Course Information (1)

• Lecture
  – 11:10 to 12:30 pm Tuesday, Thursday
  – Room: Cory 241

• Instructor:
  – Professor Ming C. Wu
  – 511 Sutardja Dai Hall (SDH), wu@eecs.berkeley.edu
  – Office hours: tba
  – Best way to communicate: Email

• GSIs:
  – Mark Hettick, Head GSI
  – Korok Chatterjee
  – Dominic E. Labanowski (10 hour GSI)
  – Thomas Rembert
Course Information (2)

• Prerequisites:
  – EE16A/B and Physics 7B or equivalent

• Course Description
  – EE143 teaches the fundamentals of integrated-circuit (IC) fabrication, giving the student a basic understanding of IC processes and the effect of processing choices on device performance.
  – Students learn to use process simulation tools and also fabricate and characterize devices in the laboratory.
  – This lecture part will cover the processing techniques and design methodologies of microfabrication.

Course Information (3)

• In addition to transistors and IC’s, you will fabricate simple MEMS (micro-electro-mechanical systems) structures

• The second part of the course will cover process simulation, layout design rules, MOS, IC, and MEMS process integration.

• The laboratory part of the course will provide students opportunities to have hands-on experience to fabricate and characterize a NMOS chip with simple MEMS components.
Textbook

- Introduction To Microelectronic Fabrication (2nd edition)
  - R. C. Jaeger
  - Prentice Hall

- Minimum reading
  - Assigned sections in syllabus

- Best to read the relevant sections before lecture
  - Enables meaningful in class discussions

Reference Book for MOS Devices

- Modern Semiconductor Devices for Integrated Circuits
  - Prof. Chenming Hu
  - Prentice Hall, 2010

- Available online
Course Web Sites

• Open website
  – General course info, lecture notes, Labs, HW problems
  – http://www-inst.eecs.berkeley.edu/~ee143/fa16/

• bcourses
  – https://bcourses.berkeley.edu/
  – Grades (check frequently, and inform your GSI if you find any discrepancy)
  – HW solutions
  – Exam solutions

• Piazza
  – Discussions

Grades

• Laboratory: 35%
  – Includes quizzes, lab work, and reports
  – You must complete all labs to pass the course!

• Homework: 5%
  – Lowest score will be dropped from grade calculation
  – (You can miss one HW without impacting your grade)

• Midterms: 15% x 2 = 30%

• Final Exam: 30%
  – Closed book. 3 sheets of notes allowed.

• Cheating will result in automatic Fail
Laboratory Requirements
(35% of the total grade)

• Lab attendance: 10 pts (5% of the total grade).
  – Each absence results in -2 pts. Each lateness results in -1 pt.
  – Students receiving a lab attendance grade of 0 pts or less will automatically fail the course.
  – Make-up lab sections are allowed (student will be attending a different lab section for that week), however, prior written request must be submitted to Professor Wu. Students attending pre-approved make-up sections will not lose points.
  – Note that being unprepared, unwilling to participate in the lab activities, and/or not following the safety procedures will result in losing lab attendance points.

• Lab Quizzes: (5% of the total grade).
  – They will be given often (unannounced) at the beginning of each lab.

• Lab Report 1: 100 pts (15% of the total grade).
• Lab Report 2: 100 pts (10% of the total grade).
  – Note for both Lab Reports: For every day that it is turned in late, you will lose 20 pts. We will not collect after 4 days past the deadline.

Midterm & Final Dates

• Midterm 1:
  – 10/4/16 (Tue) in class

• Midterm 2:
  – 11/1/2015 (Tue) in class

• Final Exam:
  – 12/14/16 (Wed), 8-11 am

• General rule: no early or late exams
  – Rare exceptions, e.g., presenting a paper in a conference
  – Need to inform the instructor well in advance
Course Structure – Lab and Lecture

• You learn the theories in class; you practice them in lab

• You are going to make:
  – Resistors, diodes, MOS-cap
  – Bipolar transistor, MOS-transistor, …
  – Some MEMS structures, like beams, …

• By the end of the semester, you should have learned
  – Basic lab techniques
  – How to operate some fabrication equipment
  – How to characterize the devices you made

Lecture Schedule

• Introduction to Materials and Processing (1-2 weeks)
• Photolithography (2 weeks)
• Etching (1 week)
• Oxidation (1 week)
• Deposition (1 week)
• Diffusion (1 week)
• Ion Implantation (1 week)
• Metallization/CMP (1 week)
• Simulation/Layout
• Process Integration (throughout)
• Introduction to Devices (2 weeks)
The EE143 Chip

