

MANIPAL INSTITUTE OF TECHNOLOGY

# VII SEMESTER B.TECH. (MECHATRONICS ENGINEERING) END SEMESTER EXAMINATIONS, NOV 2017

## SUBJECT: MICRO ELECTRO MECHANICAL SYSTEMS [MTE 4102]

## **REVISED CREDIT SYSTEM**

#### Time: 3 Hours

#### MAX. MARKS: 50

#### **Instructions to Candidates:**

- ✤ Answer ALL the questions.
- Data not provided may be suitably assumed
- 1A Determine the force induced by the flow of the gas at a velocity of 85 cm/min and a volumetric rate of 450000 cm<sup>3</sup>/min for the Micro-valve as shown in Figure 1A. Also, calculate the split of mass flow over the lower surface of the plate. The mass density of gas is 0.0826 kg/m<sup>3</sup>. 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 15-degree tilt from the horizontal closed position.



## Figure 1A

- 1B Explain with sketch the three principal signal transduction methods for 04 micro pressure sensors. Provide one major advantage and one disadvantage for each of these methods.
- 1C With sketch explain the working principle of a sensor used to detect 02 concentration of glucose in the blood sample.
- 2A Justify the use of electrostatic force compared to Electromagnetic force 02 in micro actuation devices. Derive the scaling law equation for the same.
- 2B Estimate the reduction of torque required in turning a micro mirror in "Y" 02 direction with a reduction of 50 percentage in dimensions. (Take length as "b", width as "c" and thickness as "t")
- 2C Compare silicon and gallium arsenide material used in microsystems. 03

- 2D Describe the methods used to convert polymers into electrically 03 conductive materials.
- 3A A thin piezoelectric crystal film, Rochelle Salt is used to transduce the signal in a micro accelerometer involving a cantilever beam made of silicon. The accelerometer is designed for maximum acceleration / deceleration of 100 m/s<sup>2</sup>. The transducer is located at the support of the cantilever beam where the maximum strain exists (near the support) during the bending of the beam as illustrated in Figure 3B. Determine the electrical voltage output from the Rochelle Salt film at a maximum acceleration/deceleration of 100 m/s<sup>2</sup>. Piezoelectric coefficient = 350 X 10<sup>-12</sup> m/V





- **3B** List and compare three types of CVD process with respect to the **03** process parameters, advantage, disadvantage and application.
- **3C** Discuss the types of photo resist material and with sketch explain how **04** photoresist materials are applied on the substrate material.
- 4A A silicon substrate is doped with phosphorus ions at 100 KeV. Assume 02 the maximum concentration after the doping is 60 x 10<sup>18</sup>/cm<sup>3</sup>. The projected range is 135nm and straggle or scatter is 53.5nm. Find:
  - a. The dose
  - b. The dopant concentration at the depth 0.20  $\mu$ m
  - c. The depth at which the dopant concentration is at 10% of the maximum value.
- **4B** Explain the physical vapor deposition process and mention its **02** applications.
- 4C Differentiate between dry etching and wet etching in bulk 03 micromachining.
- 4D Sketch and explain working principle of micro-manufacturing process 03 used to manufacture non silicon based microstructures.
- 5A List and explain the techniques used in wet etch stop of micro 03 manufacturing.
- 5B Explain the different levels of packaging in microsystem.
- 5C List and explain any four types of interface problems associated with 04 various kinds of microsystems.

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