Fundamentals of MEMS  
(Micro-electromechanical Systems)  
Course Number: ME-585  
(Spring 2017) – San Diego State University  
(Professor Sam Kassegne)  

Course Description:
Micro-electro-mechanical systems, or MEMS, is an emerging area with applications to a variety of engineering fields such as mechanical, electrical, aerospace and bioengineering. This course is an introductory course and forms the first part of a 2-series MEMS course at SDSU. This introductory part concentrates in educating students the manufacturing techniques (micromachining), materials, mask layout, and multi-physics simulation of MEMS. The course work is complemented with a comprehensive design project and a review paper of a MEMS technology of the student's choice.

Course Objectives:
Upon completion of the course work, the students will:
- Acquire skills in detail the fundamental micromachining processes such as lithography, surface and bulk micromachining.
- Acquire skills in MEMS design layout using CAD tool and then populate a wafer with these layouts.
- Carry-out simulation of MEMS devices.
- Develop and exercise critical thinking in microengineering design issues such as fabrication, packaging and testing.
- Develop an understanding of microscale physics for use in designing MEMS system applications.
- Review current MEMS and BioMEMS applications.

This is a graduate-level course open to mechanical, bioengineering, aerospace, electrical, and computer engineering students.

Instructor:
Dr. Kassegne is a professor of mechanical engineering at the Mechanical Engineering department of SDSU. He was previously at Marc Madou's BioMEMS Research Group at UC Irvine and had also worked at Microfabrica, a MEMS start-up company and Nanogen, a San Diego based DNA-chip Company. He conducts research in the areas of NeuroMEMS, SolarMEMS, microfluidics, variety of sensors and actuators for applications in the life sciences and next generation lithography. He has taught several courses in FEA, computational modeling, numerical prototyping and MEMS and has over ten years of industrial experience.

E-mail: kassegne@mail.sdsu.edu
Web-site: http://www.digitaladdis.com/sk
Telephone: 619-594-1815
Office Hours: Wednesday 1 – 4 PM.
Cleanroom Location: Parking Lot 16, Building A
Office Location: Parking Lot 16, Building A.

Grading and Assignments:
1 Mid-Term 40%
Final Design Project: 30%
Howe works 15%
Research Review Paper 15%
1. **Review Paper**

This will involve reviewing an existing MEMS technology in such areas as Micro-mirrors, Inertial Sensors, Pressure Sensors, Accelerometers, DNA chips/arrays, Biosensors, Microfluidics, Optoelectronics, RF MEMS, etc.

The graduate student is expected to critically examine the core IP of an application, its engineering (including manufacturing) and business sense and market potential/performance. Some of the examples are:

Analog Devices, Microfabrica, QMT (Qualcomm MEMS Technology), Genoptix, Nanogen, Intel, Aviva Biosciences, CapitalBio, Gamera Biosciences, Bosch, Honeywell, Kionix, Microfabrica, Agilent, Hewlett Packard – Inkjet, Agilent – Gene Chip, Affymetrix, Coventor, IntelliSense, MEMSCap, etc.

2. **Design Project**

The design project involves a group work on the complete engineering of a MEMS device. Included are the physical layout (using Tanner, Coventorware, AutoCAD, etc) and simulation/modeling (FEMLAB, Coventorware, ANSYS, etc). Some aspects of micromachining and testing will be done at the ME 685 level.

### Additional Readings & Reference Materials

**NeuroMEMS**


**BioNano/Microfluidics**


**SolarMEMS/RFMEMS**


# Lecture Outline

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<th>Topic</th>
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<td>MEMS Introduction</td>
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<td>MEMS Microfabrication Technology - Introduction</td>
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<td>Holiday</td>
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<td>3</td>
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<td>MEMS Microfabrication – Microfabrication Methods + Surface micromachining</td>
<td>Design teams assigned</td>
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<td>4</td>
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<td>MEMS Microfabrication – Next Generation Lithography, Process Integration</td>
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<td>5</td>
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<td>Mask Layout using MEMS CAD.</td>
<td>Review paper topic due</td>
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<td>Mask Layout using MEMS CAD – Lab Class 1</td>
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<td>Mid-Term 1</td>
<td>Review paper progress report</td>
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<td>Mask Layout using MEMS CAD – Lab Class 2</td>
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<td>Microfluidics</td>
<td>Design project abstract due</td>
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<td>Engineering in Microfluidics</td>
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<td>Materials for MEMS – Silicon, Silicon Oxide, Silicon Nitride, Metals, Polymers.</td>
<td>Review paper due. Design project progress report due</td>
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<td>Packaging and Electronic Interface Design</td>
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<td>Clean Room Visit @ SD</td>
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<td>MEMS Design Application – Accelerometer &amp; Gyroscopes (IMU)</td>
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<td>MEMS Design Application – RF MEMS</td>
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<td>MEMS Design Application – BioMEMS (Possibly a Guest Lecturer)</td>
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<td>Design Project Presentation</td>
<td>Design Presentation and Poster due</td>
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