Reg. No.										

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

VII SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOVEMBER 2018

SUBJECT: MICROELECTROMECHANICAL SYSTEMS [MTE 4102]

(24/11/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Data not provided may be suitably assumed with justification

1A. Suggest and explain with example the construction and working of a MEMS sensor for gas detection. **3**

1B. Explain with a diagram the design of capacitive microaccelerometer with shear damping used in automotive applications. **3**

1C. Differentiate the two types of photo-resist used in photolithography. **4**

2A. Explain with a diagram the czochralski method of producing single-crystal silicon. **3**

2B. Differentiate the doping process of ion implantation and diffusion. **3**

2C. List the three chemical vapour deposition techniques in microfabrication. Elucidate their advantages and disadvantages. **4**

3A. A polysilicon cantilever beam over silicon substrate is to be micro-machined. Propose the steps involved in this micromachining process with suitable diagrams. **3**

3B. A silicon substrate is doped with boron ions at 30 KeV. Assume the maximum concentration after the doping is 30 x $10^{18}/cm^3$, Range, R_p is 106.5nm and Straggle is 39nm. Calculate: **3**

(a) dose in atoms/cm^2,

(b) depth at which the dopant concentration is at 0.1% of the maximum value.

3C. You are required to produce silicon mechanical components for high end wrist watches with very high aspect ratio and steep side walls ($\theta \approx \pm 2^o$). Suggest and illustrate the steps involved in fabricating the 3D structures. **4**

4A. Derive the scaling factor for acceleration of a rigid body, considering the Trimmer force scaling vector. **2**

4B. Discuss about the factors affecting the rate of deposition in CVD. **4**

4C. Describe the two popular techniques of etch stop in wet etching. **4**

5A. "Polymers can be easily made electrically conductive to be used in microelectronics applications". Justify the above statement with suitable example. **4**

5B. Determine the maximum stress and deflection in a square silicon diaphragm used in a micro pressure sensor as shown in the Fig.5B.1. The maximum applied pressure P = 70 MPa. Also estimate the change of resistance in p-type silicon piezoresistors as shown in Fig.5B.2 which is attached to the diaphragm of the pressure sensor.(Young's modulus of silicon is 129.5GPa) **6**

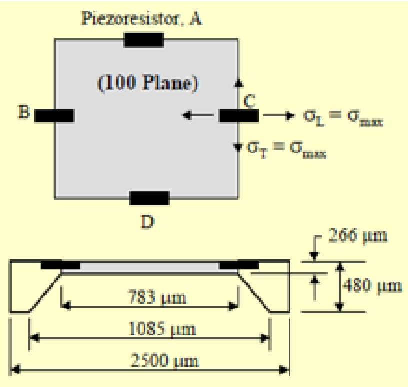

Figure 5B.1

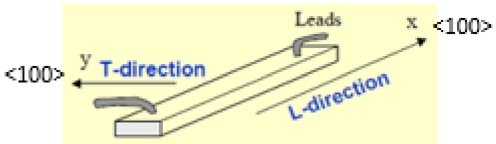

Figure 5B.2

The piezoresistive coefficients of p-type silicon piezoresistors in various directions are as shown in table 5B.1

Table 5B.1

Crystal Planes	Orientation <x>	Orientation <y>	π_L	π_T
(100)	<111>	<111>	$+0.66\pi_{44}$	$-0.33\pi_{44}$
(100)	<110>	<100>	$+0.5\pi_{44}$	~ 0
(100)	<110>	<110>	$+0.5\pi_{44}$	$-0.5\pi_{44}$
(100)	<100>	<100>	$+0.02\pi_{44}$	$+0.02\pi_{44}$

Resistivity and piezoresistive coefficients of silicon at room temperature in <100> orientation is in table 5B.2

Table 5B.2

Material	Resistivity (Ω-cm)	π_{11}(in $10^{-11}m^2/N$)	π_{12} (in $10^{-11}m^2/N$)	π_{44} (in $10^{-11}m^2/N$)
p-silicon	7.8	+6.6	-1.1	+138.1