



INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

End-Spring Semester Examination, 2022-2023

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

Date: 28.04.2023 (FN)

Time: 3 Hrs

Full Marks: 50

No. of Students: 133

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 can potentially fetch zero!
4. As much as possible, answers should be accompanied with figures.
5. If you feel any question is wrong, make suitable assumptions. NO DOUBTS will be entertained during the examination.

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

1. (a) What are the different types of Photo Resist Tones. Explain with suitable figures. (2)
(b) What is Soft Baking? (1)
(c) What are the different Printing modes in photolithography? Discuss which mode offers the possibility of fabrication of features that are smaller (in lateral dimension) than those printed on the photo-mask. (2+1)
(d) Why is the time required for **development** crucial? (2)
(e) What is native oxide layer? Why it is essential to grow the oxide layer in Photolithography? (1+2) [Total Marks in Q1: 11]

2. (a) Explain why the patterns made by NIL have significantly higher levels of residual stress. (2)
(b) What is the role of Solvent Vapor Exposure to a polymer film? (3)
(c) Discuss the method of Micro Contact Printing. On what does proper pattern replication by this method depend on? (2+1)
(d) Discuss briefly the method of Roller NIL. How it is different from standard NIL and consequently what critical control is essential. (2+1)

[Total Marks in Q2: 11]

3. (a) What is the fundamental difference between the working of an STM and that of an AFM? In which of the instruments vacuum is required, and why? (1+1)
(b) Describe the steps of approach of an AFM in contact mode. (4)
(c) How is set point chosen in Tapping (Intermittent Contact) mode. Also describe how “imaging” is performed in this mode. (2+3=5)

[Total Marks in Q3: 11]

4. (a) Obtain an expression for the Excess Interfacial Free Energy (ΔG_{Ex}^{LW}) for a thin film of material 1 coated on a semi-infinite substrate of materials 2. 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 $G_{Film}^{LW} = -G_{Interface}^{LW}$. The symbols carry their usual meaning. (3)
- (b) Define Effective Interface Potential, Conjoining Pressure and Disjoining Pressure. (2)
- (c) Discuss how the Sign of A_E can be correlated to film stability. (4)

[Total Marks in Q4: 9]

5. (Thought provoking questions)

- (a) You know that spin coating over a flat substrate leads to a uniform, smooth and flat film. What do you think will happen if you coat the film over a topographically patterned substrate (let's say with simple grating geometry)? (3)
- (b) You know that by executing several soft lithography techniques (such as NIL, CFL, REM etc.) properly, one can get a perfect negative replica of the stamp patterns. Can you think of some conceptual technique that would in principle allow you to make patterns that have same lateral dimension as that of the stamp features but will have different feature height (simple terms: Let's say height of the stamp features is h_0 , can you now make patterns with any feature height varying between 0 and h_0).

Disclaimer: Roller NIL is NOT the answer I am looking at.

Clue: Please start thinking in terms of material property of the different polymers that you have studied in this course. (5)

[Total Marks in Q5: 8]

***** 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 *****