo Speed, Resolution, etc.)
   Coat and Coaters (Thickness control, uniformity, etc.)
   Soft Bake and its effects on the film properties and consequent steps
   Patterning and exposure, Criteria, limits, resist dependency, equipment, alignment, etc.)
   Bosung Curves, Focus-exposure matrix
   Post Exposure Bake, and its effects on the pattern
   Develop (batch, spray, and puddle)
   Developer chemistry, develop time
   Critical Dimensions (CD) and Inspection (pattern integrity, notching, bridging, etc.)
8. Interconnects:
   Metal (Al, Ti, TiN, W, etc.)
   CVD and PVD techniques and systems,
   Al, Al:Si, Al:Si:Cu in VLSI (properties, alloys, etc.)
   Sputter Deposition for VSLI (glow discharge, RF sputter, magnetron sputter, mechanism, deposition rate, advantages and disadvantages, etc.)
   Contacts and Vias
   Morphology and Step Coverage, Aspect Ratio
   Refractory Metals and applications
   Barrier metals
   Ohmic and Schottky contacts
   Silicide formation
   Effects of contamination (water, carbon, etc.)
   Planarization and Passivation
   Chemical Mechanical Polishing
9. Etch:
   Etch type (wet, dry)
   Dry Etch, Plasma etch (Process, mechanism, its chemistry and physics)
   Reactive Ion Etching (Process, mechanism, characteristics. damage etc.)
   Wet Etching (chemical and chemistry, etch rate, application and process, etc.)
10. Process Integration and Device Fabrication (all steps)