

**THIN FILM BASED MICROSTRUCTURE FABRICATION  
(CHEN 4221)**

**Time Allotted : 2½ hrs**

**Full Marks : 60**

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and  
any 4 (four) from Group B to E, taking one from each group.*

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

**Group – A**

1. Answer any twelve:

**12 × 1 = 12**

*Choose the correct alternative for the following*

- (i) The mechanical properties of a thin film are mostly influenced by
  - (a) Chemical composition of the film
  - (b) Grain size of the film
  - (c) Thermal conductivity of the film
  - (d) Chemical bonds in the film
- (ii) Adatoms are
  - (a) Quasiparticles within the film
  - (b) Vapor phase atoms in contact with the film
  - (c) Present in the bulk of the vapor
  - (d) Free to move on the film surface
- (iii) One example of physical vapor deposition process is
  - (a) chemo-mechanical polishing
  - (b) sputtering
  - (c) etching
  - (d) none of the above
- (iv) Epitaxial films are fabricated by
  - (a) chemomechanical polishing
  - (b) sputtering
  - (c) etching
  - (d) none of the above
- (v) Patterns can be formed on thin films through the use of
  - (a) reactive ion etching
  - (b) photolithography
  - (c) chemical vapor deposition
  - (d) none of above
- (vi) The process of dry etching involves
  - (a) acids
  - (b) inert gas
  - (c) a plasma
  - (d) none of above
- (vii) Raman spectroscopy characterizes material based on
  - (a) the optical reflection of light from a group of atoms
  - (b) the absorption of light by a group of atoms
  - (c) the vibrational energy of a group of atoms
  - (d) the bandgap energy of the material

- (viii) X-ray diffraction is based on light undergoing diffraction through  
 (a) an aperture in the sample (b) atomic layers in the sample  
 (c) the grain boundary (d) none of above
- (ix) Wet etching of a film is \_\_\_\_\_ than dry etching  
 (a) slower (b) more difficult to control  
 (c) faster (d) less efficient
- (x) Atomic force microscopy (AFM) characterizes  
 (a) the chemical composition of the sample  
 (b) the crystalline nature of the sample  
 (c) the surface roughness of the sample  
 (d) none of the above

*Fill in the blanks with the correct word*

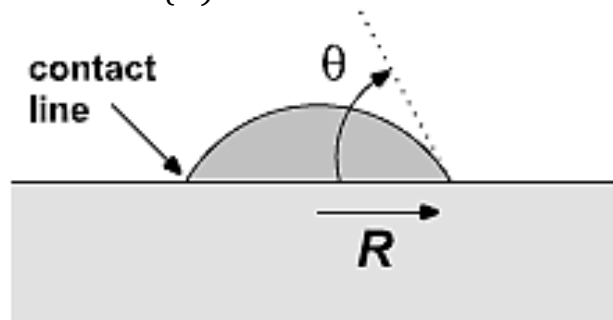
- (xi) The difference between homoepitaxy and heteroexpitaxy are \_\_\_\_\_.
- (xii) For film growth to be possible at substrate temperature,  $T_s$  the condition is \_\_\_\_\_.
- (xiii) The contact angle of a drop on the surface is explained through this diagram \_\_\_\_\_.
- (xiv) Wetting angle of a fluid droplet on a rigid surface is mathematically expressed as \_\_\_\_\_.
- (xv) The two most important factors that influence a vapor deposited film are \_\_\_\_\_.

### Group - B

2. (a) What is a polycrystalline film? What conditions induced the formation of a polycrystalline film? Give an example of a material that will have a polycrystalline nature. [[CO1] (Understand/LOCQ)]
- (b) Describe the Stranksi-Krastanov growth mode of film formation. [[CO1] (Apply/IOCQ)]
- (c) Explain the process of layer by layer film growth mode also known as Frank-van der Merwe growth mode. [[CO1] (Remember/LOCQ)]

**4 + 4 + 4 = 12**

3. (a) Shown in the following figure, where  $V$  is the island volume and  $A$  is the island surface area and  $\gamma_s$  and  $\gamma_f$  are the substrate and film free energy respectively. State the equation for  $\cos(\theta)$ .



- (b) What is the name of the equation and state its significance. [[CO1](Apply/IOCQ)]
- What are epitaxial films? What are the applications and advantages of epitaxial films? [[CO1] (Remember/LOCQ)]

- (c) State the mathematical expression used to determine the energy associated with cluster formation explaining all terms. From the expression, state the maximum value of the cluster size possible why?

[[CO1] (Apply/IOCQ)]

$$4 + 4 + 4 = 12$$

### Group - C

4. (a) Draw a schematic of the system in which CVD is conducted and give a specific example of APCVD.  
 (b) Give three points of difference between sputtering process and the evaporation process. Which is more advantageous and why?

[[CO2] (Apply/IOCQ)]

[[CO2] (Remember/LOCQ)]

$$6 + 6 = 12$$

5. (a) What is plasma? What is the advantage of using plasma enhanced chemical vapor deposition?  
 (b) Describe the reactor where plasma enhanced chemical vapor deposition is conducted.

[[CO2] (Understand/LOCQ)]

[[CO2] (Understand/LOCQ)]

$$6 + 6 = 12$$

### Group - D

6. (a) What is glass transition temperature? Why are 'descumming' and 'post baking' important steps after the resist development in photolithography?  
 (b) What is a photolithographic mask? Explain the process carried out in the 'exposure' step of photolithography.

[[CO3] (Apply/IOCQ)]

[[CO3] (Remember/IOCQ)]

$$(1 + 5) + 6 = 12$$

7. (a) What are the different methods of physical etching? Where is physical etching needed? Explain the mechanism by which physical etching is done.  
 (b) With a schematic explain the film surface phenomena occurring during plasma etching. State the reactions occurring during wet chemical acid etching.

[[CO3] (Remember/LOCQ)]

[[CO3] (Analyse/IOCQ)]

$$(2 + 2 + 2) + (3 + 3) = 12$$

### Group - E

8. (a) Explain with a schematic the working principle of a scanning electron microscopy.  
 (b) What are the two different modes of operation for AFM. With a schematic explain the difference between the two.

[[CO4] (Remember/LOCQ)]

[[CO4] (Evaluate/IOCQ)]

$$6 + 6 = 12$$

9. (a) Explain the operation of the transmission electron microscopy (TEM) with the help of a schematic. State two main operational differences between a scanning electron microscope (SEM) and transmission electron microscope (TEM).

[[CO4] (Remember/IOCQ)]

(b) Explain the working principle of a scanning tunnelling microscope.

[[CO4) (Understand/LOCQ)]

**3 + 9 = 12**

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| Cognition Level         | LOCQ  | IOCQ  | HOCQ |
|-------------------------|-------|-------|------|
| Percentage distribution | 53.13 | 46.87 | 0    |