Government of Karnataka
Department of Technical Education
Board of Technical Examinations, Bengaluru

Course Title: Micro Electro Mechanical Systems		Course Code:15MC54A
Mode (L:T:P) : 4:0:0	Credits:4	Core/ Elective: Elective
Type of Course: Lectures & Student Activities		Total Contact Hours: 52
CIE= 25 Marks		SEE= 100 Marks

Pre-requisites: Knowledge of Applied Science, measurement system

Course Objectives: Understand the importance and application of micro electro mechanical systems.

Course Outcome: At the end of the course, the student should be able to

1. Explain the concept of Microsystems & Smart system
2. Explain the Concept working of Micro sensors & Actuators Understand various welding processes
3. Explain the various materials used for Microsystems & Smart system
4. Explain scaling in Microsystems
5. Explain various Micro manufacturing techniques & Micro fabrication processes
6. Explain various factors to be considered in Micro system Design & levels of Micro system Packages

Course Outcome		Cognitive Level	Linked with PO	Teaching Hours
CO1	Explain the concept of Microsystems & Smart system	*U*	2	6
CO2	Explain the Concept working of Micro sensors & Actuators	*U*	2	9
CO3	Explain the various materials used for Microsystems & Smart system	*U*	2	8
CO4	Explain scaling in Microsystems	*U*	1,2	8
C05	Explain various Micro manufacturing techniques & Micro fabrication processes	*U*	2	10
C06	Explain various factors to be considered in Micro system Design & levels of Micro system Packages	*U*	2	11
		Total sessions		**52**

Legend: R; Remember, U: Understand A: Application

Mapping of Course Outcomes with Program Outcomes

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
Micro Electro Mechanical Systems	**1**	**3**	-	-	-	-	-	-	-	-

Course Content and Weightage For SEE

Unit No	Unit Name	CO	Hour	Marks allocated for different Cognitive level Questions			Marks weightage (%)
				R	U	A	
1	Introduction to Micro System and Smart System	1	06	-	**15**	-	**10.34**
2	Micro Sensors & Actuators	2	09	-	**25**	-	**17.24**
3	Materials for Microsystem and Smart System	3	08	-	**20**	-	**13.80**
4	Scaling in Microsystem	4	08	-	**20**	-	**13.80**
5	Micro manufacturing and Microsystem Fabrication	5	10	-	**30**	-	**20.68**
6	Microsystem Design & Packaging	6	11	-	**35**	-	**24.14**
	Total		**52**	**145 Marks**			**100**

Contents

Unit-I

Introduction to Micro System and Smart System

Microsystem, MEMS, System-on-a-chip, Application of MEMS, Smart Material System, Components of a Smart System, Engineering disciplines involved in Micro system Design, Manufacture & Packaging. 06 **Hours**

Unit-II

Micro Sensors & Actuators

Introduction to sensors and actuators, principle of operation, advantages and applications of Silicon Capacitive Accelerometer, Piezoresistive Pressure Sensors, Conductometric Gas Sensor, Electrostatic Comb-Drive, Magnetic Micro relay, Portable Blood Analyzer, Piezoelectric Inkjet Print head.

9 Hours

Unit-III

Materials for Microsystems and Smart System

Properties of Materials used in MEMS Design, Substrates & Wafers, Group of materials classified as Conductors, Semiconductors & Insulators, reasons for the popular application of Silicon as Substrate Material, three Silicon Compounds often used in Microsystems, Silicon Piezoresistors, Piezoelectric Crystals and its application, Quartz, Polymers with its advantages and applications, Smart Materials & Shape Memory Alloys (SMA) with examples of their application in smart system

8 Hours

Unit-IV

Scaling in Microsystems

Introduction to Scaling and its importance, simple scaling law, Scaling in Geometry, Comparision of Macro & Micro worlds with pictorial depiction, Dynamic Forces, scaling in Heat Transfer, Scaling in, Electrostatic Forces, Scaling in Electricity, scaling in electromagnetic forces, scaling in fluid mechanics,

8 Hours

Unit-V

Micro manufacturing and Microsystems Fabrication

Introduction to Micromachining or Micro manufacturing, Bulk Micro manufacturing by dry and wet etching with their comparison, Surface Micromachining, LIGA Process, Introduction to Microsystems fabrication- Silicon Wafer Preparation, Thin Film Deposition by thermal evaporation, sputtering and CVD processes, key processes involved in Photolithography, surface micro machining.

