**INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR**

**Mid-Spring Semester Examination, 2023-2024**

***Subject*: Instability and Patterning of Thin Polymer Films** ***Subject No.*: CH 62052**

***Date*: 24.04.2023 (AN)** ***Time*: 3 Hrs** ***Full Marks*: 50** **No. of Students: 1**

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*Instructions*:

1. All Questions are compulsory.
2. **Please answer all parts of the same question together. Else marks will be deducted.**
3. **Be Precise with your answers. Long, redundant answers will fetch zero!**
4. **As much as possible, answers should be accompanied with figures.**
5. **If you feel any question is wrong, or data is missing, please make suitable assumptions. NO DOUBTS will be entertained during the examination.**

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******** Please answer all parts of the same question together *********

**Note:** For all the questions,

You can use the following expressions: $G^{lw}(d) = -(A_{12}/12\pi)\left[\frac{1}{(d_1+d_2+d)^2} + \frac{1}{d^2} - \frac{1}{(d+d_1)^2} - \frac{1}{(d+d_2)^2}\right]$ and $G^{LW}_{Film} = -G^{LW}_{Interface}$. The symbols have their usual meaning.

1. Find out an expression for the Excess energy in a Thin film coated on a semi-infinite substrate. (Please start from the total energy of the system). Subsequently find out the expressions of **Conjoining Pressure** and **Disjoining Pressure**. Then, in the context of a single undulation, please discuss how spontaneous instability in a thin film will be possible based on the sign of effective Hamaker constant. Is there any difference if the stability of a film is predicted in terms of Effective Hamaker constant and spreading Coefficient? (3+2+3+2=10)

**[Total Marks in Q1: 10]**

2. Why a polymer thin film is used for performing dewetting experiments? Discuss the evolution sequence of a thin polymer film dewetting on a defect free, smooth, solid surface. Why does a Rim form around a growing hole? What will be the eventual morphology you will observe 24 hours after dewetting experiment is completed? What will be the final morphology you will see 24 hours after performing dewetting experiments with an Acetone thin film?

(3+3+2+1+1=10)

**[Total Marks in Q2: 10]**

3. Discuss (with possible evolution sequence and explanatory sketches) all the possible morphologies when a thin polymer film dewets on another thin polymer film. (Bottom layer is thin enough and both layers participate in dewetting). (5)

**[Total Marks in Q3: 5]**

4. (a) Describe the basic steps/ mechanism of film formation in spin coating. When does film formation start in spin coating?

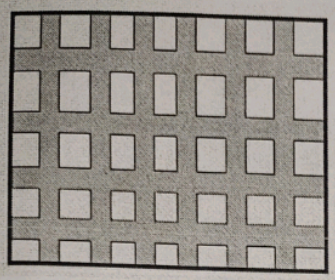
   (b) What are the parameters that influence the thickness of a spin coated film?

(c) If you continue to reduce the Concentration of the dispensed solution in spin coating, keeping all other parameters same, what do you expect to happen?

(d) Is it advantageous to use a slowly evaporating solvent? Justify! **(3+2+3+2=10)**

**[Total Marks in Q4: 10]**

**(Thought provoking questions)**



Hydrophilic

~~Hydrophilic~~ Hydrophobic

Figure 1

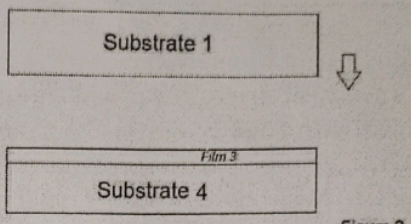



Figure 2

5. (a) You have a chemically patterned substrate comprising of square box patterns (as shown in the sketch). A glassy polymer thin film is coated on this substrate and then the film is annealed over the glass transition temperature. What will happen? (5)

   (b) What will happen if the Hydrophilic and the hydrophobic domains are swapped? (2)

   (c) A film of thickness h coated on a Substrate 4 is approaching a base substrate 1 (as per figure 2). Find the change in the excess free energy of the system when the film is brought from a very large separation distance to a separation distance D (D is the gap between substrate 1 and film 3, as per figure 2). (8)

**[Total Marks in Q5: 15]**

******** **Please ensure that you have looked into the instructions on the top of the question paper very seriously and have cared to answer all parts of the same question together** *********

All the best everyone ☺

It was a pleasure to teach Instability to each one of you. Thank you. – *RM*