Academic Course Description

SRM University
Faculty of Engineering and Technology
Department of Electronics and Communication Engineering

EC0032 Introduction to MEMS

Eighth semester, 2015-16 (Even Semester)

COURSE (CATALOG) DESCRIPTION

The objective of this course is to make students to gain basic knowledge on overview of MEMS (Micro electro Mechanical System) and various fabrication techniques. This enables them to design, analysis, fabrication and testing the MEMS based components. And to introduce the students various opportunities in the emerging field of MEMS.

Compulsory/Elective course: Elective course for 8th Semester ECE students

Credit hours: 3 credits

Course coordinator Mrs.P.Ponnammal ,Assistant Professor (O.G), Department of ECE

INSTRUCTOR(S)

Name of the instructor	Class handling	Office location	Office phone	Email @ktr.srmuniv.ac.in	Consultations
Dr.S.Dhanalakshmi	X	TP1003 A	2059	dhanalakshmi.s@ktr.srmuniv.ac.in	D4-6,7,D5-6,7
P.Ponnammal	Y	TP1006 A	2061	ponnammal.p@ktr.srmuniv.ac.in	D3-FN,D4-AN

Relationship to other courses

Pre-requisites : EC0204 Electronic Circuits

Assumed knowledge : Basic knowledge in material science

Following courses : *Nil*

SYLLABUS CONTENTS

UNIT-1 INTRODUCTION TO MEMS AND MICROFABRICATION

History of MEMS Development, Characteristics of MEMS-miniaturization - micro electronics integration - Mass fabrication with precision. Micro fabrication - microelectronics fabrication process- silicon based MEMS pro cesses- new material and fabrication processing- points of consideration for processing.

UNIT-2 ELECTRICAL AND MECHANICAL PROPERTIES OF MEMS MATERIALS 9

Conductivity of semiconductors, crystal plane and orientation, stress and stain – definition – relationship between tensile stress and stain- mechanical properties of silicon and thin films, Flexural beam bending analysis under single loading condition- Types of beam- deflection of beam-longitudinal stain under pure bending- spring constant, torsional deflection, intrinsic stress, resonance and quality factor.

UNIT-3 SENSING AND ACTUATION 9

Electrostatic sensing and actuation-parallel plate capacitor – Application-Inertial, pressure and tactile sensor- parallel plate actuator- comb drive.

Thermal sensing and Actuations-thermal sensors-Actuators- Applications- Inertial, Flow and Infrared sensors.

Piezoresistive sensors- piezoresistive sensor material- stress in flexural cantilever and membrane- Application-Inertial, pressure, flow and tactile sensor.

Piezoelectric sensing and actuation- piezoelectric material properties-quartz-PZT-PVDF –ZnO- Application-Inertial, Acoustic, tactile, flow-surface elastic waves

Magnetic actuation- Micro magnetic actuation principle- deposition of magnetic materials-Design and fabrication of magnetic coil.

UNIT-4 BULK AND SURFACE MICROMACHINING 9

Anisotropic wet etching, Dry etching of silicon, Deep reactive ion etching (DRIE), Isotropic wet etching, Basic surface micromachining process- structural and sacrificial material, stiction and antistiction methods, Foundry process.

UNIT-5 POLYMER AND OPTICAL MEMS 9

Polymers in MEMS- polymide-SU-8 liquid crystal polymer(LCP)-PDMS-PMMA-Parylene- Flurocorbon, Application-Acceleration, pressure, flow and tactile sensors. Optical MEMS-passive MEMS optical components-lenses-mirrors-Actuation for active optical MEMS.

Text book(s) and/or required materials:

[1].Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.

References:

[2].Gaberiel M.Rebiz, "RF MEMS Theory,Design and Technology", John Wiley & Sons,2003

[3].Charles P.Poole, Frank J.Owens, "Introduction to nanotechnology" John Wiley & sons, 2003.

[4].Julian W.Gardner, Vijay K Varadhan, "Microsensors, MEMS and Smart devices", John Wiley & sons, 2001.