10 **Hours**

Unit-VI

Microsystem Design & Packaging

Overview of Mechanical Design of Microsystems, Factors to be considered for the design, Design constraints, principal substrate materials-advantages and disadvantages, three principal manufacturing process-advantages and disadvantages, options for signal transduction in Microsystems, suitability of a particular process design, Mechanical Design Parameters with respect to Thermo Mechanical Loading, Thermo mechanical Stress Analysis, Dynamic Analysis, Introduction to Mechanical Packaging of Microsystems, Principal design requirements in packaging design, three levels of micro system packaging

11Hours

REFERENCE BOOKS

1: MEMS & MICROSYSTEMS - Design and Manufacture by Tai-Ran Hsu , McGraw Hill Education Private Ltd.,

2: Micro and Smart Systems by G.K.Ananthasuresh, V.K.Aatre, K.J.Vinoy, S.Gopalakrshnan, K.N.Bhat, Wiley-India

3: MEMS by Mahalik, McGraw Hill Education Private Ltd.,

e-Reference

1. http://www.slideshare.net/navinec1/micro-electromechanical-system-mems
2. **https://www.mems-exchange.org/MEMS/what-is.html**
3. **http://mspde.usc.edu/inspiring/resource/sensor/Microsensors.pdf**
4. **http://www.engr.sjsu.edu/trhsu/ME189_Chapter%207.pdf**
5. **http://www.technologystudent.com/equip1/sma1.htm**
6. **http://www.slideshare.net/deepika46/smart-materials-39205546**
7. **http://www.engr.sjsu.edu/trhsu/ME189_Chapter%206.pdf**
8. **http://www.engr.sjsu.edu/trhsu/ME189_Chapter%209.pdf**
9. **http://www.gbv.de/dms/ilmenau/toc/330321218.PDF**
10. **http://www.pitt.edu/~qiw4/Academic/ME2080/lecture23.pdf**

Student Activity

Activity No	Description of the Student Activity
1	Write a report on micro systems or micro sensors not mention in the curriculum.(Hand written 2 or 3 pages)

Note:

1. Group of max four students should do any one of the above activity or any other similar activity related to the course COs and get it approved from concerned Teacher and HOD.
2. No group should have activity repeated or similar
3. Teacher should asses every student by using suitable **Rubrics** approved by HOD

Sample Rubrics

Dimension	Exemplary	Accomplished	Developing	Beginning	Roll No. of the Student				
	5/4	3	2	1	1	2	3	4	5
Organization	Information presented in logical, interesting sequence	Information in logical sequence	Difficult to follow presentation--student jumps around	Cannot understand presentation--no sequence of information	Ex: 2				
Subject Knowledge	Demonstrates full knowledge by answering all class questions with explanations and elaborations	At ease with expected answers to questions but does not elaborate	Uncomfortable with information and is able to answer only rudimentary questions	Does not have a grasp of the information. Cannot answer questions about subject	4				
Graphics	Explain and reinforce screen text and presentation	Relate to text and presentation	Occasionally uses graphics that rarely support text and presentation	Uses superfluous graphics or no graphics	5				
Oral Presentation	Maintains eye contact and pronounces all terms precisely. All audience members can hear	Maintains eye contact most of the time and pronounces most words correctly. Most audience members can hear presentation	Occasionally uses eye contact, mostly reading presentation, and incorrectly pronounces terms. Audience members have difficulty hearing	Reads with no eye contact and incorrectly pronounces terms. Speaks too quietly	3				
Total Score=2+3+4+5=14/4=3.5=4									

