INTRODUCTION TO MEMS (AEIE 4111)

Time Allotted : 3 hrs

1.

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A (Multiple Choice Type Questions)

| Cho | ose the correct altern | $10 \times 1 = 10$ | | | | |
|-------|--|---|---|---|--|--|
| (i) | Sputtering is a proce (a) Physical Vapour (c) Chemical Vapour | Deposition | (b) Dry etching (d) Doping. | | | |
| (ii) | 0 0 | in Geometry "an eleg ume ratio (S/V) of dra (b) 1/100 | | s easily as a dragonfly", (d) 1/10000. | | |
| (iii) | In smart phone, the r (a) MEMS gyroscope (c) MEMS capacitive | 2 | (b) MEMS accel | ch screen sensor is (b) MEMS accelerometer (d) MEMS inductive sensor. | | |
| (iv) | Spin coating is a form (a) Etching (c) Ionisation | n of | | pour Deposition oour Deposition. | | |
| (v) | The silicon compour (a) Silicon dioxide (S (c) Silicon nitride (Si | SiO ₂) | electric material in M (b) Silicon carbi (d) Polysilicon. | | | |
| (vi) | The etching process (a) DRIE | preferred for the fab | rication of comb driv (b) Wet etching | | | |

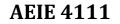
(c) Plasma etching

(b) wet etching

(d) Isotropic etching.

- (vii) The problem of "Stiction" is mostly seen in finished micro-structures made by (a) bulk micromachining (b) surface micromachining (d) LASER microfabrication. (c) LIGA
- (viii) The most common Chemical Vapour Deposition (CVD) process is (a) LPCVD (b) APCVD (c) PECVD (d) Sputtering.
- (ix) In lithography, more clear edge definitions is achieved by (a) positive resist (b) negative resist (c) wet etching
 - (d) plasma etching.

Full Marks : 70



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- (x) The high aspect ratio is achieved by
 - (a) bulk micromachining(c) ion implantation

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(b) surface micro-machining(d) LIGA.
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Group-B

2. (a) When and in which institute did Richard Feynman give a milestone presentation on micro-electromotor? When was the first LIGA process introduced?

[(CO1)(Remember/LOCQ)] [(CO4)(Analyze/IOCQ)]

(b) List the popular MEMS structures.

(c)

Assess the steps related to design process flow of MEMS structures.

[(CO1)(Evaluate/HOCQ)] (2 + 2)+ 5 + 3 = 12

[(CO1)Remember/LOCQ]

- 3. (a) Describe the reasons behind miniaturization.
 - (b) Discuss the importance of scaling laws in miniaturization. [(CO2)Evaluate/HOCQ]
 - (c) List the pros and cons of capacitive type MEMS pressure sensor over piezo resistive type. [(CO4)Apply/IOCQ]

4 + 3 + 5 = 12

Group - C

- 4. (a) Describe the steps involved in microfabrication technique with a suitable block diagram. [(CO4)(Remember/LOCQ)]
 - (b) Compare MEMS fabrication techniques with conventional IC fabrication technology. [(CO2) (Analyze/IOCQ)]
 - (c) Explain the importance of photoresistive material in photolithography.

[(CO1)(Evaluate/HOCQ)] 4 + 5 + 3 = 12

- 5. (a) Identify different types of Chemical Vapour Deposition (CVD) techniques used in micro-fabrication process. [(CO4)(Apply/IOCQ)]
 - (b) Explain the process of doping in semiconductors. [(CO2)(Evaluate/HOCQ)]
 - (c) What are the advantages of dry etching over wet etching? [(CO3)(Remember/LOCQ)]

5 + 3 + (2 + 2) = 12

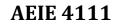
Group – D

- 6. (a) Justify the role of Silicon as an ideal substrate material for MEMS fabrication.
 [(CO4)(Evaluate/HOCQ)]
 (b) How is Si₂O manufactured?
 [(CO2)(Understand/LOCQ)]
 - (c) Indentify the key chemical reactions involved in this process.

[(CO1)(Analyze/IOCQ)]3 + 4 + 5 = 12

7. (a) What is wet etching? What are the limitations of wet etching?[(CO4)(Remember/LOCQ)]

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- Make a distinction between deep reactive ion etching from plasma etching. (b)
- Evaluate the pros and cons of bulk micromachining. (c)

[(CO2)(Analyze/IOCQ)] [(CO1)(Evaluate/HOCQ)] 4 + 5 + 3 = 12

Group - E

List the basic input information required for Finite element based analysis. 8. (a)

[(CO6)(Remember/LOCQ)]

- Examine the possible sources for intrinsic stresses in thermomechanical stress (b) [(CO5)(Analyze/IOCQ)] analysis.
- Define the modes which are to be considered for Interfacial fracture mechanical (C) [(CO6)(Remember/LOCQ)] analysis.

4 + 5 + 3 = 12

- 9. (a) Identify 'Death' and 'Birth' elements in microfabrication simulation method using [(CO5)(Analyze/IOCQ)] FEM.
 - Discuss the dynamic analysis required in MEMS structure. (b)

[(CO5)(Remember/LOCQ)]

(c) List at least three softwares those are based on FEM codes. [(CO6)(Analyze/IOCQ)] 4 + 5 + 3 = 12

| Cognition Level | LOCQ | IOCQ | HOCQ |
|-------------------------|-------|-------|-------|
| Percentage distribution | 37.50 | 43.75 | 18.75 |

Course Outcome (CO):

After the completion of the course students will be able to:

- 1. Appreciate the underlying working principles of MEMS and NEMS devices.
- 2. Identify the fabrication procedure like deposition, lithography and etching.
- 3. Understand the issues related to deposition and etching
- 4. Learn different types of micro-manufacturing techniques
- 5. Acquire knowledge regarding mechanics of micro and nano devices.
- 6. Design and model of MEMS devices.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question

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