INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
Mid-Autumn Semester 2018-19

Date of Examination : 19-09-2018 Session (FN/AN) AN Duration 2 hrs
Subject No. : CH62039 Subject Name : Microscale Transport Process
Department/Center/School : Chemical Engineering
Specific charts, graph paper, log book etc., required No
Special Instructions (if any) : Make assumptions as necessary

Q1. a) Refer the filling of prepolymer with catalyst into a feature of the mold (open ended capillary) due to surface force – Derive an expression for the position of the front with time. Treat the feature as a horizontal capillary of internal diameter d that is to be filled by a liquid of viscosity μ. Assume the surface tension and contact angle as σ and θ respectively. Consider the initial liquid meniscus position in the capillary as L_0. Show a rough sketch of position vs. distance plot.
b) When the capillary in the abovementioned problem is closed at the other end, and the external environment is at atmospheric pressure, derive an expression of the fraction of the total length that can be penetrated as a function of capillary diameter. Show a rough sketch of this functionality.
c) State the differences between casting, molding, and microinjection. **3+3+3=9 Marks**

Q2. a) A Silicon wafer is exposed to high temperature in presence of oxygen for development of a thick oxide layer. If the density of Si is 2.3296 gm/cc, and the density of SiO_2 is 2.20 gm/cc, calculate the thickness of SiO_2 layer arising due to the consumption of 1 μm thick Si sub-layer. The atomic weight of Si is 28.
b) Derive an expression for the oxide layer thickness as a function of time. Also, show the simplified expressions at the two limits of thin and thick layers, and draw a rough sketch of thickness vs. time plot to show these two limits.
c) Explain the differences between the physical dry etching, chemical dry etching, RIE, DRIE, and wet etching for a silicon wafer. **3+3+3=9 Marks**

Q3.(i) What would be the apparent change in the shape of a microdrop as compared to a larger drop on the same hydrophobic substrate? Which dimensionless group is important in this case?
(ii) Cite the reasons for the very high heat flux possible in ultrathin film evaporation as compared to nucleate boiling.
(iii) Show and explain, with the help of a sketch how does a nucleating vapor bubble behave differently in a microchannel relative to that in a macrochannel.
(iv) In microjet impingement cooling, draw with proper reasons, the variation of the heat transfer coefficient with distance from the point of impingement.
(v) How would a difference in curvature sustain liquid flow towards the extended meniscus region in an evaporating droplet?
(vi) What are the criteria for the selection of the material of construction of the tubes in a microscale heat exchanger?
(vii) What would be the starting point and subsequent steps for the design of a microscale facility for a specific process?
(viii) Why cleaning is extremely important in the photolithography process?
(ix) Enumerate the steps involved in your decision about the suitability of a specific reaction to be carried out in a microreactor. **1x9 = 9 Marks**

Q4. Explain the coolant flow in a mircoheat pipe (MHP) with the help of appropriate equations and diagrams showing the cross sections of the MHP at appropriate locations and the relative distributions of the liquid and its vapor. **3 Marks**