Institutional Activity

Activity No	Description of the Institutional Activity
1	Organize seminar, workshop, lecture from eminent person in the following domain: a) micro sensors and actuators b) micro electro mechanical systems c) nano technology

Course Assessment Pattern

Particulars			Max Marks	Evidence	Course outcomes
Direct Assessment	**CIE**	Three test (Average of three tests)	20	Blue books	1,2,3,4,5,6
		Student Activity	05	Student Activity Sheets	1,2,3,4,5,6
	SEE	End of the course	100	Answer scripts at BTE	1,2,3,4,5,6
Indirect Assessment	**Student Feedback on course**	Middle of the course		Feedback forms	1, 2&3
		End of the course		Feedback forms	1,2,3, 4, 5&6

Note: I.A. test shall be conducted for 20 marks. Average marks of three tests shall be rounded off to the next higher digit.

Note to IA verifier*: *The following documents to be verified by CIE verifier at the end of semester

1. Blue books (20 marks)
2. Student suggested activities report for 5 marks and should be assessed on RUBRICS
3. Student feedback on course regarding Effectiveness of Delivery of instructions & Assessment Methods.

Model Question Paper (CIE)

Date and Time	Semester	Course	Max Marks
1Test(6 th week of sem) 10-11 Am	V SEM	**Micro Electro Mechanical Systems**	20
	Year: 2017-18	Course code:15MC54A	

Name of Course coordinator : **Units:1,2 Co: 1,2**

All questions carries equal marks

Question No	Question	CL	CO	PO
1	Explain briefly miniaturization and micro system OR Explain typical smart system with block diagram	U	1	1,2
2	Explain application of MEMS in automotive industry. OR Explain application of MEMS in aero space industry	U	1	1,2
3	Explain in detail of functioning sensors with examples OR Explain in detail of functioning actuators with examples	U	2	1,2
4	Explain the principle of operation of Magnetic Micro relay OR Explain the principle of operation of Piezoelectric Inkjet Print head	U	2	1,2

Model Question Paper
V Semester Diploma in Mechatronics Engineering
Micro Electro Mechanical Systems
Instructions: Answer any six questions from part A and Seven full questions from part B

PART-A

Answer any six questions. **5X6=30 marks**

1. Explain difference between MEMS and micro system
2. Explain materials used for capacitive accelerometer and for Electrostatic Comb-Drive
3. Explain micro sensor and micro actuator with an example for each
4. Explain group of materials that are classified as electric Conductors, Semiconductors & Insulators
5. Explain Scaling in Geometry
6. Explain general process of Surface Micro machining
7. Explain silicon wafer preparation
8. Explain merits and demerits of bulk micro manufacturing
9. Explain mechanical engineering Design of micro system over that of other products

PART- B

Answer any seven full questions. **10X7=70M**

1. Explain five engineering discipline involved in micro system design, manufacture and packaging

2. Explain the principle of operation of silicon capacitive accelerometer

3. a) Explain micro sensor and micro actuator with an example for each
   b) Explain the applications of polymers for mems and micro systems

4. Explain briefly 3 silicon compounds often used in micro systems

5. a) Explain Scaling in Geometry
   b) Explain scaling in fluid mechanics

6. a) Explain pictorial depiction of the scaling law compare Macro & Microworlds
   b) Explain principal substrate materials used in micro system

7. Explain thin film deposition by thermal CVD processes

8. Explain with sketches major steps in the LIGA Process

9. Explain principal design requirements in packaging design

10. Explain mechanical design parameters with respect to thermo mechanical stress analysis

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Model Question Bank
V Semester Diploma in Mechatronics Engineering
Micro Electro Mechanical Systems

Unit -1

Introduction to Micro System and Smart System

Cognitive level- Understanding

1. Explain briefly miniaturization and micro system
2. Explain MEMS
3. Explain system- on-a- chip with graphical representation.
4. Explain difference between MEMS and micro system
5. Explain application of MEMS in healthcare industry.
6. Explain application of MEMS in aero space industry.
7. Explain application of MEMS in automotive industry.
8. Explain application of MEMS in industrial and consumable product.
9. Explain typical smart system with block diagram
10. Explain the purpose of various components of a smart system.
11. Explain application of smart system in various areas along with purpose.
12. Explain five engineering discipline involved in micro system design, manufacture and packaging.

