Advanced Microsystem Design

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Lecture 1
Introduction and Orientation

Agenda:
- Introduction
- Syllabus
- Overview: MEMS research at UF
Instructor: Prof. Hui-Kai Xie  
- Dept. of Electrical and Computer Engineering  
- Office: 221 Benton Hall  
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- Phone: 846-0441  
- Office hours: 1:50-3pm MWF

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Guest Instructors:  
- Prof. Toshi Nishida (nishida@ufl.edu)  
- Prof. Mark Sheplak (sheplak@ufl.edu)

Syllabus (1)

- COURSE TITLE: EEL6935: Special Topics -- Advanced Microsystem Design and Manufacturing
- INSTRUCTOR: Dr. Hui-Kai Xie; 221 Benton; 8460441; Email: hkk@ufl.edu
- CREDITS: 3
- PREREQUISITE: EEL5225 or permission of instructor
- MEETING ROOM: Psychology Building, PSY 287
- MEETING TIME: 12:50-1:40pm (6th period), MWF
- TEXTBOOK: No required textbook. Lecture notes and supplemental materials will be handed out.
- WWW site: http://www.mems.ece.ufl.edu/EEL6935
Syllabus (2)

- **GRADING:** 25% Homework, 25% Test, 50% Project, no final exam
- **HOMEWORK:** Homework problems will be assigned on a weekly or biweekly basis. Late homework is only accepted with permission of instructor, and will be graded with a 20% reduction per day.
- **PROJECT:** Project topics will be provided. Students can also propose new topics. Team projects are encouraged.
  
  (Proposal writing 15% + proposal presentation 15% + final presentation 30% + final report 40%)
- **SOFTWARE:** Coventorware, PSPICE, Matlab

Syllabus: Objectives

1. To develop expertise in the MEMS field through studying in depth advanced micro/nano fabrication technologies, various microsystems and MEMS packaging;
2. To obtain hands-on experience on MEMS design and problem-solving skills through case studies which are closely tied with the ongoing research at UF;
3. To keep students updated on the state-of-art progress in the MEMS field; and
4. To gain experience on proposal writing through supervised, peer-reviewed projects.
Syllabus: Topics

Introduction (1)

Module 1: Advanced Micro/Nano Fabrication Technologies (5)
Module 2: CMOS-based Sensors and Interface Circuits Design (6)
Module 3: Optical MEMS (9)
Module 4: Case Study: MEMS-based Biomedical Imaging (8)
Module 5: RF MEMS (4)
Module 6: MEMS Packaging (2)

5 Homeworks (1)
1 test (1)

Term project: Proposal (1); Final Presentation (2)

Topics: module 1

Advanced Micro/Nano Fabrication Technologies
- Plasma physics, ICP etch, Deep Si etch, Deep oxide etch
- Surface micromachining: thick poly-Si, tensile stress
- Bulk micromachining: multiple wafer stack, SOI, SCREAM
- Surface/bulk micromachining (SBM); SU-8; PMMA
- CMOS-MEMS: Thin-film, bulk, DRIE

High aspect-ratio combined poly and single-crystal silicon (HARPSS) MEMS
**Topics: Module 2**

**CMOS-based Sensors and Interface Circuits Design**
- Chemical
- Thermal
- Inertial
- Interface circuit design

- Thermal Accelerometer (MEMSIC)
- Accelerometer (Analog Devices)
- Metal-oxide gas sensor (ETH)
- Uncooled infrared bolometer (METU)

**Topics: Module 3**

**Optical MEMS**
- Fundamentals of light: Propagation, Interference, Doppler Effect, Polarization, Coherence
- Micromirrors; Microlens; Microgratings; Corner cube reflectors
- Applications
  - Optical communications: phase modulators, attenuators, switches, add/drop, VCSELs
  - Displays, Scanners
  - Biosensors, Spectroscopy; Biomedical Imaging

- Corner cube reflector (UC-Berkeley)
- Optical bench (UCLA)
- Optical switch (Lucent)
Topics: Module 4

RF MEMS: Introduction
- RF MEMS switches and Micro Relays
- MEMS varactors and inductors
- MEMS phase shifters and filters
- Micromachined Antenna

Metal-contact switch (ADI)

Capacitive-contact switch (MIT Lincoln Lab)

Raytheon RF MEMS capacitive switch

Rockwell MEMS varactor

Topics: Module 5

Case Study: MEMS-based Biomedical Imaging
- Interaction of light with tissue: Scattering, Fluorescence, Birefringence, Dispersion, Polarization
- Optical Coherence Tomography (OCT)
  - Low-coherence interferometry; Confocal microscopy; Optical fibers
  - Fiberoptic OCT: Principle, Design issues
  - Confocal imaging: optical coherence microscopy (OCM)
- MEMS-based fiberoptic OCT/OCM
  - Limitations of conventional OCT/OCM
  - Miniature OCT/OCM designs; Endoscopic probes; Intravascular probes
Topics: Module 6

MEMS Packaging

- Packaging design, materials
- Packaging techniques: Bonding, Sealing, Dicing, Wafer-level packaging
- Packaging for medical, aerospace and RF MEMS applications

Bosch/Stanford single-wafer encapsulation

U-Michigan thin-film metal vacuum packaging

Flip-chip packaging

Reflowed solder bumps on electroless nickel/gold

Syllabus: References

Books
5. B. Bouma and G. Tearney, Handbook of Optical Coherence Tomography, Marcel Dekker, Inc., 2003

Journals
2. Sensors & Actuators
3. IEEE Sensors Journal
4. Journal of Micromechanics and Microengineering (JMM)

Conferences
1. IEEE MEMS conference
2. Solid-State Sensors and Actuators workshop (Hilton Head)
3. Transducers
4. IEEE Sensors conference
5. IEEE/LEOS Optical MEMS conference
6. SPIE

MEMS clearinghouse: http://www.memsnet.org