| Reg. No.  |  |  |  |  |  |
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| Reg. 110. |  |  |  |  |  |



MANIPAL INSTITUTE OF TECHNOLOGY Manipal University



## TIME: 3 HOURS

MAX. MARKS: 50

## Instructions to candidatesAnswer ANY 5 questions.

- Missing data may be suitably assumed.
- 1A. With neat diagram explain the working of micro cantilever based hydrogen sensor.
- 1B. Find the Reynolds number associated with two cases: i) a person swimming in a swimming pool filled with molasses with a kinematic viscosity of 10,000 centistrokes and 1.8 m and swims at a woeful. And ii) a 1.8 mm long tadeploe moving in water ( with kinematic viscosity of 1 centistroke at a velocity of 1 cm/s.
- 1C. What is the resonance frequency for a silicon cantilever beam 1000 um long, 100 um wide and 3 um thick? The density of silicon is 2.3 g/cm<sup>3</sup>.Assume E=190GPa.

(5+3+2)

- 2A. With neat diagrams explain any two Non optical techniques. What are the advantages compared to traditional photolithography
- 2B. What is Stiction in MEMS ? Explain any two techniques to overcome stiction.
- 2C. A 30 um thick membrane is needed for a pressure sensor application. Calculate the size of the mask opening W needed for the v-groove if the full wafer thickness is 600 um.

(5+3+2)

- 3A. Explain the working principle of Biochip? Give its merits and demerits for implanting over human body.
- 3B. What are miller indices? Draw a <110> and <111> plane inside a cubic unit cell. Obtain the Miller indices of the plane which intercepts at a ,b/2,3c in a simple cubic unit cell.
- 3C. What are the purposes of having wafer, sacrificial material and structural material in typical MEMS fabrication?

(5+3+2)

- 4A. What is the major difference between fluidics in the macro scale and micro scale? What are the implications for microfluidics?
- 4B. A <100> silicon wafer is 500um thick. A mask consists of rectangular window of unknown size. The sides of the window are parallel to <100>. After wafer etch a hole size of 50um x 80 um is formed on the other side of the wafer .Find the size of the mask window. The undercut rate is negligible.
- 4C. Compare and contrast surface micromachining with bulk micromachining.

(5+3+2)

- 5A. Explain proximity and projection printing mechanisms used to obtain high resolution of contact printing.
- 5B. If an exposure tool has numerical aperture of 0.25 and an exposure wavelength of 428nm and spatial coherence S of 0.4, what is the minimum feature size that this tool can resolve .What is depth of focus? If this source were replaced with i-line source (wavelength=365nm), how would these number change .Comment on your answer.
- 5C. Design a mask for a 15um long ,5um deep v-groove trench using EDP (anisotropic etchant) .how wide should the mask window be? If EDP has a Si <100> plane etch rate of 1um/min ,how long should the etchant be applied.

(5+3+2)

- 6A With neat diagram explain the working of Electro hydrodynamic micro pump.
- 6B Write short notes on the following mechanical MEMS elements:
  - a) Micro cantilever
  - b) Diaphragm
- 6C With neat diagram explain any two wafer bonding techniques in MEMS.

(5+3+2)