

**SOFT METHODS IN MICROSTRUCTURE FABRICATION
(CHEN 4127)**

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 5 (five) from Group B to E, taking at least one from each group.*

Candidates are required to give answer in their own words as far as practicable.

**Group – A
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) The ratio of inertial to viscous forces in flow through microcapillaries is
(a) inversely proportional to the characteristic length
(b) inversely proportional to velocity
(c) inversely proportional to viscosity
(d) does not depend on the above parameters.
- (ii) In Stokes flow in a cylindrical channel, the velocity scales as
(a) the second power of the channel diameter
(b) inversely proportional to the distance between the two planes
(c) inversely proportional to the square of distance between the two planes
(d) directly proportional to the square of distance between the two planes.
- (iii) Local curvature of the surface affects the
(a) film thickness
(b) pressure difference
(c) free energy of the surface
(d) none of above.
- (iv) Injection molding process is done with polymers such as
(a) PDMS (b) PMMA (c) SU8 (d) none of (a), (b) & (c).
- (v) Third generation hydrogels are primary _____
(a) pH sensitive hydrogels (b) temperature sensitive hydrogels
(c) enzyme sensitive hydrogels (d) stereo-complexed hydrogels.
- (vi) Surfactant with high HLB is _____
(a) more soluble in water (b) less soluble in water
(c) more soluble in oil (d) less soluble in oil.
- (vii) One of the steps involved in synthesizing patterned SAMs is _____
(a) capillary moulding (b) microstereolithography
(c) microcontact printing (d) LIGA.
- (viii) Microstereolithography is used to create structures on
(a) semiconductors and metals (b) any polymers
(c) photosensitive resin (d) organic monolayers deposited on substrate.

- (ix) Which of the following is a bottom-up process?
(a) Capillary moulding (b) Casting
(c) Self assembly (d) Injection moulding.
- (x) Atomic Layer Deposition is not used for depositing
(a) films of biomaterials (b) silicon nitride films
(c) tungsten films (d) copper films.

Group- B

2. (a) Write out the equation that describes forces between two polar molecule explaining each term. Explain with a graph the relationship between force of attraction / repulsion versus separation distance. [(CO1)(Remember/LOCQ)]
(b) Surface curvature of nanoparticles affects the surface free energy and the Gibbs free energy. Explain mathematically how and why this happens. [(CO1)(Analyze/IOCQ)]
6 + 6 = 12
3. (a) While developing a microfluidic chip, you decide on a macroscale model that would give an idea of the flow characteristics at the microscopic scale. Assume that oil will be flowing through the microscopic device (viscosity 81 cP and density 0.92 gm/mL) in square channel of side 100 μm at $T = 25\text{C}$. If the Reynolds number is to be kept constant, what would be the velocity through the macroscale device?
[(CO1)(Evaluate/HOCQ)]
(b) How do you define the hydraulic diameter, D_H of a channel? Why is D_H used instead of the regular channel diameter? [(CO1)(Analyse/IOCQ)]
(c) State two important parts of a microfluidic device. State and elaborate two applications of a microfluidic device. [(CO1)(Remember/LOCQ)]
5 + 4 + 3 = 12

Group - C

4. (a) State two advantages of PDMS that make it suitable for constructing bio-MEMS device? [(CO2)(Remember/LOCQ)]
(b) What is the role of a template in soft lithography process? How are templates developed? [(CO2)(Analyze/LOCQ)]
(c) Explain the steps involved in building a microfluidic device with open channels using soft lithography. [(CO2)(Remember/LOCQ)]
2 + 3 + 7 = 12
5. (a) Thick resist lithography is used to create features with high aspect ratio. Describe the steps involved in creating a patterned SU8 structure on a substrate. Provide schematics for explanation. [(CO2)(Remember/LOCQ)]
(b) What properties of SU8 render it suitable for this lithographic process?
[(CO2)(Analyse/IOCQ)]
8 + 4 = 12

Group - D

6. (a) What is meant by anionic and cationic hydrogels? Identify the functional groups responsible for their surface charge. [(CO3)(Remember/LOCQ)]
- (b) At 300 K, measurements of the surface tension of the solutions of the surfactant $C_{12}H_{25}(OC_2H_4)_2OH$ in water as a function of its concentration are given in the following table

Concentration (mmol/m ³)	0.001	0.0018	0.0032	0.0056	0.01	0.018	0.032	0.056
Surface tension (mN/m)	69	64	59	52	45	38	31	29.5

Find out the critical micelle concentration (CMC) of the surfactant with the help of the above information in the table. [(CO3)(Evaluate/HOCQ)]

- (c) "After attaining CMC, a dynamic equilibrium is setup for the surfactant at the interface of the micelle with the dispersed phase." – Comment of the appropriateness of the statement based on the graphical plot you had in 6(b). [(CO3)(Analyze/IOCQ)]
(4 + 2) + 4 + 2 = 12
7. (a) During the formation of core-shell hydrogel E@A, where E is an enzyme and A is alginate, what is the sequence for reagent addition one should maintain? What will happen if the sequence will be exactly the reverse one? [(CO3)(Create/HOCQ)]
- (b) A monomer and its polymer both are hydrophobic in nature. If a hydrogel needs to be prepared from it, which of the polymerization technique you prefer-emulsion or precipitation, when water is used as the solvent medium? Justify your answer in light of the polymerization process mechanisms for both the techniques.
[(CO3)(Apply/IOCQ)]
(2 + 2) + (2 + 3 + 3) = 12

Group - E

8. (a) State the three constituents that are needed to create a stable SAM structure. Provide typical examples of the three components. [(CO4)(Remember/LOCQ)]
- (b) Patterned SAMs are created through a series of processing steps. Describe the steps using schematics. [(CO4,CO2)(Understand/LOCQ)]
6 + 6 = 12
9. (a) Describing the process of Layer by Layer deposition? Why is it better than the Langmuir Blodgett process? [(CO4)(Analyse/IOCQ)]
- (b) State two applications of this method in detail. [(CO4)(Understand/LOCQ)]
- (c) How is L-b-L done by spin coating? State the differences observed in film deposition using the immersive technique versus the spin coating technique.
[(CO4)(Analyse/IOCQ)]
4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	53.12	33.34	13.54

Course Outcome (CO):

After completion of the course students will be able to:

1. Demonstrate the concept of microscopic system.
2. Identify various applications and fabrication methods of microfluidics.
3. Illustrate the basics of hydrogels and its fabrication technologies.
4. Summarise the concept of organometallic structure and compare various methods of self-assembly of organic molecules in nanostructures.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question