Biomicroelectromechanical systems - Video course

COURSE OUTLINE

During the last several decades, micro-system research mainly addressed electromechanical systems and in recent years, the focus has shifted to Bio-Microelectromechanical Systems (BioMEMS). This shift is driven primarily by the potential applications of the micro-systems to chemistry, biology and medicine.

In fact, a combination of BioMEMS and microsystems has made possible the realization of physical systems at scales and dimensions similar to biological entities such as bacterial and mammalian cells, viruses, spores, etc., and this has resulted in the development of a variety of diagnostic and therapeutic applications, intelligent biochips and sensors.

BioMEMS today finds many applications within the chemical, health-care, biotechnological and manufacturing industries and this has necessitated a considerable shift in the focus of engineering education.

This proposal illustrates a post graduate level introductory course in BioMEMS and microsystems. The course is designed with the following three fold objective:

1. To provide basic educational foundation in micro-systems engineering emphasizing Biomedical micro-devices. This would also include some basic biological/ biochemical concepts and techniques which are necessary for understanding of diagnostics and therapeutics.
2. To provide education and training in fundamental micro-fabrication/microelectronic processing technologies, and
3. To provide experience in micro-system design issues and various characterization schemes / biomedical/ chemical testing practices and procedures.

This course would be relevant for mechanical engineering manufacturing science/ fluidic streams graduate students and some senior undergraduate students. The interdisciplinary nature of the course would also be able to attract students from various disciplines like biosciences/ bioengineering, chemical engineering and environmental engineering. A considerable portion of the material will also be directly taught from review articles and publications. The highly interdisciplinary nature and research focus of this course may eventually be able attract some undergraduate students into graduate programs.

COURSE DETAIL

Sl. No	Topic	Hours
1.	**Introduction to BioMEMS and Microsystems technology** • Biochips/ biosensors and introduction to device fabrication, Introduction to Cell biology. • DNA & Protein chemistry, Microfluidics.	6

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Mechanical Engineering

Pre-requisites:

Engineering Mathematics.

Additional Reading:

Reference papers and review articles for different lab-on-chip and bio-sensing technologies.

Hyperlinks:

1. Purdue University: https://engineering.purdue.edu/LIBNA
2. BioMEMS: http://mmadou.eng.uci.edu/
3. My Home Page: http://home.iitk.ac.in/~bhattacs/index.html

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	• Biochip Sensors & detection methods. • Potential of Micro-fluidics and introductory continuum mechanics at small scales, Microarrays and Lab-on-chip devices, Introduction to MEMS Design.	
2.	**Micro-fluidics** • **Continuum mechanics at small scales** • Basics of micro-fluidics. • Gas Flows. • Liquid flows. • Boundary conditions. • low Reynold's s no. flows. • Entrance effects, surface tension. • Electro-kinetic techniques like electrophoresis. • Electro-osmosis and dielectrophoresis. • Micro-fluidics for internal flow control (micro-pumps and micro-valves, device building and characterization). • Micromixer design and characterization, Micro-fluidics for life sciences and chemistry.	8
3.	**Microsystems-fabrication processes** • Review of basic fabrication processes for silicon: • Introduction to microelectronic fabrication. • Optical lithography. • Photo-resists. • Non optical lithography techniques. • LIGA processes. • **Design Considerations** • Vacuum science and plasmas. • Etching techniques. • Physical vapor deposition (evaporation and sputtering). • Chemical vapor deposition. **Review of basic fabrication processes for polymers** • Polymer materials for micro-systems. • Polymeric micromachining technology like softlithography. • Bulk and surface micromachining. • Replication technologies.	10 6

	• Laser machining. • Micro-stereo lithography. • Micro-molding. • Assembly and packaging of micro-systems. • Biocompatibility of materials and processes.	
4.	**Overview of Lab-on-chip technology/ biomedical and chemical sensors, specific cases** • Integrated gene analysis systems. • Petri dish on a chip technology (Integrated trapping, culture, growth, lysis and analysis of pathogenic bacteria). • Single cell and single molecule analysis using lab-on-chip techniques. • Pharmaceutical analysis using lab-on-chip technology. **Biomedical and chemical sensors:** • Electrochemical. • Optical (labeled and unlabeled). • Piezoelectric sensors. (In this module most of the discussion will be based on review articles and papers)	10

References:

1. Fundamentals of Microfabrication (Second Edition), Marc J. Madou, CRC press Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL33487- 2724, 2002.
2. BioMEMS Technologies and Applications, Edited by Wanjun Wang, Steven A. Soper, CRC press Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL33487-2724, 2006.
3. Biomolecular sensing, processing and analysis, Rashid Bashir, Steve T. Werely, Mauro Ferrari, Springer Science and Business Media LLC, 233 Spring Street, New York, NY10013, USA, 2006.
4. Fundamentals and applications of Microfluidics, Nam-Trung Nguyen, Steve T. Werely, Artech house Inc., 685 Canton Street, Norwood, MA02062, 2002.
5. The Science and Engineering of Microelectronic Fabrication (Second Edition), Stephen A. Cambell, Oxford University Press, 198, Madison Avenue, New York 10016, 2001.
6. Molecular Biology of the Cell (fourth edition), Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Kate Roberts, Peter Walter, Garland Sand, Taylor and Francis group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL33487-2724, 2002.