Course Title: BIOEN 455 – BioMEMS

Instructor: Albert Folch, Credits: 4

UW General Catalogue Course Description:

Introduction to BioMEMS. State-of-the-art techniques in patterning biomolecules, machining three-dimensional microstructures and building microfluidic devices. Various biomedical problems that can be addressed with microfabrication technology and the engineering challenges associated with it. Weekly labs. Offered: W

Instructor's Detailed Course Description:

This course introduces students to the techniques and applications of microfabrication technology for biomedical applications. The topics include: 1) **Scaling in biology:** basic review of the various sizes, time, and energy scales found in biological systems from organisms to atoms; 2) **Microfabrication techniques:** extensive review of the fundamentals of microfabrication technology: photolithography, electron beam lithography, micromachining, micromolding, and soft lithography; 3) **Micropatterning non-conventional materials:** Review of self-assembled monolayers, chemical grafting of biomolecules and thin polymeric layers; approaches to patterning those materials as well as cells); 4) **Microelectromechanical sensing of cell behavior:** Introduction to bioelectricity, interaction of cells with electric fields, microphysiometer; 5) **Microengineered biosensors:** Introduction to massively parallel measurements, implantable electrodes, microtweezers, immunosensors; 6) **Microengineering fluid flows:** Introduction to microfluidics, properties of biological fluids in microchannels, mathematical modeling of fluid flow; 7) **Tissue microengineering:** Introduction to biomimetic substrates, microscaffolds, cellular co-cultures; 8) **Microengineering in cell biology:** Microfabrication techniques that enable the control of cell-substrate, cell-cell, and cell-medium interactions; 9) **Microengineering for biotechnology:** Introduction to enzymatic assays, DNA microarrays, optical detection methods amenable to miniaturization; 10) **The frontiers of BioMEMS:** Nanolithography, biomimetic nanodevices. Laboratory exercises will reinforce critical concepts provided in lectures.

Prerequisites by Topics:
None.

Textbooks:
None.

Learning Objectives:
Introduces students to the principles and techniques that allow engineers and biologists to fabricate microdevices, to interface microdevices with cells and tissue, to tailor the microenvironment of single cells, and to manipulate or measure biomolecules on the micron scale. Also teaches students how to critically read a scientific paper, how to manufacture a microdevice by photolithography and micromolding, and how to create protein and cellular micropatterns with a microfluidic device.

Topics Covered:
1) Biologically-relevant scales; 2) Fundamentals of miniaturization technology; 3) Extension of traditional traditional microfabrication techniques to pattern novel materials such as cells and biomolecules; 4) Bioelectrical measurements on the microscale; 5) Biosensors; 6) Microfluidics;

7) Tissue engineering on the microscale; 8) Applications of microfabrication technology to cell biology; 9) Applications of microfabrication techniques to biotechnology; 10) Novel, far-reaching applications of microtechnology.

Class Schedule:
Lectures (3 hours/week), Labs (one 3-hour session per week).

Computer Use:
None.

Laboratory Projects:
Laboratory exercises will reinforce critical concepts provided in lectures. Topics include: Lab 1: photolithography of a simple pattern with SU-8 photoresist; Lab 2: micromolding of the pattern from lab 1; Lab 3: microstamping of fluorescently-labeled protein pattern from Lab 2; Lab 4: selective cellular adhesion on the protein pattern from Lab 3; Lab 5: microfluidic patterning of fluorescently-labeled protein pattern from Lab 2; Lab 6: creation of cellular micropattern on substrate from Lab 5; Lab 7: Laminar flow in microchannels, microfluidic valves, and microfluidic multiplexers.

Course Outcomes and Assessment:
BIOEN455 offers interactive lectures, weekly laboratory exercises, weekly assignments (critical literature reviews), and lab reports. As such, this course addresses certain ABET outcome criteria at a variety of levels.

Specific outcomes in BIOEN 455 and their assessment mechanisms to be used by the department for **program assessment** are:

- ***(b)*** Design and conduct experiments, as well as analyze and interpret data (*lab exercises and reports*). All the labs require that the students, in teams, prepare a microdevice/substrate/pattern of their choice for the subsequent lab, and that the students report the problems/advantages associated with their device.
- ***(d)*** To work in teams *(lab exercises)*. All laboratory exercises involve students working in teams. The teams must collectively build the devices or setups and troubleshoot. Reports are sent individually.
- ***(e)*** Identify, formulate, and solve engineering problems *(lectures)*. Lectures typically present a microfabrication-based solution to a problem, which is presented as a challenge ahead of the technological solution; the students are actively engaged in a discussion to identify other approaches to solve the problem.
- ***(g)*** To communicate effectively *(literature assignments and lab reports)*. The students are engaged by the instructor to participate in lecture discussions. In all written exercises, clarity in writing is part of the grade.

Additional specific outcomes and their assessment mechanisms (in parentheses) considered **of high relevance** by the department for BIOEN455 are: None

Additional specific outcomes and their assessment mechanisms (in parentheses) considered **of medium relevance** by the department for BIOEN455 are: None

Relationship of Course to Departmental Objectives:
The course serves to introduce senior-level BioE students to fundamentals of microfabrication and its application to biological and medical problems. This course also reinforces critical

discussion, critical reading abilities, and team-working. Overall, the course increases the students' awareness of a novel technology of broad applicability, and as such it broadens the students' ability to brainstorm with physicians, biologists and other engineers when presented with "microscale problems".