ME599/ChE696 -Winter 2011
Introduction to BioMEMS and Microfluidics

Course Description: This course targets to: (1) introduce fundamental design and microfabrication concepts of BioMEMS, microfluidics and lab-on-chip systems, (2) expose students to the relevant biomedical and biological applications and (3) teach students how to write and evaluate an NIH-type research proposal. The course is divided into three main sections: (i) BioMEMS/Microfluidic materials and microfabrication, (ii) BioMEMS sensors and actuators, and (iii) Microfluidic and Lab-on-chip systems.

Instructor: Prof. Nikos Chronis, Room 3112 G.G. Brown, (734)-7630154, chronis@umich.edu

Course Web: class material is located on the CTOOLS web site

Class Meetings: Lecture, Tuesdays and Thursdays, 1123 LBME, 10:00 - 11:30 pm.
Instructor Office Hours, Thursdays from 12:00 pm – 1:30 pm.

Textbooks: No textbooks are required. Teaching materials are provided by the instructor via the course website.

Recommended Books:

General MEMS books

- G.T.A. Kovacs, "Micromachined Transducers - Sourcebook," McGraw-Hill, 1998. *Good reference covering all the aspects of MEMS.*
- S.M. Sze, "Semiconductor Sensors," John Wiley & Sons, Inc, New York, 1994. *Informative, fundamentals of micromachined sensors are introduced with rigorous analysis.*

BioMEMS/Microfluidics books

- Ellis Meng, 'Biomedical Microsystems', CRC Press. *It focuses on microfuidics and lab-on-chip systems. It is a good reference for various microfabrication processes.*
- Nam-trung Nguyen, Seven Wereley, 'Fundamentals and Applications of Microfluidics', Artech house, 2006. *A good reference that is specialized in microfluidics and their life science applications.*
- Steven Saliterman, 'Fundamentals of BioMEMS and Medical Microdevices', Willey Interscience, SPIE Press, 2005. *A good reference for BioMEMS sensors and actuators as well as for lab-on-chip systems.*

Grading:		
	Homework	20%
	Presentations (Paper Reading & Project Presentation)	10%
	Midterm (Take-Home) Exam	30%
	Term Project (NIH-proposal)	40%

Homework Policies:

(1) You may discuss the homework assignments with your classmate. But you are asked to independently prepare your homework answer sheet.
(2) Homework is collected at the beginning of the class on the indicated due date (typically Tuesdays).
(3) In case of unavoidable circumstances, the student may notify the instructor in person, at the end of a class prior to the due date, in order to avoid a penalty. For 1-day delay, there will be a 20% penalty and 40% for a 2-day delay.

Paper Reading:
A BioMEMS/Microfluidics related paper will be presented by a group of two students during the first 10 min of each class**.** Students are encouraged to use 5-6 powerpoint slides and they must be prepared to answer questions.

Exam Policies:

(1) The midterm exam is an open-book, take-home exam for one-week duration. You need to independently work on it without any help from others.
(2) The honor code must be strictly observed.

Final Project: The final event of this class is a term project carried out by a group of *2* students taking the course. In the project, you are asked to write a 12-page R01 NIH (National Institute of health) proposal (for more information see: http://grants.nih.gov/grants/guide/pa-files/pa-10-067.html). The main body of the proposal (excluding references and biosketches) should include 4 sections:

- Specific Aims (1 page),
- Background and significance (2 pages),
- Preliminary data (5 pages),
- Experimental design and methodology (4)

The proposal should be written in Times New Roman with Font Size 11. The preliminary data section should include quantitative design, modeling, and analysis of a BioMEMS/Microfluidic device of your interest. Specifically, the project will be completed in 4 phases:

(1) Two one-page pre-proposals (describing two different projects) are due on **2/10 (Thu)**.
(2) Proposals will be presented/discussed in class on 2/15 (Tue). After the project presentation/discussion, only one proposal will be selected.
(3) 10-min group presentations are given in class on **4/19 (Tue)**.
(4) The final NIH proposal is due on **4/19 (Tue) at 5pm**. The proposal should be prepared with a 11-point font size in a single column (**12 page limit including figures**). A hardcopy as well as an electronic copy should be sent to Prof. Chronis (chronis@umich.edu).

