BITS F415: Introduction to MEMS

Mid-Semester Examination (November 05, 2022)

Max. Time: 1 hr 30 min, Max Marks: 75

Section – 1 (Objective Type): 15 x 1 Mark = 15 Marks (Provide answers in the QP itself)

1. **Electro-wetting on a dielectric-coated surface is called electro-wetting-on-dielectric (EWOD). Choose the correct statement in this regard**

a. On application of voltage, the contact angle decreases

b. On application of voltage, the contact angle increases

c. On application of voltage, the contact angle remains constant

d. The contact angle cannot be calculated

2. **EWOD contact angle variation can be expressed as**

a. $\cos\theta' = \cos\theta + \frac{\frac{1}{2}CV^2}{\sigma_{lv}}$

b. $\cos\theta' = \cos\theta - \frac{\frac{1}{2}CV^2}{\sigma_{lv}}$

c. $\cos\theta' = \cos\theta + \frac{\frac{1}{2}CV}{\sigma_{lv}}$

d. $\cos\theta' = \cos\theta - \frac{\frac{1}{2}CV}{\sigma_{lv}}$

3. **Choose the wrong statement regarding electrical double layer**

a. The surface charge is balanced by a net surplus of oppositely charged ions in a thin fluid layer adhering to the substrate. This charged layer is called Electrical Double Layer.

b. The layer of mobile ions beyond the Stern layer is called Gouy Chapman layer or the diffuse layer.

c. The thickness of EDL is a few mm

d. The thickness of EDL is a few nm

4. **The motion of charged particles or surfaces relative to the stationary fluid under an applied electric field is called**

a. Electro osmosis

b. Electrophoresis

c. Sedimentation Potential

d. Streaming potential

5. MEMS devices are within the range:

a. 1 pm - 1 nm

b. 1 nm - 1 µm

c. 1 µm - 1 mm

d. 1 mm - 1 cm

6. Choose the correct governing equation Nernst Planck Equation for capillary electrophoresis without advection flux

a. $\frac{\partial C_i}{\partial t} + \mu_i E \frac{\partial C_i}{\partial x} = D_i \frac{\partial^2 C_i}{\partial x^2}$

b. $\frac{\partial C_i}{\partial t} - \mu_i E \frac{\partial C_i}{\partial x} = D_i \frac{\partial^2 C_i}{\partial x^2}$

c. $\frac{\partial C_i}{\partial t} + \nabla . (uC_i) + \frac{\partial}{\partial x}(\mu E C_i) = 0$

d. $\frac{\partial C_i}{\partial t} + \frac{\partial}{\partial x}(uC_i) + \frac{\partial}{\partial x}(\mu E C_i) = \frac{\partial}{\partial x}\left(D \frac{\partial C_i}{\partial x}\right)$

7. Choose the correct statement about electro osmotic pump

a. No moving components or parts

b. Continuous flow without noise

c. Flow can be easily regulated with the applied voltage

d. All the above

8. _____is the change in the electrical resistivity of a solid induced by applied mechanical stress.

a. Piezo resistance

b. Electromechanical stress

c. TCR

d. Stiffness

9. The wet etching process is _____

a. Isotropic

b. Anisotropic

c. Isotropic for a few materials

d. Isobaric process

10. Due to which 3D printing defect, fabricating sphere shape is difficult?

a. Stair-stepping lines

b. Warpage

c. Under extrusion

d. Over extrusion

11. The temperatures at which the 3D printer build plate and extruder head are set, respectively?

a. Melting temperature of the material and Peak temperature of the material

b. Around the Glass transition temperature of the material and printing temperature of the material

c. The printing temperature of the material and the Glass transition temperature of the material

