

MICRO SENSOR SCIENCE AND TECHNOLOGY
(AEIE 5231)

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) In micro/robotic surgery, linear actuation is initiated by the principle of
(a) electrostatic effect (b) electromagnetic effect
(c) electro-mechanical effect (d) electro-chemical effect.
 - (ii) The angle between (100) plane and (111) plane in silicon crystal is
(a) 45.75 degree (b) 58.89 degree
(c) 46.54 degree (d) 54.74 degree.
 - (iii) The silicon compound preferred as pizeo-resister in MEMS pressure sensor is
(a) Silicon dioxide (SiO₂) (b) Silicon carbide (SiC)
(c) Silicon nitride (Si₃N₄) (d) Polysilicon.
 - (iv) The wet etching process is
(a) Isotropic (b) Anisotropic
(c) Conformal (d) Planarization.
 - (v) First surface micromachined accelerometer ADXL50 was developed by
(a) Bosch (b) DARPA
(c) Analog Devices (d) Omron.
 - (vi) The shape of Quartz crystal is
(a) face centred cube (b) tetrahedron
(c) body centred cube (d) cylindrical.
 - (vii) The problem of “Stiction” is mostly seen in finished micro-structures made by
(a) bulk micromachining (b) surface micromachining
(c) LIGA (d) LASER microfabrication.
 - (viii) Quartz crystal is a compound of
(a) SiO₂ (b) polysilicon (c) SiC (d) AgCl.

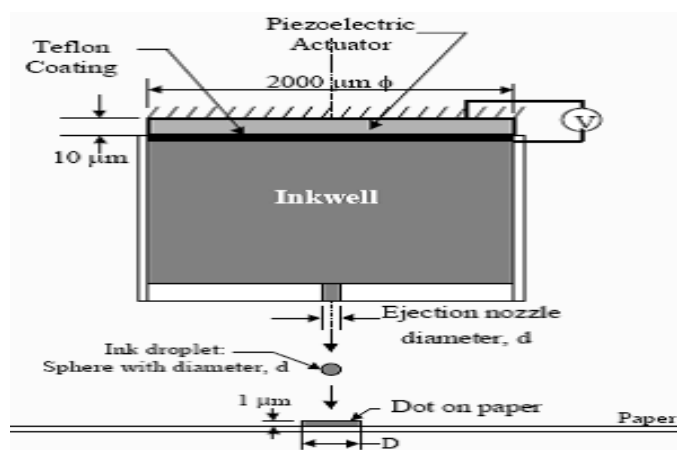
- (ix) Piezoelectric actuator works on the principle of
 (a) electric heating (b) mechanical-electrical conversion
 (c) electrical-mechanical conversion (d) both (c) & (b).
- (x) The (111) plane in silicon crystal consists of
 (a) 5 atoms (b) 8 atoms (c) 6 atoms (d) 7 atoms.

Group- B

2. (a) Describe the working principle of a Bio-MEMS based sensor. [(CO1)(Understand/LOCQ)]
 (b) Classify micro pressure sensors according to their transduction effect. [(CO1)(Analyze/IOCQ)]
 (c) What are the applications of micro-grippers? Explain the operation of micro-motor. [(CO2)(Analyze/IOCQ)]
3 + 4 + (2 + 3) = 12
3. (a) Explain the working principle of SAW sensor. [(CO1)(Analyze/IOCQ)]
 (b) How does it differ from chemical sensor? [(CO1)(Remember/LOCQ)]
 (c) What do you mean by MOEMS? State any one type of optical sensor. [(CO1)(Understand/LOCQ)]
5 + 3 + (1 + 3) = 12

Group - C

4. (a) What is polysilicon? How does the silicon piezoresistor work? [(CO5)(Understand/LOCQ)]
 (b) Does Polysilicon work as a piezoresistor? [(CO4)(Remember /LOCQ)]
 (c) Determine the required electric voltage for ejecting a droplet of ink from an inkjet printer head using PZT piezoelectric crystal as a pumping mechanism. The ejected ink will have a resolution of 300 dpi (dots per inch). The ink droplet is assumed to produce a dot with a film thickness of 1 μm on the paper. The geometry and dimension of the printer head is shown below. Assume that the ink droplet takes a shape of a sphere and the inkwell is always re-filled after ejection. [(CO3)(Evaluate /HOCQ)]



(2 + 2) + 3 + 5 = 12

5. (a) "Silicon- an ideal substrate material for micro-sensor fabrication" – Justify. [(CO5)(Evaluate/HOCQ)]
(b) Why are Polymers preferred as industrial material? [(CO5)(Analyze/IOCQ)]
(c) How to prepare Si₂O in lab? State the key chemical reactions involved in this process. [(CO5)(Understand/LOCQ)]
5 + 3 + (2 + 2) = 12

Group - D

6. (a) State the different types of chemical vapor deposition techniques in micro-fabrication process. [(CO3)(Remember/LOCQ)]
(b) Distinguish the advantages of positive photo resist over negative photo resist in photolithography. [(CO4)(Analyze/IOCQ)]
(c) State MEMS fabrication technique with a suitable block diagram. [(CO2)(Analyze/IOCQ)]
(2 + 3) + 2 + 5 = 12
7. (a) Explain the difference between dry and wet etching techniques. [(CO3)(Evaluate/HOCQ)]
(b) How does metal vapour form in sputtering? What is used as carrier gas in sputtering? [(CO3)(Understand/LOCQ)]
(c) What do you mean by epitaxial growth? State any one type of reactors for epitaxy. [(CO3)(Analyze/IOCQ)]
3 + (2 + 2) + (3 + 2) = 12

Group - E

8. (a) Define "Smart Sensor" in electronic measurement system. [(CO2)(Remember/LOCQ)]
(b) How does micro electronics differ from micro-system? [(CO1)(Analyze/IOCQ)]
(c) Explain the pros and cons of surface micromachining. [(CO6)(Evaluate/HOCQ)]
3 + 5 + 4 = 12
9. (a) State the differences between bulk and surface micro machining. [(CO6)(Remember/LOCQ)]
(b) What are the mechanical problems associated with surface micro machining? [(CO6)(Apply/IOCQ)]
(c) When will you prefer LIGA process? Define its advantages over the conventional micro machining technologies. [(CO6)(Analyze/IOCQ)]
(2 + 3) + 2 + (2 + 3) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	39.58	42.71	17.71

Course Outcome (CO):

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

1. Gain the concept of transduction principle in micro-sensors.
2. Understand the atomic structure of matter, doping process, ionization process and diffusion in semiconductor.
3. Learn the process microfabrication technology.
4. Identify the pattern generation and transfer process like masking, photolithography, etc.
5. Learn different types of materials used in micro-sensor fabrication.
6. Understand various types of micro-manufacturing techniques and concept of smart sensors.

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