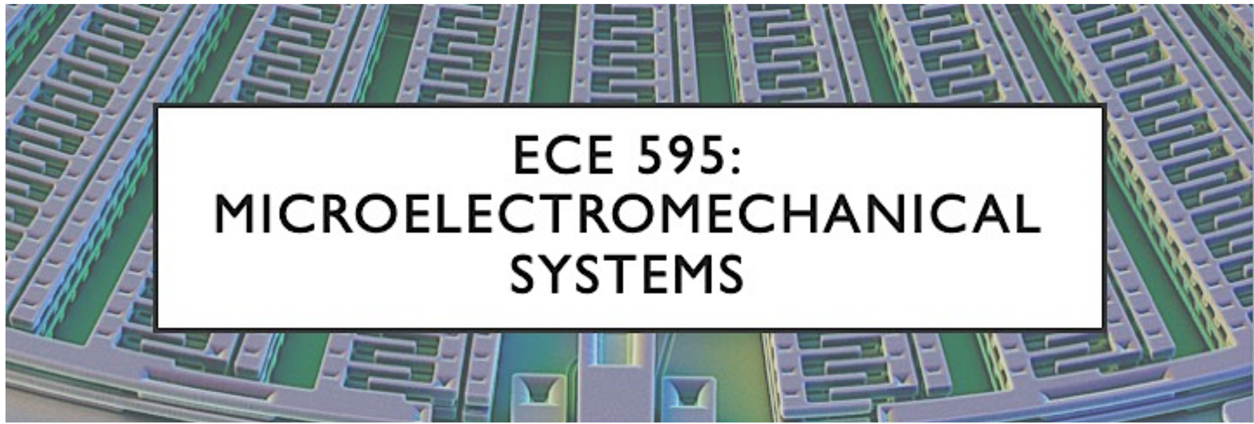

3 unique 1-credit modules

FALL 2019

Prof. Dana Weinstein

Microelectromechanical devices (MEMS), such as pressure sensors, accelerometers, rate gyroscopes, and opto-mechanical assemblies and displays, require knowledge of a broad range of disciplines, from microfabrication to mechanics to electromagnetism. We offer a series of 3 one-credit modules intended as an introduction to MEMS primarily for graduate students and ambitious undergraduates. The split of content across three modules is intended to improve flexibility for our undergrad and grad students, as well as for the Professional Masters Program. Taking all three units sequentially over the course of the semester is equivalent a semester-long 3-credit course and is encouraged for those who are seeking a comprehensive understanding of the field.

MEMS I: Microfabrication and Materials for MEMS (5 weeks)

Module Description

This module introduces the fundamentals of microfabrication used for wafer-scale manufacturing of Microelectromechanical Systems (MEMS). Borrowing some techniques from the integrated circuit (IC) fabrication and engineering new techniques to solve MEMS-specific challenges, MEMS microfabrication boasts an extensive toolbox employed both in research-level prototyping and in mass production in MEMS industry. The course reviews key methods for deposition, patterning, release, and packaging of MEMS devices. Considerations for benefits and levels of integration of MEMS and ICs are discussed. Micro-fabrication case studies of several MEMS devices are reviewed. **Prerequisites:** None.

MEMS II: Fundamentals of MEMS Design (5 weeks)

Module Description

This module introduces the fundamentals of MEMS design. We begin with the design and analysis of micromechanical springs most commonly used in successful MEMS devices. Next, we investigate popular transduction mechanisms, which allow the needed conversion of energy between electrical signals and mechanical motion (and vice versa). This is a critical component of all MEMS actuators and sensors. The course focuses primarily on electrostatic and piezoelectric transduction. Modeling of MEMS devices is then considered, with focus on linearized models and electromechanical resonance. **Prerequisites**: PHYS 172 and 272 or equivalent. **Text:** Kaajakari, Ville. *Practical MEMS*. Las Vegas: Small Gear Pub., 2009. Print.

MEMS III: Applications in MEMS (5 weeks)

Module Description

This module surveys both established and emergent applications of MEMS. With the growing demand for cheap, microscale, low power sensors, the first part of this course will cover MEMS sensor applications including inertial, chemical, field, and IR sensor devices. We will discuss limits of sensitivity, design, fabrication, and system-level integration. Other topics will include microrobotics, optical MEMS, BioMEMS and Lab on a Chip, and quantum computing with MEMS/NEMS. **Prerequisites**: ECE 595 MEMS II or equivalent **Text:** Kaajakari, Ville. *Practical MEMS*. Las Vegas: Small Gear Pub., 2009. Print.

		ECE 595		**Introduction to MEMS**	HW	60%		
		TENTATIVE Schedule Fall 2019			Exams (ea)	40%		

	Day	Date	Lecture	Subject	Issued	Due	Exams	Prereqs
MEMS I	T	8/20	1	Intro to MEMS				None
	Th	8/22	2	Microfabrication basics: surface vs bulk, wafer scale	HW1			
	T	8/27	3	Deposition methods: PVD, CVD, thermal processes				
	Th	8/29	4	Patterning techniques: contact, stepper, direct write, ebeam, lift-off	HW2	HW1		
	T	9/3	5	Etching methods: wet etching processes				
	Th	9/5	6	Etching medhods: dry etching - RIE, DRIE, XeF2	HW3	HW2		
	T	9/10	7	In-class fabrication exercise				
	Th	9/12	8	Assembly: release & CPD, singulation, packaging, integration with IC		HW3		
	T	9/17	9	Microfabrication metrology				
	Th	9/19	10	Exam I			Exam I	
MEMS II	T	9/24	1	Properties of materials	HW1			Phys 172+272 or equivalent
	Th	9/26	2	Beams I: fundamentals of beam bending				
	T	10/1	3	Beams II: designing MEMS springs	HW2	HW1		
	Th	10/3	4	Capacitive Transduction (gap closing + comb drive)				
	T	10/8		October Break				
	Th	10/10	5	Piezoelectric Transduction	HW3	HW2		
	T	10/15	6	Lumped Element Modeling				
	Th	10/17	7	Linearized transducers & resonators		HW3		
	T	10/22	8	Actuator selection				
	Th	10/24	9	Exam II			Exam II	
MEMS III	T	10/29	1	Noise in micromechanical systems	HW1			MEMS II or equivalent
	Th	10/31	2	Physical Sensors: XLs				
	T	11/5	3	Physical Sensors: Gyros	HW2	HW1		
	Th	11/7	4	Chemical and field sensors				
	T	11/12	5	IR sensor: Bolometer	HW3	HW2		
	Th	11/14	6	Optical MEMS, TI DMD case study				
	T	11/19	7	Actuators/Microrobots		HW3		
	Th	11/21		Thanksgiving				
	T	11/26	8	Microfluidics/BioMEMS				
	Th	11/28	9	Exam III			Exam III	