d. Solidification temperature and glass transition temperature of the material

12. The absence of a secondary flat indicates which type of Si wafer?

a. n-type – 111

b. n-type – 100

c. p-type – 111

d. p-type – 100

13. Which of the following is the correctly matched concentration for the photolithography process?

a. Developer Solution: 1 % Sodium Bi-Carbonate

b. Developer Solution: 1 % Sodium Hydroxide

c. Developer Solution: 1 % Sodium Carbonate

d. Developer Solution: 1 % Ferric Chloride

14. One of the following properties is an advantage of MEMS Technology

a. Miniaturization with loss of functionality

b. High power

c. Fast actuation techniques

d. None of the above

15. What will happen to resistance if the length of the conductor is increased?

a. Decreases

b. No change

c. Increases

d. Doubles

Section – 2 (Subjective Type): 6 x 10 Marks = 60 Marks

1.

a. Briefly explain the working principles involved in Photolithography, 3D Printing, Softlithography, and Co_2 laser-assisted graphene synthesis (Schematics are recommended). In each technique, examples of real-time applications/working devices should be mentioned. **(7 Marks)**

b. Briefly explain the importance of the surface area to volume (S/V) ratio. Calculate the surface-to-volume ratio for a cube 1 mm^3 and the S/V for a sliced cube into 4 equal quarters. **(3 Marks)**

2.

a. Explain the differences between a sensor, an actuator, and a transducer. What does MEMS stand for, and what is its importance? Provide examples for microactuators along with a few of its commercially available products. **(4 Marks)**

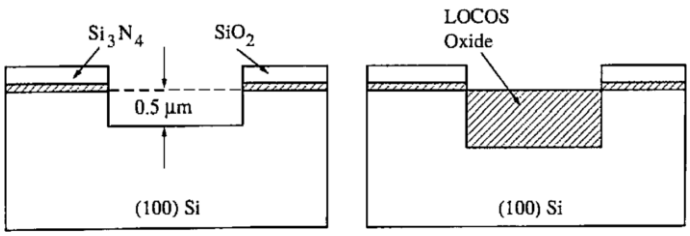
b. Explain active and passive components in an IC with suitable examples. Provide specific differences between microelectronics and MEMS. **(3 Marks)**

c. Why is a clean room required to fabricate ICs? What are the 4 possible ways the contaminants can enter the clean room? What are the two types of clean rooms available based on the type of ventilation? **(3 Marks)**

3.

a. What is wafer oxidation and explain its importance on the surface of a wafer? What are the types of oxidation and oxidation defects? Explain the assumptions of the Deal-Grove model and then derive the model equation. **(7 Marks)**

b. Local oxidation is widely used to provide lateral isolation between devices in IC chips. In some cases, it is desirable to end up with a more planar surface than standard LOCOS provides, so silicon etch is used prior to the oxidation step, as illustrated in Figure below. For the structure shown on the left, with 0.5 μm of silicon etched prior to the oxidation, how long must the wafer be oxidized at 1000 ℃ in H_2O to produce the planar oxide shown on the right? **(3 Marks)**



4.

a. In a dynamic analysis of a spring-restrained parallel-plate capacitor, dynamic pull-in? Obtain a formula for the dynamic pull-in voltage. **(6 Marks)**

b. What are the possible reasons and effects of residual stress in MEMS components? Deduce an expression for the radius of curvature because of the stress gradient. **(4 Marks)**

5.

a. Discuss the effect of applied frequency on the response to micro-sensors with suitable expressions and diagrams. **(3 Marks)**

b. Electrical actuation and control in MEMS and Microfluidics strongly depend on Electrical Double Layer (EDL) formation adhering to an electrically charged substrate. Discuss EDL and Zeta potential with suitable plots. **(5 Marks)**

c. What is capillary zone electrophoresis? Explain with proper illustrations. **(2 Marks)**

6.

a. Discuss the Electrowetting on Dielectric (EWOD) with the help of Young Lippmann Equations. What applications can be foreseen? **(5 Marks)**

b. What is the working principle of an Electroosmotic pump (EOS pump)? Also, derive the flow expression through the single circular microchannel EOS pump. **(5 Marks)**