MECH 597 Advanced Microsystem Technology

Fall Semester, 2005

Course summary:

Microfabrication technology: bulk micromachining; surface micromachining: film deposition, chemical and plasma etching, DRIE; wafer bonding; surface treatment for bio-compatibility; application in accelerometers, pressure sensors, micromirrors and microfluidic devices; nano-fabrication.

Prerequisites: MECH 595 Introduction to Microsystem Technology or equivalent (such as Introduction to CMOS fabrication)

Lecturer: Dr. Yi-Kuen Lee, Email: meyklee@ust.hk
Tel: 2358-8663, Rm 2563, Office hour: 5:30pm-6:30pm, Tuesday

Lectures schedule: 6:30pm-9:20pm, Tuesday

Venue: Rm 2463

Course website: http://www.me.ust.hk/~mech597

Reference Textbook:

Fundamentals of Microfabrication: The Science of Miniaturization, 2nd ed., Marc Madou, CRC Press, ISBN: 0849308267, 2001 (book website: http://biomems.net)

1. Bookstore online: Sunmido, Taiwan, http://www.sunmido.com.tw/
2. Asia Publishers Services LTD, Hong Kong: Tel: 2553-9289, email:apsjani@netvigator.com

Grading policy:

25% - Mid term exam
40% - Term project (proposal due: TBA, final presentation and report due during final exam week)
25% - homework. No numerical credit given if late. However, it is most important that you turn it in, even if late. You are expected to do your own work.
10% - Class attendance and participation

Course conduct:

Please respect your classmates and others by turning off your pagers and mobile phones during the class.

Syllabus:

1. Introduction to Microsystem Technology (MEMS), NHK Nanospace video

2. Photolithography and Layout

3. Thin film formation: dry and wet oxidation

4. Thin film formation: LPCVD (polysilicon, low stress nitride, PSG), PECVD

5. Thin film formation: e-beam evaporation and sputtering

6. Impurity Doping: diffusion and ion implantation

7. Wet etching: isotropic and anisotropic (KOH, EDP, TMAH)

8. Dry etching: reactive ion etching (RIE) and Deep RIE for high-aspect-ratio silicon etching

9. Wafer bonding: fusion bonding, anodic bonding, eutectic bonding

10. MEMS CAD

11. Microfabrication processes for accelerometers and pressure sensors

12. Microfabrication processes for digital micromirrors and microfluidic devices

13. Bio-MEMS and Bio-compatibility

14. Introduction to Nanotechnology and NEMS

Reference:

Books:

1. Micromachined Tranducers Sourcebook, Gregory T.A. Kovac, McGraw-Hill, ISBN: 0072907223, 1998.

2. Microelectromechanical systems : advanced materials and fabrication methods, National Academy Press, ISBN: 0309058856, 1997.

3. Semiconductor Sensors, S.M. Sze, John Wiley & Son, ISBN: 0471546097, 1994.

4. Microsystem Design, Stephen D. Senturia, Kluwer Academic Publishers, ISBN: 0792372468, 2001.

5. Microsensors, Principles and Applications, Julian W. Gardner, John Wiley & Son, Inc, ISBN: 0471941352, 1994.

Journals:

1. Journal of Microelectromechanical System, IEEE/ASME.
2. Journal of Micromechanics and Microengineerings, Institute of Physics Publishing.
3. Proceeding of the IEEE,Vol. 86, No.8, August 1998, Special Issue on Integrated Sensors, Microactuators, and Microsystem (MEMS): http://ieeexplore.ieee.org/
4. Sensors and Actuators A: Physical, Elsevier Science Ltd.
5. Sensors and Actuators B: Chemical, Elsevier Science Ltd.
6. Biomedical Microdevices, Kluwer Academic Publishers.
7. Science, the American Association for the Advancement of Science, www.sciencemag.org
8. Lab on a chip - Miniaturisation for Chemistry and Biology, Royal Society of Chemistry (www.rsc.org)

Conferences:

1. IEEE International MEMS Conference: 19th (http://ieeexplore.ieee.org/)
2. ASME International Mechanical Engineering Congress (IMECE) Conference, MEMS and Microfluidics section
3. International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers, 1981-): 12th
4. Hilton Head Conference, Solid-State Sensor, Actuator and Microsystem Workshop
5. European Conference on Solid-State Transducers (EuroSensors, 1987-): 19th
6. International Symposium on Micro Total Analysis (Micro TAS): 9th
7. International Conference on Microreaction Technology (IMRET): 8th

