

ECE 543
Introduction to Microfabrication and MEMS
Fall 2006

Class Time/Location:

EH 215
MWF 1:00 - 1:50 PM

Office Hours:

BRB 239
WF 9-10

Instructor:

Dr. Shamus McNamara
BRB 239
shamus.mcnamara@louisville.edu

Textbook:

Introduction to Microelectronic Fabrication
Richard C. Jaeger

Grading:

| | | |
|----------|------|----------------|
| Homework | 30 % | A+ Top Student |
| Exam #1 | 15 % | A 90 - 100 |
| Exam #2 | 15 % | A- 85 - 90 |
| Exam #3 | 15 % | B+ 80 - 85 |
| Project | 25 % | B 70 - 80 |

Homework:

There will be a weekly homework assignment that is typically due every Friday. Late assignments will be accepted at a penalty of 10% per day. Late assignments will not be accepted after the solution is posted. You may work with other students on the homework, but **do not copy** from another student or from homework solutions obtained elsewhere.

Exams:

There will be three exams during the semester. No books or notes are allowed for the exams. A formula sheet will be provided. A copy of the formula sheet will be handed out prior to the exam. Calculators are permitted, but I request that you do not use them to store equations or text.

Project:

The project is due at the end of the semester. The project will include the following elements: layout, process flow, hand calculations, and finite-element simulation. Additional details of the project will be given out later in the semester. **You must receive a minimum of 70% on the project to receive a passing grade.**

| Week | Date | Topics |
|------|-----------------------------|--|
| 1 | Aug. 21, 23, 25 | Introduction, Overview of microfabrication, Yield and Cost, Photoconductor |
| 2 | Aug. 28, 30, Sept. 1 | Lithography, Evaporation (thermal & e-beam) |
| 3 | Sept. 4 | No Class – Labor Day |
| | Sept. 6, 8 | Diode, Thermal Oxidation |
| 4 | Sept. 11, 13, 15 | Diffusion |
| 5 | Sept. 18, 20, 22 | Ion Implantation |
| 6 | Sept. 25 | Review |
| | Sept. 27 (Wed) | Exam #1 |
| | Sept. 29 | BJT, Epitaxy |
| 7 | Oct. 2, 4, 6 | Isotropic wet etching, cleaning |
| 8 | Oct. 9 | Mid-term break |
| | Oct. 11, 13 | Accelerometer, Electroplating |
| 9 | Oct. 16 | Lapping & Polishing, Review |
| | Oct. 18 (Wed) | Exam #2 |
| | Oct. 20 | Pressure Sensor, Plasma, Sputtering |
| 10 | Oct. 23, 25, 27 | Sputtering, Anisotropic Etching |
| 11 | Oct. 30, Nov. 1, 3 | Deep Boron Diffusion, CMOS |
| 12 | Nov. 6, 8, 10 | Dry etching: plasma, RIE, ICP |
| 13 | Nov. 13, 15 | Chemical Vapor Deposition |
| | Nov. 17 (Fri) | Exam #3 |
| 14 | Nov. 20 | Project Details, Layout, Simulations |
| | Nov. 22, 24 | Thanksgiving break |
| 15 | Nov. 27, 29, Dec. 1 | Computer Simulations, DRIE, Wafer to Wafer Bonding |
| 16 | Dec. 4 | Packaging Project DUE |

Homework typically due on Fridays (dates in bold)

COURSE LEARNING OUTCOMES

At the completion of ECE543, the student should be able to accomplish the following:

1. Be able to answer short qualitative questions about semiconductor fabrication techniques.
2. Be able to calculate thermal oxidation thicknesses for a given set of processing conditions.
3. Be able to calculate a dopant profile for diffusion, for both constant and limited source diffusion and for a drive-in.
4. Be able to calculate a dopant profile for ion implantation, before and after annealing.
5. Be able to answer short qualitative and quantitative questions about the various thin-film deposition techniques, including evaporation, sputtering, CVD and epitaxy.
6. Be able to answer short qualitative and quantitative questions about microelectronic yield.
7. Be able to answer short qualitative and quantitative questions about MEMS processes, MEMS devices and their applications.
8. Be able to layout a device using a CAD software package, such as LEDIT.
9. Be able to model fabrication processes using a CAD software package, such as SUPREM.

