

# HANDOUT # 1 ECE 870, F'11

## Course Info: 07/27/10

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## ECE 870: Introduction to MEMS

(MEMS: Micro-Electro-Mechanical Systems)

**LIVE LECTURE SCHEDULE: 2320 EB, 06:40 - 08:00 p.m., M W**

### INSTRUCTOR AVAILABILITY:

Mondays, Wednesdays: 4:15 – 5:00 p.m.

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Course TAs: **Zongliang Cao**; [alanczl@gmail.com](mailto:alanczl@gmail.com), **Sean Hatch**; [s.g.hatch@gmail.com](mailto:s.g.hatch@gmail.com)

### Unique Aspects of ECE870

- ❖ Doctoral students assist Prof. Dean Aslam in the teaching of MEMS simulation using CoventorWare.
- ❖ Although the main lecture material will be offered by Prof. Dean Aslam, additional lecture videos will be available from the University of Michigan, MIT and other websites.
- ❖ This is the only MSU course covering fundamentals of MEMS.

### Course Introduction

This course focuses on fundamentals of (a) micro- and nano-fabrication, sensors and actuators, capacitive MEMS, (b) BioMEMS and RFMEMS, and (c) case studies using the following Text: *Foundations of MEMS* by Chang Liu, 2nd Edition, Prentice Hall, 2012.

MEMS are capable of performing many tasks and functions that involve mechanical, electrical, optical, fluidic, and other types of signals. *Sensors and actuators* allow us to interface our electronic systems to the non-electronic world providing analog information through signal conditioning circuits to a microcontroller, which then interprets the information, makes appropriate decisions and implements those decisions via the **actuators and micro-instruments**.

### Course Outlines:

#### 1. Introduction [week 1-2]

Basics of MEMS, sensors and actuators (chapter 1)

➡ Start with *CoventorWare: Layout, solid modeling, MEM-Mech, MEM-Electro, MEMS-Solve, etc.*

#### 2. Fundamentals of Microfabrication [week 2-3]

Microfabrication processes, MEMS processes, packaging and system integration, process selection and design (chapter 2)

#### 3. Electrical and Mechanical Concepts [weeks 3-4]

Conductivity, crystal planes, stress & strain, beam bending, intrinsic stress, resonance frequency & quality factor. (chapter 3)

**4. Electrostatic Sensing and Actuation [weeks 5-6]**

Parallel plate capacitor with a moveable plate, applications of capacitors, comb-drives and applications. (chapter 4)

**5. Piezoresistive Sensing [weeks 6-7]**

Piezoresistivity and sensors, applications of piezoresistive sensors. (chapter 6)

**6. Bulk Micromachining [weeks 8-9]**

Wet and dry etching. (chapter 10)

**7. Surface Micromachining [weeks 10-11]**

Basic surface micromachining processes and sacrificial materials. (chapter 11)

**8. Polymer MEMS [weeks 12-13]**

Polymer MEMS materials and applications. (chapter 13)

**9. Microfluidics [weeks 13-14]**

Basics of fluid mechanics and fabrication of microfluidics circuits. (chapter 14)

**10. Case Studies [weeks 15]**

MEMS products: Blood pressure sensors, accelerometers, microphones, etc. (chapter 15)

**Grading Policy**

**Problem Sets & CAD Assignments .. 30%**

**Quizzes\*\* ..... 30%**

**Final Exam\*: ..... 40%**

\* See MSU's final examination schedule for time and date of the final.

\*\* There will be total of 2-3 quizzes and the dates will be announced usually 2 weeks before every quiz.

A Gaussian curve will be used for final grading. In the past, class average has been around a grade of 3.5.

**Prerequisites:**

This course, intended for senior level undergraduates and beginning graduate students, is an introductory course designed for those students who are not familiar with MEMS, microfabrication technologies, integrated circuits, or non-electrical devices and systems. Therefore, the course pre-requisites are selected to allow students from MANY engineering or science disciplines, including mechanical, electrical, chemical, aerospace, biomedical, and materials engineering to take the course. The course is organized into lectures (Mondays) and recitations (Wednesdays). The following academic background is required for this course:

1. College math and calculus, and differential equations
2. Basic college-level physics and chemistry

**Computer Aided Design and Modeling Software:**

Because of their multi-domain nature, and due to their intrinsically three-dimensional nature,

design and analysis of MEMS is often complicated and requires access to a host of modeling and simulation tools. Through University of Michigan, Coventor Inc. has partially donated licenses for their *Coventorware* suite of design and modeling software for the sole use in this course. We will use this software to aid in teaching the material covered in the course.

## **Textbook and References:**

The Fundamentals of MEMS by Liu Chang, Pearson/Prentice-Hall, 2012

### **Reference Books:**

- 1) Hornyak, Tibbals, Dutta, Moore, "Intro to Nanoscience & Nanotechnology", CRC Press, 2009
- 2) Senturia, S., *Microsystems Design*, Springer, 2000: [Available on GoogleBooks](#)
- 3) Gregory T.A. Kovacs, *Micromachined Transducers Sourcebook*, McGraw Hill, 1998
- 4) S. M. Sze, ed., *Semiconductor Sensors*, New York: John Wiley, 1994.
- 5) R. S. Muller, et.al., *Microsensors*. New York: IEEE Press, 1991.
- 6) M. Madou, *Fundamental of Microfabrication*, CRC Press, Inc. Boca Raton, FL., 1997
- 7) M. Elwensiek, H. Jansen, "Silicon Micromachining," Kluwer Academic Publishers, 2001
- 8) J.W. Gardner, "Microsensors – Principles and Applications," John Wiley & Sons, 1994

### **Internet Resources:**

A number of Internet based lecture materials will be used in this course including streaming video lectures from the University of Michigan.

#### **MEMS books available on Google:**

<http://books.google.com/books?um=1&q=MEMS&btnG=Search+Books>