Introduction:

This course presents an overview of various thin film and thick film processing, microfabrication and micromachining techniques utilized for producing microsensors, microelectromechanical systems (MEMS) and microactuators. Device design for piezoresistive, piezoelectric, electromagnetic, thermal, optical, and chemical sensors and actuators will be discussed.

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Course website: cuLearn

Outline:

The course covers a class of silicon devices, often referred to as microelectromechanical devices or MEMS, and a variety of microsensor devices, both silicon-based and polymer-based. Example devices are chosen with a broad and interdisciplinary interest, ranging from automotive, wireless networks, health monitoring and wearable systems. It is inevitable that engineers and researchers working in different engineering disciplines will encounter microfabricated sensors in some part of their work, however, the standard electrical engineering curriculum focuses on the electrical energy domain and largely neglects the sensor interface with mechanical, optical, thermal, and chemical energy domains, where most sensor responses transpire. This course focuses on the physical design of such microfabricated sensors rather than signal processing, with the primary objective of raising awareness of the capabilities and limitations of semiconductor, emerging materials, thin film, and thick film devices for both commercial and research applications.

Proposed Topics

1. Fabrication technologies and micromachining techniques.
2. Mechanical structures for MEMS
3. Polymer-based microsensors and polymers in MEMS.
4. Piezoresistive, capacitive, and piezoelectric sensors.
5. Thermal sensors and actuators.
6. Magnetic sensors and actuators.
7. Photodetectors and optical MEMS.
8. Chemical and biological sensors for health and environmental monitoring.

References:

1. *Foundations of MEMS*, C. Liu, Pearson Prentice Hall, ISBN: 0131472860 (first edition 2006, library reserve) ISBN: 0132487360 (second edition 2012)
2. *Microsystem Design*, S.D. Senturia, Kluwer Academic Publishers ISBN: 0792372468 (library electronic resource)
3. *Fundamentals of Microfabrication*, M. Madou, CRC Press ISBN: 0849308267 (second edition)

Power point slides, weekly reading material and weekly lecture notes will be shared through the course cuLearn webpage.

Grading:

Assignments	30%
Midterm exam	20%
Final exam	50%

The final exam is for evaluation purposes only and will NOT be returned to the student.

The **assignments** will be quantitative - calculate process tolerances, sensor performance, etc. Some knowledge of MATLAB or other calculation and data analysis programs is desired. If you require a Carleton user account and access to certain softwares, please contact ITS (https://carleton.ca/its/all-services/computers/site-licensed-software/).

Assignment and Exam grade postings:

All in-term assessment grades will be posted on the course cuLearn website. Students will be notified through cuLearn announcements about marks posting. Please check your marks online and report any discrepancies immediately.

Academic Accommodation:

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:
Pregnancy obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: https://www.carleton.ca/equity/
Religious obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: https://www.carleton.ca/equity/

Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable) at https://www.carleton.ca/pmc/new-and-current-students/dates-and-deadlines/. You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at https://carleton.ca/equity

Use of Course Materials:

Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors and students, are copyright protected and remain the intellectual property of their respective author(s). All course materials, including PowerPoint presentations, outlines, and other materials, are also protected by copyright and remain the intellectual property of their respective author(s). Students registered in the course may take notes and make copies of course materials for their own educational

Course Schedule:

	Topic	Foundations of MEMS (2nd ed)	Microsystems Design	
Week 1:	Introduction, Thin film processes	Chapter 1, Chapter 2	Ch 1-3	Assignment 1
Week 2:	Bulk micromachining	Chapter 10	Ch 3-4	
Week 3:	Surface micromachining	Chapter 11, Chapter 12	Ch 3-4	
Week 4:	Mechanical structures at microscale	Chapter 3	Ch 8-9	Assignment 2
Week 5:	Polymers in MEMS: Emerging topics	Review papers, research articles, instructor notes		
Week 6:	MEMS piezoresistive sensors and capacitive sensors	Chapter 4	Ch 6, 19, 20	
Winter break				
Week 7:	Piezoelectric sensors and actuators	Chapter 7	Ch 21	Mid-term Examination
Week 8:	Thermal sensors and actuators	Chapter 5	Ch 11, 23	Assignment 3
Week 9:	Magnetic sensors and actuators	Chapter 8		
Week 10:	Optical MEMS	Review papers, research articles, instructor notes		
Week 11:	Chemical and Biological sensors	Review papers, research articles, instructor notes		
Week 12:	Review	Lecture notes		