This is How Your Chip Looks Like
Measure Your Devices

- The resulting structures may be characterized electrically or mechanically

17-stage Ring Oscillator

Laboratory Information

- Lab starts in the week of Aug. 29
- We do our best to limit lab size to 6 students; as a result, your telebears enrollment is not a guarantee of being assigned to a lab.
- You MUST send an email to Professor Wu (wu@eecs.berkeley.edu) by this Friday 10am including the following information:
  - Email Subject: EE143 Lab
  - 1) Full Name
  - 2) Major
  - 3) Year (Jr., Sr., Grad student, etc.)
  - 4) Rank list of preferred lab sections in descending order of preference (i.e., 1st choice, 2nd choice…)
  - 5) List of any lab sections that you CANNOT attend
- Failure to send an email by this Friday may result in you being dropped from the course, even if you are registered on telebears.
- Final lab assignment will be sent to you via email. PLEASE ENSURE THAT YOUR EMAIL ADDRESS ON TELEBEARS IS CORRECT, SINCE THIS WILL BE USED FOR OFFICIAL CORRESPONDENCE!!!
Lab Cleanliness

- Fully gowned before entering cleanroom
  - Hair net + lab coat + glove + shoe net + safety goggles
- Do NOT touch chemicals / equipment with bare hands
- Always handle wafers with tweezers and trays (unless told otherwise)
- Wash hands before and after entering the lab (why??)
  - Before: so as not to contaminate wafers or equipment
  - After: avoid chemicals being ingested
- 3rd week, GSIs will demonstrate how to clean masks
- 4th week, GSIs will demonstrate how to piranha-clean wafers

Lab Safety

- First week is on Lab Safety (week of Aug. 29)
- Mandatory Lab attendance required
- You will have a lab orientation session, and will have to pass a safety quiz before you are officially enrolled in this course.
- You MUST attend the lab session to which you are assigned.
Lab Safety

• Do NOT enter the lab when GSI aren’t present
• Know all the emergency exits
  – Ask GSIs to show you
• Know where to find the MSDS
  – Under the whiteboard in characterization room
• Know where to find the closest water sources, shower, eye wash, sink
• Always ASK if you are not sure what to do!
  – Do NOT try things out without permission
• NO eating, drinking, playing, etc. inside the lab
• Things in the lab can be dangerous if not carefully handled. Be sure to respect the chemicals.

Chemical Handling

• Wear protective gear when handling corrosive chemicals
  – Face shield, chemical apron, chemical gloves, respirator if necessary
• Check glove for holes
• Check pH of unknown spillage, label everything
• Corrosive chemicals: H₂SO₄, HF, aluminum etch, TMAH
• Wash and rinse the exposed body parts with water for > 15 mins
• Add acids to water, not the other way around
• Handle wet chemicals only at sinks, acid on right, others on left side
Chemical Handling (cont’d)

- HF:
  - be very very careful
  - HF will penetrate your body and attack your skeletal system; once you feel it, it is already eating your bones!!!
  - apply calcium gluconate if exposure is suspected
  - use only plastic beakers for HF (why??)

- H2SO4:
  - very painful, severely burns
  - add H2O2 to H2SO4 to prepare piranha
  - do not carry the beaker around after mixing (HOT!!)
  - use only glass beakers for piranha (why??)

- Chemicals used in the lab are often harmful. Don’t breathe and avoid exposure if possible.
- Use Teflon-ware when handling wafers in acids. Be careful, those Teflon tweezers do not hold the wafers very well!!

Chemical Disposal

- Organic chemicals are discarded in designated containers
- NOTE: in this lab, photoresist (PR) is also dumped down the drain.
- Do NOT mix organic wastes with acids (why??)
  - Can cause fire or even explosion
- Do NOT mix acids and bases
Lab Floor Plan

Note: Not drawn to scale

Characterization Lab
- Station 1
- Station 2
- Station 3
- Station 4
- TA Station
- Gowning Area

Clean Room
- Microscope with camera
- Oven, hotplates
- Spinning
- Mask aligner
- Nanosep
- 4-point probes

Cory Hall Corridor

Lab sink (organic solvents)
Solid sink (acids)
Furnace
Gas tareios
Evaporator
Chemical cabinets
Shower
Sink

Lab Floor Plan

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