Computer usage: Nil

Class schedule: Three 50 minutes lecture sessions per week, for 13-14 weeks

Section	Schedule
X	D3-3rd hr,D4-5th hr,D5-5th hr
Y	D3-7th hr,D4-5th hr,D5-5th hr

Professional component

General	-	0%
Basic Sciences	-	10%
Engineering sciences & Technical arts	-	10%
Professional subject	-	80%

Broad area : Communication | Signal Processing | **Electronics** | **VLSI** | Embedded

Course objectives

The objectives of this course is to	Correlates to Program Objective
1. Introduction to MEMS and micro fabrication	(1)
2. To study the essential material properties	(3), (4)
3 .To study various sensing and transduction technique	(3)
4. To know various fabrication and machining process of MEMS	(3)
5. To know about the polymer and optical MEMS	(3)

Course Learning Outcome:

This course provides the foundation education in MEMS through lecture and out-of-class assignments, students are provided learning experience that enable them to:	Correlates to program outcome		
	H	**M**	**L**
1. Be familiar with the important concepts applicable to MEMS, their fabrication.	a	e	b
2. Be fluent with the design, analysis and testing of MEMS.	f	d	c
3. Apply the MEMS for different applications.	d	k	j

H: high correlation, M: medium correlation, L: low correlation

Evaluation methods

Cycle Test – I	-	10%
Cycle Test – II	-	10%
Model Test	-	20%
Surprise Test	-	5%

Attendance - 5%
Final exam - 50%

Test Schedule

S. No.	Test	Portions	Tentative Dates	Duration
1	Cycle Test-1	Session 1 to1 4	24-2-2016	2 Periods
2	Cycle Test-2	Session15 to 22	23-3-2016	2 Periods
3	Model Test	All Sessions	25-4-2016	3 Hrs
4	University Exam	All Sessions	16-5-2016	3 Hrs

Teaching Plan

Session #	Unit #	Topic	Text / Chapter	Problem Solving	Correlation of Topics with IOs
1	1	**UNIT 1 INTRODUCTION TO MEMS AND MICROFABRICATION** History of MEMS development,	[1] Chapter(s) 1	No	a,b,j,k
2	1	Characteristics of MEMS.	[1] Chapter(s) 1	No	a,b,j,k
3	1	Miniaturization, Microelectronics integration	[1] Chapter(s) 1	No	a,b,j,k,
4	1	Mass fabrication with precision	[1] Chapter(s)1	No	a,b,j,k,
5	1	Microfabrication	[1] Chapter(s1	No	A,b,j,k
6	1	micro electronics fabrication process	[1] Chapter(s) 2	No	A,b,j,k
7	1	Silicon based MEMS processes	[1] Chapter(s) 2	No	A,b,j,k

Session #	Unit #	Topic	Text / Chapter	Problem Solving	Correlation of Topics with IOs
8	1	New material and fabrication processing	[1] Chapter(s) 2	No	A,b,d,j,k
9	1	Points of consideration for processing	[1] Chapter(s) 2	No	A,b,d,j,k
10	2	**UNIT-2 ELECTRICAL AND MECHANICAL PROPERTIES OF MEMS MATERIALS** Conductivity of semiconductors,Crystal plane and orientation	[1] Chapter(s) 2,3	No	A,b,d,j,k
11	2	Stress and stain –definition-relationship between tensile stress and stain.	[1] Chapter(s) 3	No	A,b,d,j,k
12	2	Mechanical properties of silicon and thin films	[4] Chapter(s) 3	No	A,b,d,j,k
13	2	Flexural beam bending analysis under single loading condition	[4] Chapter(s) 3	No	A,b,j,d,k
14	2	Types of beam-deflection of beam-longitudinal stain under pure bending	[2] Chapter(s) 3	No	A,b,j,d,k
15	2	longitudinal stain under pure bending	[2] Chapter(s) 3	No	A,b,j,d,k
16	2	Spring constant	[2] Chapter(s) 3	No	A,b,d,j,k
17	2	Tensional deflection, intrinsic stress	[4] Chapter(s) 3	No	A,b,d,j,k
18	2	Resonance and quality factor	[2] Chapter(s) 3	No	A,b,d,j,k

Session #	Unit #	Topic	Text / Chapter	Problem Solving	Correlation of Topics with IOs
19	3	**UNIT-3 SENSING AND ACTUATION** Electrostatic sensing and actuation-parallel plate capacitor Application-inertial, pressure and tactile sensor	[1] Chapter(s) 4	No	A,b.k
20	3	Parallel plate actuator-comb drive	[1] Chapter(s) 4	No	A,b.k
20	3	Thermal sensing and actuations-thermal sensors-actuators	[1] Chapter(s) 5,6	No	A,b.k
21	3	Application-inertial, flow and infrared sensors ,Piezoresistive sensors-piezoresistive sensor material	[1] Chapter(s) 5,6	No	A,b.k
22	3	Stress in flexural cantilever and membrane	[1] Chapter(s) 6	No	A,b.k
23	3	Application-inertial, pressure, flow and tactile sensor,Piezoelectric sensing and actuation	[1] Chapter(s) 6	No	A,b.k
24	3	piezoelectric material properties-quartz-PZT-PVDF-ZnO	[1] Chapter(s) 6,7	No	A,b.k
25	3	Application-Inertial,Acoustic ,tactile,flow surface elastic waves	[1] Chapter(s) 7	No	A,b.k
26	3	Magnetic actuation – micro magnetic actuation principle	[1] Chapter(s) 7	No	A,b.k
27	3	Deposition of magnetic materials-design and fabrication of magnetic coil	[1] Chapter(s) 8	No	A,b.k
28	4	**UNIT-4 BULK AND SURFACE MICROMACHINING** Anisotropic wet etching	[1] Chapter(s) 10	No	A,b,k

