Department of Biomedical Engineering
BME 479: BioMEMS: Introduction to Microfabrication
Fall, 2006

Course Syllabus

INSTRUCTOR
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CLASS HOURS

Lecture	Wednesday 11:30am – 12:55pm	EAST 696
	Friday 10:00am – 11:25am	EAST 636

OFFICE HOURS (MICRO R200)
Wednesday 1:00pm– 3:00pm, other times by appointment.

READING MATERIAL:

Sami Franssila, Introduction to Microfabrication, John Wiley & Sons, 2004

COURSE OUTLINE
Prerequisites: Knowledge of physics, mechanics and general chemistry.

The main objective of the course is to learn basic principles of the miniaturization of biomedical devices and their integration with signal conditioning analog and digital integrated circuits. Students will be trained on design of microfabrication processes and micromachining of biomedical and bioanalytical sensors and actuators using MEMS (Micro-Electro-Mechanical Systems) and microelectronics technologies. Semiconductor processes such as pattern transfer and photolithography, bulk micromachining, surface micromachining, thin films deposition, wet etching, dry etching, oxidation, diffusion, ion implantation, and wafer bonding will be discussed for various materials and substrates - silicon, glass, polymer, and ceramic wafers. Surface science materials and devices characterization techniques will be studied as well. Emphasis will be given to bioMEMS glucose-meters, optoelectronics biosensors, and active ultrasonic transducers for medical imaging, micro-acoustic sensors, micro-valves, micro-fluidic devices, and implantable medication delivery systems.

Lecture 1. Materials and processes of microfabrication of bioMEMS. Clean room organization, structure, standards, and codes. Cleanroom safety procedures.

Lecture 2. Micrometrology and materials characterization. XRD, SIMS, AES, XPS, ESCA, SEM, AFM

Lecture 3. Pattern generation, Optical lithography, e-beam lithography, X-ray lithography. Micro- and nano-lithography. Masks design and fabrications. Photoresists. Hot embossing and injection molding of polymers techniques for bioMEMS micro- and nano-fabrication. Lift-off techniques.

Lecture 4. Silicon wafers. P- and n-type wafers. Electrical characteristics. Mechanical characteristics. Doping. Crystallographic orientations. X-ray diffraction. Epitaxial layers.

Lecture 5. Etching of silicon, glass, and polymer wafers. Wet etching. Electrochemical etching. Anisotropic etching. Dry plasma etching.

Lecture 6. Wafer cleaning and surface preparation. Contamination forms. Particle contamination. Organic contamination. Metal contamination. Physical cleaning. Wafer rinsing and drying.

Lecture 7. Thermal oxidation. Wet oxidation. Dry oxidation. Oxide growth. Oxidation rates depending on wafer's crystallographic orientation and doping.

Lecture 8. Ion implantation and diffusion. Simulation of implantation and diffusion processes. Implant damage and damage annealing.

Lecture 9. Thin film deposition techniques. Plasma-enhanced chemical vapor deposition (PECVD), low-pressure-chemical-vapor deposition (LPCVD). Silicon nitride deposition methods. Silicon dioxide deposition methods. Polysilicon. Amorphous silicon.

Lecture 10. Metallization. Evaporation. E-beam deposition. Reactive magnetron sputtering. DC sputtering. RF sputtering. Ohmic contacts.

Lecture 12. Bonding of silicon wafers. Fusion bonding. Anodic bonding. Thermocompression. Integration and packaging techniques.

Lecture 13. Design of microfabrication process flows and travelers. Examples with bioMEMS pressure sensors and glucose-meters. Fabrication of microfludic devices for drug delivery, DNA analysis, and mixing.

Lecture 14. Specific processes for microfabrication of bioMEMS. Double-side processing. Membrane structures. Through-wafer structures. Patterning over uneven topography. IC-MEMS integration.

Students will be consulted on any modifications to the syllabus during the semester.

GRADING:
Midterm test: 40%, Final test: 50%, Class Participation: 10 %.

NJIT HONOR CODE

The NJIT Honor Code will be upheld in this and all courses, and any violation will be brought to the immediate attention of the Dean of Students. The Honor Code can be found at http://www.njit.edu/academics/honorcode.php.

OUTCOMES:

Students will:

- Obtain basic knowledge of micro- and nano-fabrication of biomedical devices
- Understand the concepts of device miniaturization and design
- Learn basics of experimental technique for thin films deposition, etching, and patterning
- Gain the ability to solve practical problems of device micromachining.