Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

VII SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOV 2019

SUBJECT: MICRO ELECTRO MECHANICAL SYSTEM [MTE 4102]

(21/11/2019)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Data not provided may be suitably assumed
- Graph sheets will be provided

1A.	Choose a suitable transduction method for a micro pressure sensor used in high temperature application which provides excellent linear output signals. With a sketch explain its working principle.	**3**	**CO1**
1B.	Select a suitable pumping mechanism which uses surface forces to prompt the flow of liquids. With a sketch explain its working principle.	**3**	**CO1**
1C.	Suggest a micro manufacturing process where features are built up, layer by layer on the surface of a substrate. Explain the process in detail with an example.	**4**	**CO4**
2A	Explain with a sketch, the operating principle of micro sensor used to detect concentration of glucose in the blood sample.	**3**	**CO1**
2B	A micro-machined silicon valve utilizing electrostatic actuation is constructed as illustrated in Fig. 2B. The thin closure plate is used as the valve with a dimension of 300 μm wide x 400 μm long x 4 μm thick. The plate is bent to open or close by electrostatic actuation to regulate the hydrogen gas flow. The maximum opening of the closure plate is 12-degree tilt from the horizontal closed position. Determine the force induced by the flow of the gas at a velocity of 50 cm/min and a volumetric rate of 27,000cm^3/min. Also, calculate the split of mass flow over the lower surface of the plate. Density of the gas is 0.0826 kg/m^3	**4**	**CO4**

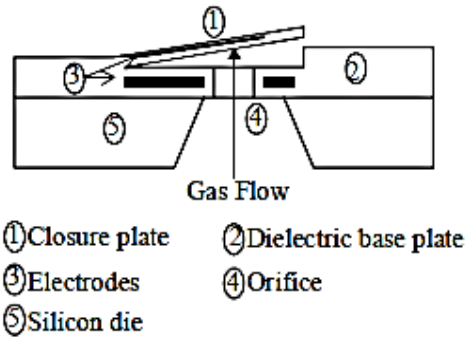

Fig. 2B. Micro Silicon valve

2C	Describe the methods used to convert polymers into electrically conductive materials.	**3**	**CO3**
3A	Suggest a technique, used to control anisotropic etching. Sketch and explain its working principle.	**3**	**CO4**
3B	Differentiate between positive and negative photoresist.	**3**	**CO4**
3C	A micro actuator is made of bilayer strip – an oxidised silicon beam is illustrated in Fig. 3C, is expected to operate with a temperature rise from 10°C to 50°C. Plot the movements of the free end of the actuator with respect to the range of temperature rise. Use a temperature increment of 10°C. Use the following material properties Young's modulus: $E_{SiO2} = E_1 = 385000$ MPa; $E_{Si} = E_2 = 190000$ MPa Coefficients of thermal expansion: $\alpha_{SiO2} = \alpha_1 = 0.5x10^{-6}/°C$; $\alpha_{Si} = \alpha_2 = 2.33x10^{-6}/°C$	**4**	**CO1**

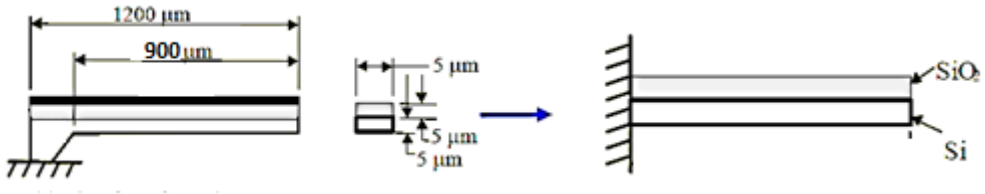

Fig. 3C. Micro Actuator

4A	Determine the thickness of the beam spring of a force balanced micro accelerometer as shown in Fig. 4A. If the maximum allowable deflection of the beam is 16.875 µm. The beam which is at neutral equilibrium position, decelerate from its initial velocity of 50 km/h to a standstill. Beam is made of silicon and its Young's modulus E = 190 GPa and density = 2.3 gm/cm^3.	**4**	**CO4**

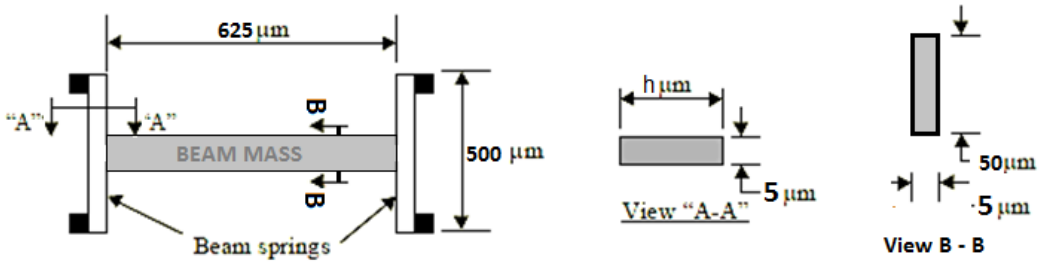

Fig. 4A. Force balance Micro accelerometer

4B	Compare different levels of packaging in microsystems.	**3**	**CO1**
4C	List out the silicon compounds which are used in microsystem. Explain their characteristic feature of each one with their possible application in microsystems.	**3**	**CO3**
5A	Choose a micro-manufacturing process used to manufacture non silicon based microstructures. Explain the process in detail.	**4**	**CO2**
5B	With the help of setup diagram, describe the fabrication process used to extend a single crystal substrate by growing a film of the same single crystal material.	**4**	**CO4**
5C	Derive scaling vectors for acceleration, time and power density based on trimmer force scaling vector.	**2**	**CO2**