SEMESTER S7

MICRO ELECTRO MECHANICAL SYSTEMS

Course Code	PEMRT744	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	Course Type	Theory

Course Objectives:

1. To develop knowledge on Micro electro mechanical systems and materials used in the manufacture
2. To understand various micro fabrication procedures, techniques and packaging considerations

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SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Micro Electronic Mechanical Systems:** Materials for MEMS- silicon- structure and orientations, properties. Other materials- shape memory alloy (SMA), polymers, silicon compounds etc, material properties. **Commercial MEMS structures and systems:** Overview of commonly used mechanical structures in MEMS - Beams, Cantilevers, Plates, Diaphragms – Typical applications. Passive MEMS structures- fluid nozzles- ink jet nozzles. Sensors- piezoresistive pressure sensors- mass flow sensors- acceleration sensors, actuators- micro mechanical valves-micro pumps.	9
2	**Process of micromachining**: Process of micromachining- pattern transfer using additive technique. Silicon growth- oxidation of silicon-molecular beam epitaxy. Physical vapour deposition (PVD)- sputtering- laser deposition- ion plating- cluster beam technology- Chemical vapour deposition (CVD)- step coverage- plasma enhanced CVD, Electron cyclotron resonance CVD (ECRCVD)- sol-gel deposition technique.	9

3	**Lithography** Photolithography- Introduction- masks- spinning- resist and soft backing- exposure and post exposure treatment- development- descumming and post baking- resists- wafer priming, wafer cleaning and contamination- clean room- resist striping. Next generation lithography-extreme ultra violet lithography (EUVL)- x-ray lithography- LIGA- charged particle beam lithography- electron beam lithography- ion beam lithography. **Etching:** Introduction- dry etching- physical etching- ion etching or sputtering- ion beam etching, plasma etching- deep reactive ion etching (DRIE)- isotropic wet etching- anisotropic wet etching.	**9**
4	**MEMS packaging:** Key design and packaging consideration- wafer stack thickness- wafer dicing concerns, thermal management- stress isolation- protective coating and media isolation. Wafer level packaging and die level packaging. Hermetic packaging- calibration and compensation- die attach process- solder alloy- bonding process using solder alloy- organic adhesive wiring and inter connections- Wire bonding- flip chip bonding- micro fluidics interconnections. Packaging material properties- mechanical- moisture penetration- interfacial adhesion, thermal- chemical- electrical.	**9**

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Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Define MEMS and elaborate on various materials used for MEMS fabrication and to describe different kinds of commercial applications like micropumps, valves and sensors.	**K2**
CO2	Describe the various techniques involved in micromachining and discuss techniques for deposition of materials to create structures.	**K2**
CO3	Discuss lithography and etching techniques.	**K2**
CO4	Develop a deep understanding of design and packaging considerations during manufacture of MEMS devices	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											3
CO2	3											3
CO3	3											3
CO4	3											3
CO5												

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

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Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An Introduction to Micro electromechanical Systems Engineering	Nadim Maluf	Artech house Boston London	6/e, 2006
2	Fundamentals of Micro-fabrication	Mark Madou	CRC Press, New York	3/e, 2011
3	Foundations of MEMS	Chang Liu	Pearson	2/e, 2011
4	MEMS and Microsystems Design and Manufacture	Tai Ran Hsu	McGraw Hill	4/e, 2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electromechanics and MEMS	Thomas B. Jones, Nenad G. Nenadic	Cambridge University Press	Illustrated edition, 2013
2	Microsystem design	Stephen D. Senturia,	Springer (India)	2nd edition, 2006
3	Smart Sensors and MEMS	Stoyan Nihtianov, Antonio Luque	Woodhead Publishing Series	2nd edition, 2006

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/117105082
2	https://nptel.ac.in/courses/117105082
3	https://nptel.ac.in/courses/117105082
4	https://nptel.ac.in/courses/117105082

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