	Class Schedule Winter 2011 - INTRUDUCTION TO BIOMEMS AND MICROFLUIDICS			
		Date		Hw Due
1	Introduction- Overview of bioMEMS/Microfluidic Technology and Applications	Thu	6-Jan	
	MATERIALS & MICROFABRICATION			
2	MATERIALS (PDMS, SU-8, PARYLENE, TEFLON, etc) and their Properties	Tue	11-Jan	
3	PHOTOLITHOGRAPHY, DEPOSITION (CHEMICAL and PHYSICAL DEPOSITION, SPINNING,)	Thu	13-Jan	
4	ETCHING - WET-DRY (RIE, STS) , BONDING, ELECTROPLATING	Tue	18-Jan	Hw 1
5	SOFT LITHOGRAPGY, MULTILAYER LITHOGRAPHY	Thu	20-Jan	
6	INJECTION MOLDING,Compression Molding, OTHER BIOMEMS RELATED FABS	Tue	25-Jan	
7	Special Guest - Kay Fuller: FDA clearence, Regulatory Pathway, Clinical Trials	Thu	27-Jan	
	BioMEMS			
8	Overview,Applications and Clinical Needs: Implantable and Ex Vivo sensors and Actuators			
9	Sensors: Optical Sensors, PZT and Capacitive Sensors, SAW devices	Tue	1-Feb	Hw 2
10	Inductive Sensors, Resonant Sensors, Resistive Sensors,Telemetry, Power Requirement	Thu	3-Feb	
11	Actuators: Electroactive, Electrothermal, Pneumatic, electrostatic	Tue	8-Feb	
12	Microgrippers, Microneedles, Deep brain stimulators (microelectrode arrays)	Thu	10-Feb	Pre-proposals due
13	Pre-proposal Presentation and Discussion	**Tue**	**15-Feb**	Hw 3
	MICROFLUIDICS - Sample Handling			
14	Introduction to Microfluidics -Theory and Applications	Thu	17-Feb	
15	Diffusion - Transport in micro flows	Tue	22-Feb	
16	Electrokinetics: Electophoresis, Electroosmotic flow, Dielectrophoresis, Electroweeting	Thu	24-Feb	
	NO CLASSES 2/26-3/6 (winter break)			
17	Microvalves, Micromixers, Micropumps	Tue	8-Mar	Hw4 - Midterm Assigned
18	Microfilters, microseparators,microdispensors, Droplet-based Microfluidics, Microreactors	Thu	10-Mar	
	Sample Detection - Optical, electrochemical			
19	Optical Detection on Chip- Theory and elements (Fluorescence/Absorption, SPR)	**Tue**	**15-Mar**	Midterm due
20	Microoptics for Detections: Microlenses, Gratings, Scanners, Waveguides Ring resonators	Thu	17-Mar	
21	Chromatography, Electrochemical Detection	Tue	22-Mar	
	INTEGRATION: LAB ON CHIP SYSTEMS			
22	Integration: Lab On Chip ystems , Point of Care Devices	Thu	24-Mar	
23	Optofluidics and Multiplexing (large scale microfluidic integration)	Tue	29-Mar	Hw 5
	Microfluidic Research and Industrial Examples			
24	Microfluidics for Genomics and Proteomics, Single molecule detection on chip	Thu	31-Mar	
25	Microfluidics for cellomics: cells lysis, trapping, separation, microFACS	Tue	5-Apr	
26	Microfluidics for Whole organisms and Tissue enginnerring	Thu	7-Apr	
27	Review and Future of BioMEMS/Microfluidics: Market Prospectives, And Challenges	Tue	12-Apr	Hw 6
28	Special Lecture: TBA	Thu	14-Apr	
29	Project Presentation, Evaluation and Final Proposal Due	**Tue**	**19-Apr**	