EEL6935 Special Topics -- Advanced Microsystem Design and Manufacturing

Spring 2005 Semester

(6th Period, MWF, Psychology Building 287)

Credits: 3

Goals: To develop expertise in the MEMS field through studying in depth advanced micro/nano fabrication technologies, microsystem design, interface circuits design and MEMS packaging. The emphasis will be on CMOS-MEMS, optical MEMS and RF MEMS.

Instructor: Dr. Huikai Xie
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Guest Instructors: Dr. Toshi Nishida and Dr. Mark Sheplak

Prerequisite: EEL5225 or permission of instructor

Textbook: No required textbook. Lecture notes and supplemental materials will be handed out.

Reference Books:
G. Kovacs, *Micromachined Transducers Sourcebook*, McGraw-Hill,1998.
S. Senturia, *Microsystem Design,* Kluwer Academic Publishers, Boston, 2001.
M. Madou, *Fundamentals of Microfabrication*, 2nd ed., CRC Press, 2002.
G. Rebeiz, *RF MEMS: Theory, Design and Technology*, John Wiley & Sons, Inc., 2003.
B. Bouma and G. Tearney, *Handbook of Optical Coherence Tomography*, Marcel Dekker, Inc., 2003

Topics

1. **Advanced Micro/Nano Fabrication Technologies**
   - Plasma physics, ICP etch, deep Si etch, deep oxide etch
   - Surface micromachining: thick poly-Si, tensile stress thin films, etc.
   - Bulk micromachining: multiple wafer stack, SOI, etc.
   - Surface/bulk micromachining (SBM)
   - CMOS-MEMS: thin-film, bulk, DRIE

2. **CMOS-based Sensors and Interface Circuits Design**
   - CMOS MEMS inertial sensors
   - CMOS MEMS thermal sensors
   - CMOS MEMS chemical sensors
   - Interface circuits: CHS vs. CDS

3. **Optical MEMS**
   - Fundamentals of light: Propagation, Interference, Doppler Effect, Polarization, Coherence
   - Optical MEMS devices: micromirrors, microlens and microgratings
   - Applications
     - Optical communications: phase modulators, attenuators, switches, add/drop, VCSELs
     - Displays, Scanners
     - Biosensors, Spectroscopy; Biomedical Imaging

4 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

5 Introduction to RF MEMS

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

6 MEMS Packaging (time permits)

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

Grading: 25% Homework, 25% Tests, 50% Design Project, no Final Exam

Design Project:

Project topics will be provided. Students can also propose new topics. Team projects are encouraged. All projects will be peer-reviewed at both proposal and final stages. Your score will be based on the evaluations of the instructor and your peers.

Computer Usage:

Layout of masks using Cadence, FEM simulation using Coventorware, circuit simulation using P-SPICE, and dynamics calculation using Matlab, Mathcad, or Mathematica.