Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

VII SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, DECEMBER-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 minimum thickness of the rectangular diaphragm of a micro pressure sensor made of Silicon with conditions: Plane area = 32 X 10^4 μm^2; a/b ratio = 2; $\alpha = 0.0277$; $\beta = 0.4974$; Applied pressure = 24 MPa; Yield strength of silicon = 7000 MPa; Young's modulus = 190 GPa and Poisson's ratio = 0.25. Also find maximum stress if rectangular diaphragm is replaced with i) Square, ii) Circular diaphragm of same plane area. **04**

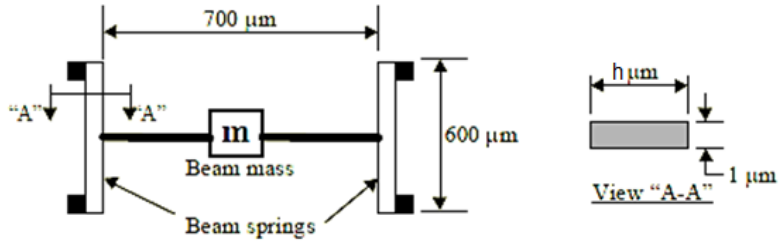
1B. With the sketch, Explain any four types of chemical sensors **03**

1C. Sketch and explain working of micro-heat pump **03**

2A. Use the scaling laws to estimate the variations of the volumetric flow and pressure drop in a circular tube if the radius of the tube is reduced by a factor of 8. What will happen to the pressure drop in the fluid if the tube radius is in micro scale? **02**

2B Derive scaling vectors for acceleration, time, power density based on trimmer force scaling vector **03**

2C Determine the thickness of the beam spring of a force balanced micro accelerometer as shown in fig., if the maximum allowable deflection of the beam is 5mm. The proof mass m = 3 x 10^{-6} kg, which is at neutral equilibrium position, decelerate from its initial velocity of 50 km/h to a standstill. Young's modulus E = 190 GPa. **03**



2D Describe the methods used to convert polymers into electrically conductive materials **02**

3A Phosphorous is to be doped into silicon wafer substrate by a diffusion process. The substrate is heated at 1000° C in the presence of the dopant. Plot the distributions of the concentration of dopant as a function of depth in the silicon substrate at the times 30, 60, 90, 120, 150 and 180 minutes. A solid solubility of phosphorous at 1000° C to be 4.5 X 10^{20} atoms/cm³. Take depth =0.075µm, Constants a = -15.8456, b = 11.1168. Table 3A presents the error functions. **04**

3B Sketch and explain working of micro pressure sensor using a vibrating beam signal transducer? Explain why the change of the state of the stress in a silicon diaphragm results in a change of its resonant frequency? **02**

3C Suggest a method to produce pure silicon crystal. With the help of neat sketch explain its working principle in detail. **04**

4A A 4 V is applied to the printer head mechanism consisting of Rochelle salt crystal (d= 350x10^{-12} m/V) to pump the ink on the paper. Determine the resolution of **03**

the ink ejected on the paper in dots per inch. The ink droplet is assumed to produce a dot with a film thickness of 750 nm on the paper. The geometry and dimension of the printer head is illustrated in Figure 4A. Assume that the ink droplet takes a shape of a sphere and the inkwell is always re-filled after ejection.

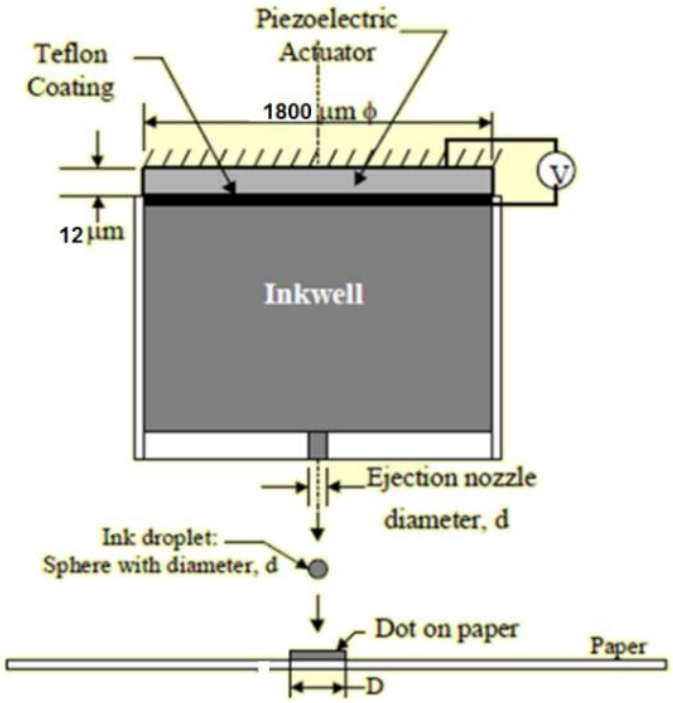


Figure 4A

4B Describe the benefits of miniaturization. **02**

4C Suggest a technique, used to control anisotropic etching. Sketch and explain its working principle in detail. **02**

4D 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. **03**

5A Explain the plasma enhanced CVD process with diagram. **02**

5B Explain the reasons for lack of automation of micro assembly technology. **04**

5C Describe any three types of surface bonding techniques used in microsystem **04**

Table 3A

The Error functions

X	erf(X)	X	erf(X)	X	erf(X)	X	erf(X)
0.0	0.0						
0.05	0.0564	0.55	0.5633	1.05	0.8624	1.55	0.9716
0.10	0.1125	0.60	0.6039	1.10	0.8802	1.60	0.9763
0.15	0.1680	0.65	0.6420	1.15	0.8961	1.65	0.9804
0.20	0.2227	0.70	0.6778	1.20	0.9103	1.70	0.9838
0.25	0.2763	0.75	0.7112	1.25	0.9229	1.75	0.9867
0.30	0.3286	0.80	0.7421	1.30	0.9340	1.80	0.9891
0.35	0.3794	0.85	0.7707	1.35	0.9438	1.85	0.9911
0.40	0.4284	0.90	0.7969	1.40	0.9523	1.90	0.9923
0.45	0.4755	0.95	0.8209	1.45	0.9597	1.95	0.9942
0.50	0.5205	1.00	0.8427	1.50	0.9661	2.00	0.9953