ECE 544 Microfabrication/MEMS Laboratory

Fall 2006

Catalog Data

ECE 544 Microfabrication/MEMS Laboratory. Credit: 1. Prerequisite or co-requisite: ECE 543. Cleanroom laboratory experience in which the student becomes familiar with microfabrication processes, semiconductor measurement techniques, MEMS/IC device fabrication, and device testing. **Consent of Instructor required.**

Prerequisites

Minimum of senior level standing plus the following courses:

CHEM 201, 203

PHYS 295, 296, 298, 299

EMCS 101, 102 or MATH 205, 206

ECE 543 Lecture Course (co-requisite)

Coordinator

Kevin M. Walsh, Professor of Electrical and Computer Engineering

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Labs

Tues. / Thurs., 2:00 – 4:45, Lutz Hall 011

Textbook

Richard Jaeger, Introduction to Microelectronic Fabrication, Second Edition, Addison Wesley, 2002

UofL website – www.mems.louisville.edu

References

Semiconductor Devices: Physics and Technology by S.M. Sze, Microchip
Fabrication by Peter Van Zant

Semiconductor Integrated Circuit Processing Technology by Runyan & Bean

Goals

This course is designed to provide a valuable hands-on laboratory cleanroom experience in the areas of microfabrication and MEMS technology. During the semester, a MEMS or IC device, such as a bulk-micromachined piezoresistive pressure sensor, is designed, fabricated, packaged and tested using state-of-the-art resources in the class 100 Lutz MicroTechnology cleanroom. Computer simulation and design tools for MEMS and microfabrication processes are implemented.

Prerequisites/co-requisites by Topic

1. Basic microfabrication processes
2. MEMS technology and applications
3. Basic concepts of college chemistry
4. Basic concepts of college calculus
5. Chemistry and physics laboratory experience

Topics

1. Cleanroom principles and safety issues (1 class)
2. Microfabrication/MEMS processes (9 classes)
3. Measurement and analysis techniques (1 class)

4. MEMS/IC packaging/testing (2 classes)
5. Examinations (1 class)

Computer Usage

L-EDIT, SUPREM, and MATHCAD software packages.

Laboratory Projects

A MEMS/IC device, such as a bulk-micromachined piezoresistive pressure sensor, is designed, fabricated, packaged and tested using state-of-the-art resources in the class 100 Lutz MicroTechnology cleanroom.

Evaluation Methods

Lab Notebook/weekly reports 40%, Final Report 40%, Lab Performance 20%.

Lab Grade

A 90 - 100% B 80 - 89% C 70 - 79% D 60 - 69% F 00 - 59%

NOTE: After missing one lab, a loss in letter grade will result for each additional lab session missed. Cheating or Plagiarizing will result in a failing grade (F).

Graduate Requirements

There are no additional graduate requirements for this 1-hour laboratory course. The additional graduate requirements have been addressed in the accompanying lecture course (ECE 543).

Estimated ABET Category Content

Engineering science: 0.5 credits or 50%, Engineering design: 0.5 credits or 50%

ABET COURSE OUTCOMES: At the completion of ECE544, the student should be able to accomplish the following.

1. Be able to answer short qualitative questions about semiconductor fabrication techniques and the equipment used for those processes.
2. Be able to demonstrate to the TA their ability to perform various microfabrication processes in the cleanroom, including thermal oxidation, thermal

diffusion, photolithography, sputtering, wet etching, plasma etching and anodic bonding.

3. Be able to package and test a custom-fabricated device.

4. Be aware of safety issues and demonstrate an ability to function in the cleanroom in a safe and deliberate manner.

5. Be able to maintain a lab notebook and record observations/results both clearly and effectively.

6. Be able to summarize their lab experience by writing an effective final laboratory report.