Unit –II

Micro Sensors & Actuators

Cognitive level- Understanding

1. Explain in detail of functioning sensors with examples
2. Explain in detail of functioning actuators with examples
3. Explain the principle of operation of silicon capacitive accelerometer
4. Explain the advantages and typical application silicon capacitive accelerometer
5. Explain the principle of operation of Piezoresistive Pressure Sensors
6. Explain the advantages and typical application Piezoresistive Pressure Sensors
7. Explain the principle of operation of Conductometric Gas Sensor
8. Explain the advantages and typical application Conductometric Gas Sensor
9. Explain the principle of operation of Electrostatic Comb-Drive
10. Explain the advantages and typical application Electrostatic Comb-Drive
11. Explain the principle of operation of Magnetic Microrelay
12. Explain the advantages and typical application Magnetic Microrelay
13. Explain the principle of operation of Portable Blood Analyser
14. Explain the advantages and typical application Portable Blood Analyser
15. Explain the principle of operation of Piezoelectric Inkjet Print head
16. Explain the advantages and typical application Piezoelectric Inkjet Print head

Unit –III

Materials for Microsystem and Smart System

Cognitive level- Understanding

1. Explain properties of materials that play important role in MEMS Design
2. Explain Substrates & Wafers in micro system

3. Explain the reasons for the popular application of silicon as substrate Material
4. Explain briefly 3 silicon compounds often used in micro systems
5. Explain Piezoelectric Crystals and its application
6. Explain Quartz with its application and advantages
7. Explain briefly Polymers and its advantages as industrial materials
8. Explain smart materials, shape-memory-alloys with examples of smart materials used in smart systems

Unit-IV

Scaling in Microsystem

Cognitive level- Understanding

1. Explain the importance of scaling and also state two types of law, simple scaling law
2. Explain Scaling in Geometry
3. Explain comparison of Macro & Micro worlds with pictorial depiction
5. Explain scaling in Dynamic Forces
6. Explain scaling in Heat Transfer
7. Explain scaling in Electrostatic Forces
8. Explain scaling in Electricity
9. Explain scaling in electro magnetic forces
10. Explain scaling in fluid mechanics

Unit-V

Micromanufacturing and Microsystem Fabrication

Cognitive level- Understanding

1. Explain bulk micro manufacturing by dry etching
2. Explain bulk micro manufacturing by wet etching
3. Explain general process of Surface Micro machining
4. Explain with sketches major steps in the LIGA Process
5. Explain silicon wafer preparation
6. Explain thin film deposition by thermal evaporation
8. Explain thin film deposition by the Sputtering.
9. Explain thin film deposition by thermal CVD processes
10. Explain the key processes involved in photolithography

Unit-VI

Microsystem Design & Packaging

Cognitive level- Understanding

1. Explain mechanical engg. Design of micro system over that of other products
2. Explain overview of mechanical design of micro system
3. Explain design constrains for micro system
4. Explain the options for signal transduction in micro system
5. Explain the suitability of particular process
6. Explain mechanical design parameters with respect to thermo mechanical loading
7 Explain mechanical design parameters with respect to thermo mechanical stress analysis
8. Explain mechanical design parameters with respect to dynamic analysis

9. Explain principal design requirements in packaging design.
10. Explain die- packaging
11. Explain – device level packaging
12. Explain system level packaging