Micro and Smart Systems - Video course

COURSE OUTLINE

This interdisciplinary course not only gives an overview of the micro and smart systems technologies but also gives an in-depth understanding of the issues involved. It begins by answering the important question: why miniaturize? This is followed by a quick summary of a variety of sensors, actuators, and systems.

It then presents a comprehensive description of microfabrication. This is followed by a detailed discussion of mechanics of solids as it pertains to micro and smart systems.

While this part may be viewed as strength of materials and design, an effort is made to relate this to micro devices and discuss such topics as residual stress and stress gradients, lumped modeling using energy methods, anticlastic curvature, etc.

The discussion ends with general equations of elasticity and their solution is discussed next using the finite element method. Here, too the basics and advanced topics are interleaved to provide a thorough understanding of the finite element method. After this, electronics circuits, control, and packaging are also presented.

COURSE DETAIL

Lecture No.	Topic
	Module 1: Introduction
1.	Glimpses of Microsystems; scaling effects
2.	Smart materials and systems: an overview
3.	Microsensors: some examples
4.	Microactuators: some examples
5.	Microsystems: some examples
6.	Examples of smart systems: structural health monitoring and vibration control
	Module 2: Microfabrication processes
7.	Structure of silicon and other materials
8.	Silicon wafer processing; Thin-film deposition

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Mechanical Engineering

Pre-requisites:

- Multi-variable calculus.

Additional Reading:

1. G.T.A. Kovacs, Micromachined Transducers Sourcebook, WCB McGraw-Hill, 1998.
2. J.W. Gardner, Microsensors: principles and applications, John Wiley & Sons, 1994.
3. M. Madou, Principles of Microfabrication, CRC Press, 1998.

Hyperlinks:

- About MEMS and Nanotechnology: http://www.memsnet.org/mems/
- Analog Devices: http://www.analog.com/en/mems-andsensors/products/index.html
- MICROSYSTEM DESIGN: http://web.mit.edu/microsystem-design/www/

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9.	Lithography, wet etching and dry etching
10.	Bulk micromachining and Surface micromachining
11.	Wafer-bonding; LIGA and other moulding techniques
12.	Soft lithography and polymer processing
13.	Thick-film processing; Low temperature co-fired ceramic processing
14.	Smart material processing
	Module 3: Mechanics of Solids
15.	Stresses and deformation: bars and beams
16.	Microdevice suspensions: lumped modeling
17.	Residual stress and stress gradients
18.	Poisson effect; Anticlastic curvature; examples of micromechanical structures
19.	Thermal loading; bimorph effect
20.	Dealing with large displacements; in-plane and 3D elasticity equations
21.	Vibrations of bars and beams
22.	Gyroscopic effect
23.	Frequency response; damping; quality factor
24.	Basic micro-flows for damping calculation
	Module 4: Finite element method
25.	Types of numerical methods for solving partial differential equations
26.	What is finite element method? Variational principles

27.	Weak form; shape functions
28.	Isoparametric formulation and numerical integration
29.	Implementation of the finite element method
30.	FEM for piezoelectrics
	Module 5: Electronics and packaging
31.	Semiconductor devices: basics
32.	OpAms and OpAmp circuits
33.	Signal conditioning for microsystems devices
34.	Control and microsystems
35.	Vibration control of a beam
36.	Integration of microsystems and microelectronics
37.	Packaging of Microsystems: why and how
38.	Flip-chip, ballgrid, etc.; reliability
39.	Case-study 1 (Pressure sensor)
40.	Case-study 2 (Accelerometer)

References:

1. S.D. Senturia, Microsustem Design, Kluwer Academic Publishers, 2001.
2. Tai-Ran Hsu, MEMS & Microsystems Design and Manufacture, McGraw Hill, 2002.
3. V.K. Varadan, K.J. Vinoy, and S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, Wiley, 2006.