MAJOR TEST

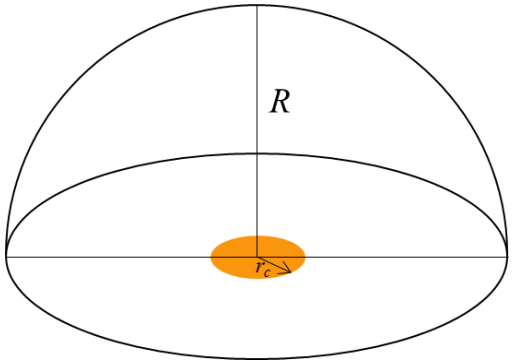
Proff : PK Muduli

PYL116 ELEMENTS OF MATERIALS PROCESSING

Dated: 7th Jan 2021

Answer all questions **Time: One Hour** **Maximum Marks 40**

1.(a) Consider the case of evaporation of gold in a hemispherical shaped vacuum chamber of radius $R = 2\ m$. The surface area of the crucible is circular with a radius of r_c =0.5 cm (see figure.). The crucible is heated to 1050 ˚C to produce a partial pressure of 10^{-5} Torr. Determine the growth rate of Au film for a substrate kept at the top of the crucible. Given partial pressure of Au at 1050 ˚C as 10^{-5} Torr, the atomic mass of Au is 197 g/mol, and the density of Au is 19.3 g/cm^3. (5)



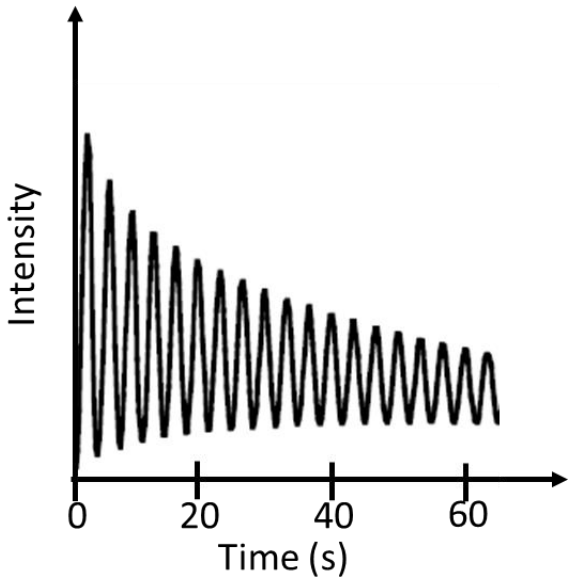
(b) Consider the evaporation of Al and Cu from two different surface sources to produce an alloy thin film. Draw a diagram to show the location of the two sources and substrate so that film uniformity is maintained. Assume the substrate size to be smaller compared to distance between the two sources. (2)

(c) Mention three differences between RHEED and LEED. (3)

2. (a) In an evaporation deposition, TiO_2 is found to decompose upon heating. Suggest two alternative methods to deposit the layers with brief justification on why TiO_2 will not decompose in those cases. (3+3)

(b) Briefly explain why PLD leads to congruent evaporation for complex materials involving different elements with different vapor pressure. (2)

(c) Find the growth rate (monolayers/sec) of GaAs from the right figure of RHEED oscillation data during the MBE growth of GaAs. (2)



3. (a) Assume that the kinetic energy (E) and angular spread of neutral atoms sputtered from a surface are given by the distribution function:

$$F(E,\phi) = C \times E\,\frac{cos\phi}{(E+U_s)^3}$$

where U_s = binding energy of surface atoms, ϕ is the angle between sputtered atoms and the surface normal, and C = constant. Sketch qualitatively the dependence of $F(E,\phi)\ vs\ E$ for two values of $U_s = 5$ and 10 eV. (4)

(b) Consider the case of sputter deposition of Ti. During the deposition, both Ar gas and N_2 gas were supplied. The resistivity is then measured as a function of the amount of N_2 gas. Plot the expected behavior of resistivity versus the amount of N_2 gas (partial pressure) and explain the behavior. (2+2)

(c) Plot the plasma I-V curves showing target self-bias in RF sputtering. No text is needed. (2)

4. (a) During CVD deposition of a thin film, assume that the temperature is high enough that the growth rate is controlled by gas mass-transfer. If the pressure of the system is decreased by a factor two and temperature is increased by factor four, by what factor growth rate will change. Assume that the concentration of the gas and the boundary layer thickness is unchanged. Explain using the expression of growth rate. (4)

(b) Suppose you need a thin film that will *conformally* cover a patterned structure. What deposition method would you choose to achieve this (i.e., sputtering, evaporation, or CVD)? Why? (2)

(c) Plot CVD growth rate vs. position along the susceptor of a CVD reactor. Mention two solutions to overcome the problem of non-uniformity of growth rate. (2+2)