

MANIPAL INSTITUTE OF TECHNOLOGY MANIPAL

## SIXTH SEMESTER B.TECH. (INSTRUMENTATION & CONTROL ENGG.) END SEMESTER EXAMINATIONS, APRIL /MAY 2017

SUBJECT: MICRO ELECTRO MECHANICAL SYSTEMS [ICE 4010]

Time: 3 Hours

## MAX. MARKS: 50

4

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## Instructions to Candidates:

- ✤ Answer ALL the questions.
- Missing data may be suitably assumed.
- 1A. Write a note on crystal structure and its types.
- 1B. Explain why silicon is preferred in micro fabrication and the process of silicon **6** growth from the melt in detail.
- 2A. Explain the steps involved in the fabrication of a micro cantilever beam with 4 necessary sketch.
- 2B. Calculate and compare the maximum deflection and stress of a circular and square diaphragm pressure sensor with an area of 196250  $\mu$ m<sup>2</sup> and thickness of 60  $\mu$ m for an applied pressure of 30MPa. Young's modulus of silicon is 131 GPa and Poison's ratio is 0.27.
- 2C. Draw the schematic of a CMOS NAND gate.
- 3A. Assemble the element equations to obtain the force-displacement relations for the system shown in FIG. Q3A. Use the boundary conditions and find the unknown displacements.



3B. A bi-layer strip is subjected to a uniform temperature rise, T as illustrated in FIG. **4** Q3B. Calculate the radius of curvature and deflection at the free end for a temperature of 70°C. Consider  $E_{Sio2} = 385$ GPa,  $E_{Si} = 190$ GPa and  $\alpha_{SiO2} = 0.5 \times 10^{-6}$  / °C,  $\alpha_{Si} = 2.33 \times 10^{-6}$  / °C.



- FIG. Q3B
- 4A. A micro device component 5g in mass is attached to a fine strip made of silicon as shown in FIG. Q4A. The equivalent beam spring constant  $k_{eq}$  is 18240 N/m. The mass is pulled down by 5  $\mu$ m initially and is released at rest. Determine (a) the natural frequency of the device and the maximum amplitude of vibration.



FIG. Q4A

4B. Estimate the change of resistance in silicon piezoresistors attached to the diaphragm 4 of a pressure sensor as shown in FIG. Q4B for an applied pressure of 50MPa. Consider E as 190GPa and  $\pi_{44} = 138.1 \times 10^{-11} \text{ Pa}^{-1}$ .



- 4C. Write a note on blood glucose bio sensor.
- 5A. A thin piezoelectric crystal film, PZT is used to transduce the signal in a micro accelerometer involving a cantilever beam made of silicon shown in FIG. Q5A. The accelerometer is design for maximum acceleration/deceleration of 10 g. The dimensions are L=800 $\mu$ m, b=50 $\mu$ m and t= 10 $\mu$ m. Calculate the voltage generated by the PZT. The piezoelectric coefficient of the crystal film is 2.3e-12 m/V.



- 5B. Explain the process of etching and its classification.
- 5C. Write a short note on lift-off technique.

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