INDIAN INSTITUTE OF TECHNOLOGY, DELHI
DEPARTMENT OF PHYSICS
MAJOR TEST PHL 702

DATE: 07.05.2007 **MAX MARKS: 45**

TIME: 10.30 A.M.– 12.30 P.M.

Q.1. Give brief explanations for the following:

a. Multiple strand tungsten wires twisted into helical shapes are preferred over single wire filaments to evaporate metals that wet tungsten easily.

b. While depositing thin films of alloys which do not melt congruently, sputtering is a preferred deposition method than evaporation.

c. Sheaths in a glow discharge have lower luminosity than the glow.

d. For efficient sputtering, using rf discharges, the area of powered target electrode is kept small compared to the total area of the other electrode.

e. Small negative values of ΔG_V (ΔG_V = change in free energy per unit volume) are conducive to monocrystalline formation.

f. A significantly higher density of nuclei is usually observed near cleavage steps and other imperfections in a substrate during very early stages of thin film deposition.

g. Thin layers of GaAs are adequate for solar cell applications whereas comparatively thicker layers of Si are required for similar applications.

h. For both metal and dielectric films, density increases with increase in film thickness.

i. Heterogeneous reactions are mostly used in CVD reactors.

j. In both horizontal and barrel reactors used in atmospheric pressure CVD, susceptors are kept tilted.

2 x 10 = 20 MARKS

Q. 2 (a) What are disproportionation reactions in CVD? Suggest a reactor design, draw the associated temperature profile and write down the reactions occurring during deposition of Ge Thin Films by this reaction. [Starting materials: Ge(s) and I_2 (g); temperatures can be indicated by T_i.]

(b) When normalized to the same reactant partial pressure, LPCVD film growth rates exceed those for conventional atmospheric CVD. Explain

4+4 = 8 MARKS

4 +4 = 8 MARKS

Q.3 (a) What is "Oswald Ripening"? Explain the underlying concept of this phenomena.

(b) What is the effect of each of the following four inequalities on the microstructure of a thin film being deposited on a substrate by condensation from the vapour phase?

i) $\left(\frac{\partial r^*}{\partial T}\right)_{\dot{R}} > 0$; ii) $\left(\frac{\partial \Delta G^*}{\partial T}\right)_{\dot{R}} > 0$

iii) $\left(\frac{\partial r^*}{\partial \dot{R}}\right)_T < 0$; iv) $\left(\frac{\partial \Delta G^*}{\partial \dot{R}}\right)_T < 0$

symbols have their usual meaning.

4+4 = 8 MARKS

4. (a) The unit cell parameters for a metal 'A' deposited on a compound semiconductor substrate 'B' are 0.2866 nm and 0.5653 nm respectively. The epitaxial geometry for film of A on B is indicated by

(110) A || (110) B; [200] A || [100] B.

Calculate the lattice misfit.* Is it positive or negative? What do the positive and negative misfits imply? in [001] direction.

(b) The early growth of an epilayer on the (100) plane of a FCC crystalline substrate has a($\sqrt{2}$ x $\sqrt{2}$) R 45° structure. Show the atomic positions of adatoms relative to substrate atoms.

© You are hired by a company which is interested in exploiting III-V semiconductors for creation of epitaxial heterojunctions. What factors will you keep in mind in designing epitaxial film substrate combinations? Give reasons.

3 + 2 + 4 = 9 MARKS