Syllabus – EE502 PMP: Introduction to Microelectromechanical Systems

Credits: 4

Course Web Site: http://www.ee.washington.edu/class/502

Course Description: Research and development of MEMS (Micro Electro Mechanical Systems) builds on the dramatic advances in silicon processing infrastructure to create micron-scale machines. Unlike conventional integrated circuits, MEMS devices can have many functions, including sensing, communication, and actuation. Just like microelectronics, MEMS technology has started to permeate our everyday lives. This class is an introduction to this exciting field. The course will cover a wide range of topics including (a) bulk and surface micromachining, (b) mechanical and electrical analysis, (c) MEMS design and layout, (d) fabrication processes, (e) applications, for example microactuator arrays for "smart surfaces", biosensors for medical applications, or inertial transducers for navigation. The class includes a one-day cleanroom session and a group research project. There will also be homeworks and a midterm exam.

Recommended Texts and/or References: The text book is *Chang Liu, Foundations of MEMS (2nd edition)*. Other useful books are *Marc Madou, Fundamentals of Microfabrication and Nanotechnology (3rd edition)*; *Stephen D. Senturia, Microsystem Design*, and *Gregory T.A. Kovacs, Micromachined Transducers Sourcebook*. The course will also discuss several research papers.

Lecture Time: Thu 5:50 – 9:50 pm, location EE037

Instructor: Prof. Karl F. Böhringer, Electrical Engineering, and guest instructors

Prerequisites: Graduate standing or permission by instructor. This class covers a broad set of topics in multiple engineering disciplines but does not have specific course prerequisites.

Course Grading: 4 homeworks (40%), 1 midterm exam (in class, open book) (25%), 1 project (35%).

Projects: The class project is a small scale research project that investigates aspects in MEMS design, modeling, simulation, fabrication, or testing. A project team consists of 2 to 4 students. A short proposal is due in week 3. The proposal will be used to check the approach and feasibility of the project. A final write-up (short conference paper style) is due at the end of the class. Papers of exceptional quality may be considered for submission to a conference

Topics to be covered in the lectures:

- Introduction - history of MEMS, market for MEMS, properties of silicon, basics of microtechnology - definitions and terminology.
- A sample MEMS process. Micromachining - lithography.
- Micromachining - subtractive processes (wet and dry etching)

- Micromachining - additive processes (thin film deposition, plating).
- MEMS foundries: MUMPs, CMOS MEMS.
- Electrostatic actuators: cantilevers, comb drives.
- Thermal sensing and actuation: “chevron actuator”, “heatuator”, biomimetic cilia.
- Piezoresistive and piezoelectric transducers: gauge factor, piezoresistive pressure sensors and accelerometers; scanning probe microscopy.
- Magnetic actuation: magnetic fields, Lorentz force, micro-coils, magnetic actuators.
- Polymer MEMS: LIKA, SU-8, Parylene PDMS.
- Scaling laws for MEMS.
- Optical MEMS: refraction, diffraction, MOEMS components; digital mirror display (DMD); grating light valve (GLV), optical scanners.
- MEMS packaging.
- Cleanroom laboratory tour.