Magazines/Newsletter:

1. Micromachine Devices, R&D Magazine 2000 Clearwater Drive, Oak Brook, IL60523 (www.rdmag.com)
2. MSTnews, VDI/VDE-Technologiezentrum, Germany (www.mstnews.de)
3. MEMS Clearinghouse, http://www.memsnet.org/
   subscribe MEMS mailing list http://mail.mems-exchange.org/

UCB Online MEMS course in Real Video format :
http://webcast.berkeley.edu/courses/index.html

UCB ME 219 Microelectromechanical Systems, Spring 2002

UCB EE 245/ME C218 Introduction to MEMS Design, Fall 2002

MECH597 Term Project

Project group: 2 or 3 students

Format:

Presentation: each will be given 15 minutes to present the results of the term project in the final exam week. The presentation with MS Powerpoint is highly recommended. The presentation is scheduled to be the final exam week.

Proposal:

The proposal, as concise as possible, 1-2 A4 page is fine, should include the title of the project, brief introduction of the devices, schematics drawing of the device, brief description about the microfabrication approach and key reference papers. The proposed project title should NOT be the same as the past projects.

Report:

A report is due at the time of presentation. The report should contain executive summary (key results of your term project), introduction (outline of the issue), current state of the art (review of previous research), approach, results, conclusion, and reference.

Requirement:

In addition to survey of literatures, you are required to come up with independent work or discussion on the topic of your choice. The discussion could be a critical comparison of various approaches from the literature, critical discussion on a particular approach, your independent analysis of a particular device, original idea with reasonable theoretical or analytical support, etc.

Suggested topics:

1. Optical MEMS components:
   MEMS optical switches (optical cross connector), 2D/3D scanning mirrors

2. RF MEMS components:
   The MEMS technology is ideal for implementing microwave (RF) components such as variable capacitors, high-Q inductors, RF switches, etc. You can perform a detailed comparison of various MEMS technologies for realizing these components, the fundamental limit of these devices (bandwidth, Quality factor, tuning range, etc)

3. Bio MEMS and Thermal/Microfluidic applications:
   There are many microfluidic components fabricated such as microvalves, micromumps, micro inkjectors, micro bubble actuators, micro flow sensors

   Lab-on-a-chip, novel micro capillary electrophoresis device for DNA separation, micro DNA sequencers, micro liquid chromatography/mass spectrometers, micro polymerase chain reaction devices (PCR), micro drug delivery systems (insulin), Micro bio-sensors for biomedical field (glucose, blood pressure etc) and for a variety of pathogen (E-Coli bacteria, anthrax (optical, electrochemical, etc): DNA-based, cell-based, etc; micro chemical sensors, micro gas sensors

4. Power MEMS:
   micro battery, micro fuel cells, micro turbines, micro/mini vibration power generators etc.

5. Surface passivation, stiction reduction, self-assembled monolayer (SAM) based MEMS, polymer based (PDMS etc) soft lithography

6 Micro reactor technology for advanced bio/chemical engineering processes, micro factory

7. Nanoelectromechanical system (NEMS):
   nanomotor, nanofluidics, nano-mechanical filters, nanorobotics, carbon nanotube based devices

8. Comprehensive market research and business proposal on potential MEMS/NEMS devices which may change the world and make you become billionaire.

List of Past Term Project (2002, 2003)

1. Micro-thermal-fluidic devices for biological applications

2. Micro polymerase chain reaction devices

3. MEMS devices help the blind to see

4. Micro droplet-impingement cooling system

5. Micro Direct Methanol Fuel Cells fabricated by Microtechnology

6. Mini Fuel Cell by MEMS

7. High-Q micro-resonator and it's applications

8. Micro scanners in confocal microscope

9. Microscopic Cantilever Aids Assay For Detecting Cancer

10. RF MEMS switches

11. Micro Power Supply: For MEMS, By MEMS

12. Fabrication of Micro Direct Methanol Fuel Cell

13. An exemplary view on state of the art nanoelectromechanical systems (NEMS)

www.enee.umd.edu/class/enee605/papers.html