Course Outline 2016-1
ENSC495/851: Introduction to Microelectronic Fabrication
(ENSC 495, 4 credits, 2-0-4: ENSC 851, 3 credits, 2-0-1)

Professor:

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Description

- Hands-on introduction to Integrated Circuit Fabrication.
- lectures: theoretical background & application of IC fabrication processes
- laboratory gives practical experience of each process
- Students build an IC from the bare silicon to final working device.

Primary text:

- "Introduction to Microelectronic Fabrication, 2nd ed", Richard C. Jaeger, Prentice Hall 2002
- Notes downloadable from

web:www.ensc.sfu/~glennc/e495out.html

Other references:

- "Microelectronic Processing", W.S. Ruska, McGraw-Hill
- "The Science and Engineering of Microelectronic Fabrication", Stephen Campbell, 2nd ed, Oxford Univ. Press.

Laboratory Engineer & TA's

- Lab Engineer: Andras Szigeti, aszigeti@sfu.ca Rm ASB 8832
- TA: Amin Rasouli, mrasouli@sfu.ca

Class notes and website
http://www2.ensc.sfu.ca/~glennc/e495out.html

Prerequisite:

- Students need understanding of basic transistor & diode operation. ENSC 220/ENSC 225 (Electronic Design I) or equivalent and application to the class

Lecture Schedule

- Lecture: Tuesday 17:30 - 19:20 SCEB1012

Week 1: Clean Room Technology & Silicon Wafer Production

- Basic outline of fabrication process: with to real structures.
- Theory behind clean room operations:
- History of semiconductor devices: diodes, transistors, Germanium/Silicon transition, monolithic integrated circuits
- Basic operation of Transistors, diodes
- Projected trends in Fabrication
- Theory and operations for contamination elimination, and safety issues.
- Silicon wafers; Crystallography, Production and Defects:
- Basic silicon wafer parameters, solid solubility of dopants in silicon, defects, and basic economics of operations.

Week 2: Thermal Oxidation

- Basic theory of the silicon oxidation, practical operations and measurement of films (thickness and quality).
- Tsupreme 4 simulation package introduction

Week 3: Lithography

- Basic operation of photolithography, chemical basis of photoresist, exposure equipment, exposure/development theory, and problems.

Week 4: Advanced Lithography
- Dealing with defects and exposure effects
- Advanced Lithography, Deep UV, Extreme UV, X-ray

Week 5: Etching
- Theory and operations of etching in general;
- Wet (chemical) etching of oxides

Week 6: Etching II
- Wet etching of silicon and metals

Week 7: Diffusion Processes & Ion Implantation
- Diffusion theory (constant, limited source, multisource).
- Theory and operation of Ion implantation doping techniques.

Week 8: Thin Film Deposition: Evaporation and Sputtering
- Theoretical and experimental operation of vacuum systems.
- Theory and operation of evaporation and sputtering systems

Week 9: Thin Film Deposition: Chemical Vapor Deposition
- Theory and operation of Chemical Vapor Deposition (CVD), Plasma Enhanced CVD
- Film thickness measurement and film problems

Week 10: Expitaxy CVD and Dry Etching Processes
- Expitaxy (deposition with same crystal structure) & laser CVD
- Dry etching processes (Plasma, Sputtering and Reactive Ion)

Week 11: Packaging, Yields, Processing Silicon Foundries
- Testing, dicing of wafers, packaging, bonding, yield theory and measurements.
- Measurement techniques: Optical microscope, Scanning Electron Microscope, energy dispersive analysis of X-rays, Augue analysis, Secondary Ion Mass Spectroscopy (SIMS), Laser Ion Mass Spectroscopy (LIMS), Rutherford Backscatter Spectroscopy (RBS), X-ray diffraction.
- Silicon Foundries

Week 12: CMOS and Bipolar Process Integration in practice
- Layer by layer process of sample CMOS and Bipolar
- Yield Analysis
- Using mask design tools

Week 13: Future of the processing
- Problems in submicron technology and Micromachining/sensors as a new fabrication area.
- Summary of main course points.

Laboratory Section

Labs: LA01 Wed. 17:30-21:20, ASB 8823
LA02 Thur. 14:30-18:20, ASB 8823 (if class is large enough)

Projects in Microfacation Lab

Students will work in 3-4 people teams which start with a bare silicon wafer and create finished IC's which include diodes, solar cells, transistors and some characterization test devices. All the process steps will be done by the students, who will also characterize the parameters for each step. Electrical characterization of the devices (diodes etc) will also be accomplished. Students get to keep samples of their own IC's. Two Laboratory reports must be submitted.

Week 1: Tour of Microfabrication facilities

- Tour of the microfabrication facilities, inspection of chips under microscopes. Learn to don clean room suits, gloves, handling wafers, use of tweezers

Week 2: Demonstration of laboratory processes

- Demonstration of oxide growth: learning how to preoxidation clean wafers, run oxidation furnaces, control of flow values, insertion/withdrawal of wafers, and measure the oxides.

Week 3-5: Growth/patterning of oxide film & P diffusion

- Set up furnace and grow oxide to stated thickness.
  measurement oxide thickness
- Characterize grown film: measure thickness.
- Pattern the first oxide layer
- P diffusion (source/drain and bipolar base)
- First Lab report done on this work

Week 6-13: Build simple 4 level structures:

- Build simple diffused diode, solar cells and test structures.
- Clean wafers, grow oxide, define oxide layers with photolithography.
- N+ diffusion (source/drain & bipolar collector) measure results.
- Oxide regrowth, measure thicknesses.
- Define contact cuts, etch oxide, inspect and measure contact size.
- Learn operation of simple sputter coater (thin film deposition).
- Deposit metal and measure thickness via profilometry.
- Deposit metal (contacts and gate), define/etch, measure thickness and line widths.
- Measure simple diode and transistor characteristics.
- Measure test devices: metal and diffusion sheet resistance, contact chains

Assignments

Assignments will be given every 2-3 weeks after the second week of class. Assignments will be emailed to the students. Each student gets a separate assignment with the same questions but different parameters and solutions. You will be emailed a solution set to your specific questions. If you used someone else's numbers you get zero on the question. If you do that twice within one assignment you get zero on the assignment. Happens on a second assignment an academic dishonesty report is filed.

Mid Term and Final Exam

- One mid term test (about week 6) and final examination

Tutorial/Problem Workshops

Tutorials will be held on an as announced basis (not every week but about every 2nd week). These will involve workshops where a problem is assigned, worked through in groups, and then solutions given. Typically 2 problems per session. Mostly these will be done during the lab portion, but there may be some extra sessions.

Graduate Students

Graduate students in the MASc or PhD program have two options.

- They can take the lab up to end of Week 5 and do the first report, and then do a Major processing project in the laboratory during the rest of the course. Major projects are only available for graduates doing microfab involved research in their thesis program.
- Alternatively they may do the entire laboratory like the undergraduate, with two Lab reports and extended tests on lab 2.

Mark Distribution

Student will receive the highest of the following distributions:

ENSC 495

- 30% laboratory reports, 20% problem assignments, 10% mid term, 40% final exam.
- 25% laboratory reports, 25% problem assignments, 50% final exam.

ENSC 851

- 30% lab reports, 20% problem assignments, 10% mid term, 35% final exam.
- 25% lab reports, 40% Major Project, 20% problem assignments, 15% mid term.