Session #	Unit #	Topic	Text / Chapter	Problem Solving	Correlation of Topics with IOs
29	4	dry etching of silicon	[1] Chapter(s) 10	No	A,b,k
30	4	Deep reactive ion etching(DRIE)	[1] Chapter(s) 10	No	A,b,k
31	4	Isotropic wet etching	[1] Chapter(s) 11	No	A,b,k
32	4	Basic surface micromachining process	[1] Chapter(s) 11	No	A,b,k
33	4	Basic surface micromachining process	[1] Chapter(s) 11	No	A,b,k
34	4	Structural and sacrificial material	[1] Chapter(s) 11	No	A,b,k
35	4	Stiction and anti stiction methods	[1] Chapter(s) 11	No	A,b,k
36	4	Foundry process	[1] Chapter(s) 11	No	A,b,k
37	5	**UNIT-5 POLYMER AND OPTICAL MEMS** Polymers in MEMS-polymide-SU-8	[1] Chapter(s) 12	No	A,b,j,k
38	5	Liquid crystal polymer(LCP)	[1] Chapter(s) 12	No	A,b,j,k
39	5	PDMS,PMMA-Parylene	[1] Chapter(s) 12	No	A,b,j,k
40	5	Fluorocarbon,Application,Acceleration	[1] Chapter(s) 12	No	A,b,j,k
41	5	Pressure,Flow and tactile sensors	[1] Chapter(s) 15	No	A,b,j,k
42	5	Optical MEMS	[1] Chapter(s) 15	No	A,b,j,k

Session #	Unit #	Topic	Text / Chapter	Problem Solving	Correlation of Topics with IOs
43	5	Passive MEMS optical components	[1] Chapter(s) 15	No	A,b,j,k
44	5	Lenses, mirrors	[1] Chapter(s) 15	No	A,b,j,k
45	5	Actuation for active optical MEMS.	[1] Chapter(s) 15	No	A,b,j,k

Prepared by:, Mrs.P.Ponnammal ,Assistant Professor (O.G), Department of ECE

Dated: 04th February2016

Revision No.: 01 **Date of revision:** 04/02/16 **Revised by:** P.Ponnammal,Asst Prof (O.G)/Dept Of ECE

Addendum

ABET Outcomes expected of graduates of B.Tech / ECE / program by the time that they graduate:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate the ability to identify, formulate and solve engineering problems.
c. Graduate will demonstrate the ability to design and conduct experiments, analyze and interpret data.
d. Graduates will demonstrate the ability to design a system, component or process as per needs and specifications.
e. Graduates will demonstrate the ability to visualize and work on laboratory and multi-disciplinary tasks.
f. Graduate will demonstrate the skills to use modern engineering tools, software's and equipment to analyze problems.
g. Graduates will demonstrate the knowledge of professional and ethical responsibilities.
h. Graduate will be able to communicate effectively in both verbal and written form.
i. Graduate will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
j. Graduate will develop confidence for self education and ability for life-long learning.

k. Graduate will show the ability to participate and try to succeed in competitive examinations.

Program Educational Objectives

1. To prepare students to compete for a successful career in Electronics and Communication Engineering profession through global education standards.
2. To enable the students to aptly apply their acquired knowledge in basic sciences and mathematics in solving Electronics and Communication Engineering problems.
3. To produce skillful graduates to analyze, design and develop a system/component/ process for the required needs under the realistic constraints.
4. To train the students to approach ethically any multidisciplinary engineering challenges with economic, environmental and social contexts
5. To create awareness among the students about the need for life long learning to succeed in their professional career as Electronics and Communication Engineers.

Class handling	Name of the instructor	Signature
X	Dr.S.Dhanalakshmi	
Y	P.Ponnammal	

Course Coordinator	Academic Coordinator	Professor In charge	HOD/ECE
P.Ponnammal	Mr.B.Viswanathan	Dr.R.Kumar	Dr.T.Ramarao