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# MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
*A Constituent Institution of Manipal University*

## VII SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

## END SEMESTER MAKE UP EXAMINATIONS, DEC 2016- JAN 2017

SUBJECT: MICRO ELECTRO MECHANICAL SYSTEM [MME 423]

**REVISED CREDIT SYSTEM**
**(30.12.2016)**

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitable assumed.

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| **1A.** | Discuss a typical MEMS Microgripper. Also explain the principle involved | **4** |
| **1B.** | Sketch and explain Czochralski method to produce pure silicon crystal. | **4** |
| **1C.** | Explain why the change of the state of the stress in a silicon diaphragm in a micropressure sensor results in a change of its resonant frequency? | **2** |
| **2A.** | Draw a flow chart for micro assembly of a pressure sensor. | **3** |
| **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 200 μm wide x 400 μm long x 3 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. Determine the force induced by the flow of the gas at a velocity of 40 cm/min and a volumetric rate of 27,000cm3 /min. Also, calculate the split of mass flow over the lower surface of the plate. Density of the gas is 0.0826 kg/m3 | **4** |
| **2C.** | Show the construction and explain the working of piezo pump . | **3** |
| **3A.** | Enumerate the benefits of miniaturization in bio medical systems. | **3** |
| **3B.** | A silicon substrate is doped with phosphorous ions at 30 keV. Assume the maximum concentration after the doping is 20 X 1016/cm3 . Find (i) the dose (ii) the dopant concentration at a depth of 0.03 μm, and (iii) the depth at which the dopant concentration is 0.2 percent of the maximum value Straggle for phosphorous ion is 19.5 nm at 30 keV and projected range is 42 nm. | **4** |
| **3C.** | Sketch and explain working principle of bulk manufacturing process used to produce MEMS with low aspect ratio. Also list its advantages and disadvantages | **3** |

**4A.** Determine the minimum thickness of the circular diaphragm of a micro pressure sensor made of Silicon as shown in the figure 4A. With conditions: Diameter d = 500 μm; Applied pressure p = 24 MPa; Yield strength of silicon $\sigma_y$ = 7000 MPa; E = 190 Gpa and ν = 0.25. **6**

**4B.** Discuss how ion implantation technique is used in the production of semiconductors. **4**

**5A.** List and compare three types of CVD process with respect to the process parameters, advantage, disadvantage and application. **4**

**5B.** Estimate the voltage output of the micro-thermopile shown in Figure 5B, if "J" type (50.37μV/°C) wire materials are used with the hot junction temperature at 145° C while the cold junction is maintained at 0° C. Determine the voltage output, If micro thermopile are replaced by "K" type (39.48 μV/°C) thermocouple for the same operating temperature. **2**

**5C.** Suggest a technique, used to control anisotropic etching. Sketch and explain its working principle in detail **4**

**6B.** Discuss how micro hinge is produced? List any four applications of the same. **4**

**6C.** One Volt is applied to the printer head pumping mechanism consisting of Rochelle salt as piezoelectric crystal (d= 350x10-12 m/V) to pump the ink on the paper. Determine the resolution of the printer interms of dots per inch. The ink droplet is assumed to produce a dot with a film thickness of 500 nm on the paper. The geometry and dimension of the printer head is illustrated in Figure 6C. Assume that the ink droplet takes a shape of a sphere and the inkwell is always re-filled after ejection. **6**

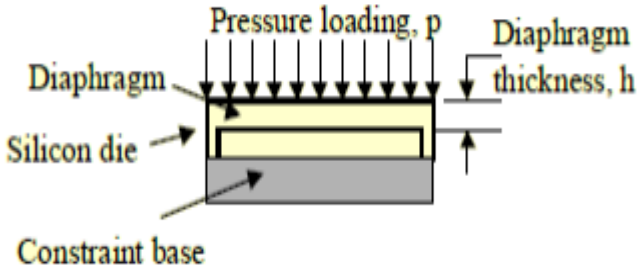


Fig. 4A

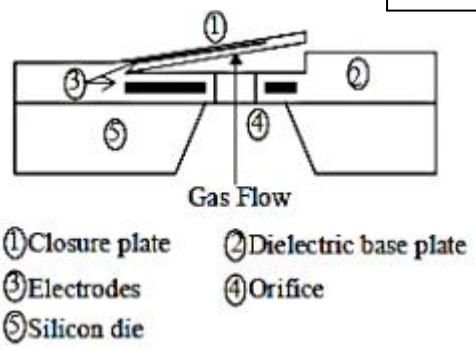


Fig. 2B

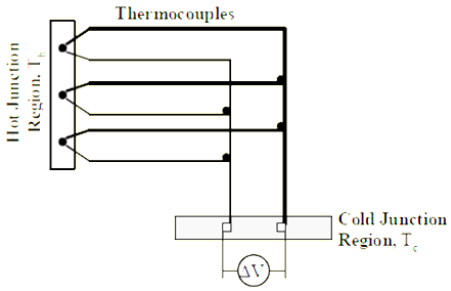


Fig. 5B