# INTRODUCTION TO MEMS
## (AEIE 4111)

**Time Allotted : 3 hrs** **Full Marks : 70**

***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)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) First surface micromachined accelerometer ADXL50 was developed by
(a) Bosch (b) DARPA
(c) Analog Devices (d) Omron

(ii) Scaling of Phenomenological behaviour depends on
(a) size of the device (b) material used
(c) both size and material (d) length of the device

(iii) Diffusion is a process of
(a) Physical Vapour Deposition (b) Dry etching
(c) Lithography (d) Doping

(iv) In smart phone, the transducer measuring orientation of the screen is
(a) MEMS gyroscope (b) MEMS accelerometer
(c) MEMS capacitive sensor (d) MEMS inductive sensor

(v) The problem of "peel off" is mostly seen in finished micro-structures made by
(a) bulk micromachining (b) surface micromachining
(c) LIGA (d) LASER microfabrication

(vi) The wet etching process is
(a) Isotropic (b) Anisotropic
(c) Conformal (d) Planarization

(vii) The process of diffusion analysis is based on
(a) Fourier's Law (b) Fick's law
(c) Hooke's Law (d) Coulomb's Law

(viii) Veil and De-veil are related to
(a) We etching (b) RIE
(c) Dry etching (d) DRIE

(ix) Implanting foreign substances through ion implantation is done by
(a) melting (b) insertion by force
(c ) slow diffusion (d) Plasma

(x) The boundary element method (BEM) is an analytical tool for micro-structures because of
(a) simple geometry
(b) complex geometry and loading/boundary conditions
(c) complex loading and boundary conditions
(d)simple loading with boundary conditions

## Group – B

2. (a) Which company manufactured the first surface micromachined accelerometer and when? State the part number of the said device When the first Disposable blood pressure transducer was reported? [(CO4) (Remember/LOCQ)]

(b) List the popular MEMS based consumer health care products.
[(CO5) (Analyze/IOCQ )]

(c) Discuss briefly the importance of MEMS in medical domain.
[(CO1)( Create/HOCQ)]
**(2 + 2) + 5 + 3 =12**

3. (a) Why are the scaling laws required in MEMS design? [(CO1) [Understand/LOCQ]

(b) Justify the use of GaAs as a candidate material for MOEMS.
[(CO4) [Evaluate/HOCQ]

(c) Determine the surface to volume ratio in case of basic scaling Law.
[(CO4) [Apply/IOCQ]
**4 + 3 + 5 = 12**

## Group – C

4. (a) Describe the taxonomy of microfabrication process with a suitable block diagram. [(CO4) (Remember/LOCQ)]

(b) Distinguish MEMS fabrication techniques from conventional VLSI technology.
[(CO2) (Analyze/IOCQ)]

(c) Explain the importance of photolithography in MEMS fabrication process.
[(CO3)(Evaluate/HOCQ)]
**4 + 5 + 3 = 12**

5. (a) What do you mean by doping? Name any one type of doping technique.
[(CO4) (Remember/LOCQ)]

(b) Describe the Ion implantation method with a suitable block diagram.
[(CO3)(Evaluate/HOCQ)]

(c) Compare the Ion Implantation mechanism from Diffusion.

[(CO2) (Analyze/IOCQ)]

**4 + 3 + 5 = 12**

## Group – D

6. (a) What is dry etching? Why is it preferred over wet etching?

[(CO4) (Remember/LOCQ)]

(b) Distinguish Deep reactive ion etching from Plasma etching?

[(CO2) (Analyze/IOCQ)]

(c) Evaluate the pros and cons of surface micromachining.[(CO1)(Evaluate/HOCQ)]

**4 + 5 + 3 = 12**

7. (a) How can DRIE achieve virtually perfect vertical etching? What are the mechanical problems associated with surface micro machining?

[(CO4) (Remember/LOCQ)]

(b) Compare the differences between bulk and surface micro machining.

[(CO2) (Analyze/IOCQ)]

(c) Explain the different mechanism of wafer bonding. [(CO4)(Evaluate/HOCQ)]

**(2 + 2) + 5 + 3 = 12**

## Group – E

8. (a) What is Finite element method? Why is it necessary for microfabrication simulation? [(CO6) (Remember/LOCQ)]

(b) Identify different sources of intrinsic stress in microfabrication?

[(CO2) (Analyze/IOCQ)]

(c) The bi-layer beam described in Fig.1 is used, but with the thickness of theSiO2 film being reduced to 2 μm and the total thickness, h remains to be 10 μm, meaningthe thickness of the Si beam being increased to 8 μm. Estimate what will be the changein the actuated strip. [(CO1)(Create / HOCQ)]

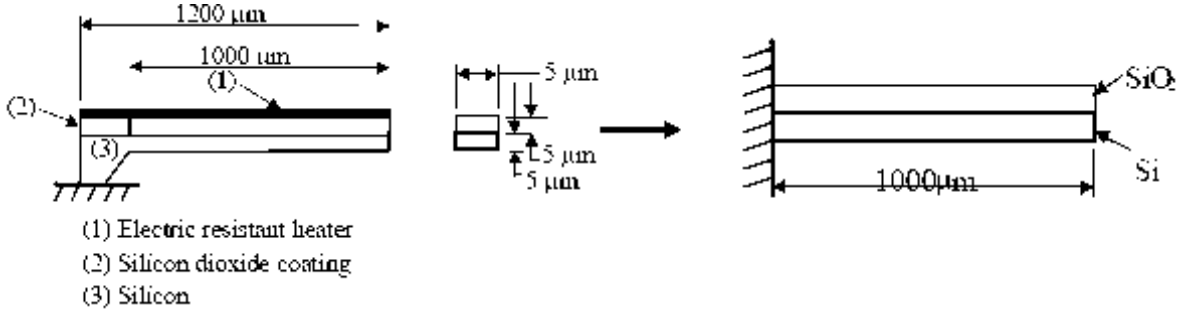


**Fig.1**

**4 + 5 + 3 = 12**

9. (a) What do you understand by Dynamic analysis in MEMS structure?

[(CO5) (Remember/LOCQ)]

(b) Distinguish 'Death' and 'Birth' elements in microfabrication simulation method using FEM. [(CO5) (Analyze/IOCQ)]

(c) Determine the maximum stress and deflection in a square plate made of silicon when is subjected to a pressure loading, p = 20 MPa. The plate has edge length, a = 532 μm and a thickness, h = 13.887 μm. Assuming E = 190,000 MPa. [(CO6)( Evaluate/HOCQ)]

**4 + 5 + 3 = 12**

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| Cognition Level | LOCQ | IOCQ | HOCQ |
|---|---|---|---|
| Percentage distribution | 33.33% | 41.67% | 25.00% |

**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

| Department & Section | Submission Link |
|---|---|
| AEIE | https://classroom.google.com/c/NDA1MTg2OTAyNzIw/a/NDY0MTk2MzY5NzY0/details |