

Questions: Exams 'Nanoprobng and nanofabrication' 2014

PLEASE USE SEPARATE ANSWER SHEETS FOR (Q1-6), FOR Q7
AND FOR Q8

- 30
- Q1. a) What are the three fundamental nucleation and growth modes in a thin film (two dimensional)? Describe each with a diagram. (4 points) 2
- b) What is the difference between heteroepitaxy and homoepitaxy? (1 point) 2
- Q2. a) With a flowchart, describe the entire cycle of a typical lithography process. (2 points) 2
- b) What is the minimum feature size that can be obtained using lithography techniques? Write down the expression for the feature size and discuss the factors on which it depends. (2 points) 2
- c) If a resist bottle has a label AZ6648 then what is the thickness of the resist? (1 point) 2
- Q3. a) Discuss the UV lithography process using negative and positive photoresist (use a diagram for both cases). (3 points) 2
- b) What are the different exposure modes in a typical UV lithography process? (2 points) 2
- Q4. a) How are structures written using Electron Beam Lithography (EBL)? (1 point) $\frac{1}{2}$
- b) What are the different types of electron-solid interaction processes in Electron Beam Lithography? (2 points) 2
- c) What is proximity effect? What could proximity effect lead to while writing patterns in EBL? Illustrate with a diagram. (2 points) $\frac{1}{2}$
- Q5. a) What are the different factors that might influence an Ion Beam Etching (IBE) process? (1.5 points)
- b) What is Reactive Ion Etching (RIE)? Cite one major advantage of RIE over IBE. (2.5 points)
- c) What are the advantages and disadvantages of wet etching technique? (1 points)
- Q6. a) How does Chemical Vapor deposition (CVD) work? What are the different CVD types? (2.5 points)
- b) How does sputtering differ from evaporation? Describe the two commonly used sputtering modes. (2.5 points)
- Q7. a) In an STM image, does an adsorbate sitting on top of a surface always look like a raised bump compared with the substrate? Explain. (1 point)
- 5
- b) Some adsorbates can be imaged in STM at low temperatures but seem to disappear at higher temperatures even though they have not desorbed from the surface. Explain. (1 point)

c) How is an STS experiment carried out? (1 point)

Describe qualitatively the I-V spectra for the following situations:

(i) Tip and sample are metallic. (0.5 point)

(ii) Tip is metallic and the sample is a semiconductor with a gap of ΔE_1 . (0.5 point)

(iii) Explain why an $I/V((dI/dV)/(I/V))$ versus V dependence is used in STS to characterize the density of states, while an I versus V dependence is insufficient. (1 point)

Q8. The spatial resolution of any conventional optical measurement is limited by the Rayleigh Criterion which we can write as:

$$d = \frac{\lambda}{2 NA}$$

Where the NA is the Numerical Aperture of the optical system.

- What is a reasonable range for the numerical aperture of an optical element and estimate the resolution of an optical device operating at visible wavelengths. (1.5 points)
 - Over the course of the two lectures we discussed several avenues by which we can 'beat' the resolution limit. Describe two such methods. (3.5 points)
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total 40 points