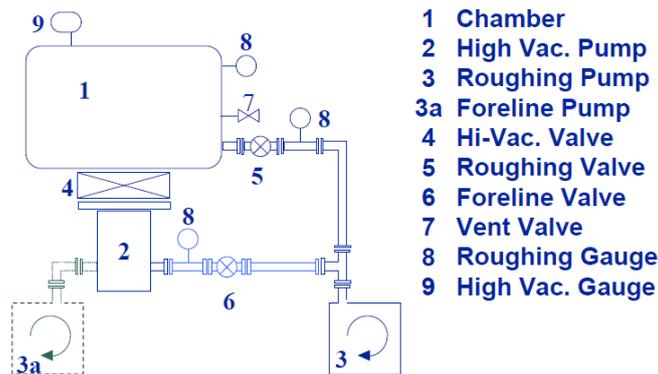
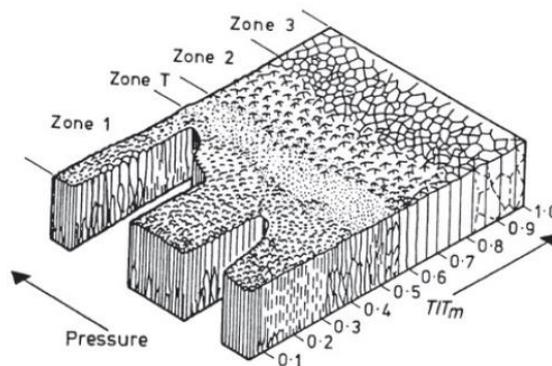


Plasma and Thin Film Technologies

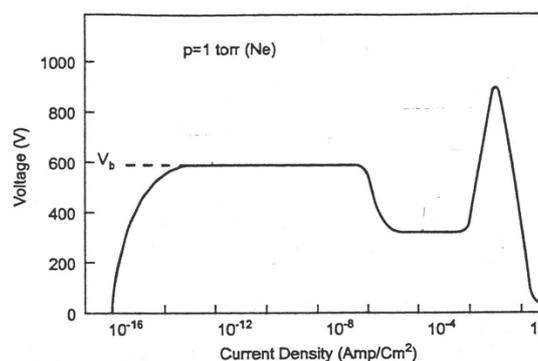
1. Please explain the three flow models of gas molecules and its relationship with pressure.
2. Please draw a diagram to illustrate the four steps of mechanical pumping.
3. Please describe the main function of vacuum pump oil.
4. As shown in the figure below, please illustrate the pump and valve switch on/off procedures of a vacuum system when it is pumped from atmospheric pressure to a high vacuum state.



5. As shown in the figure below, please discuss in detail the Thornton structure-zone diagram for films deposited by magnetron sputtering.



6. As shown in the figure below, please discuss in detail the I-V curve of glow discharge plasma, and .



7. What is gas/metal ion bombardment? What does it do? How does it operate?

8. What is different in DC and RF magnetron sputtering for the power supply used, and why?
9. What are the process control parameters in the PVD? Discuss their impacts on thin film properties.
10. Please compare the differences between PVD and CVD in process characteristics.
11. Three examples for applying plasma thin films in sensors?
12. Please list two kinds of mechanisms for growing thin films?
13. List and briefly describe two methods for the preparation of nano thin films?
14. Mechanism for generating atmospheric pressure plasma discharge?
15. How to apply plasma surface modification on powders?
16. Two methods for the preparation of organic/inorganic composite films?
17. Randomly list three kinds of vacuum pumps?
18. Description of three methods to detect the film thickness.
19. What are the similarity and difference between plasma polymerization and plasma deposition?
20. Please provide two examples of applying plasma technology in carbon fibre-reinforced composites and briefly explain their mechanisms?
21. Explain the three types of thin film growth modes and the factors that influence these growth modes.
22. What are the differences between deposition rate and sputtering rate? What factors influence the deposition rate and sputtering rate?
23. What is reactive sputtering? Why does deposition rate magnetic hysteresis occur when sputtering oxide films using a metal target? What are the methods to tackle this issue?
24. What are the differences in the sputtering principles between High-Power Impulse Magnetron Sputtering (HIPIMS) and Direct Current Magnetron Sputtering (DCMS) systems? What are the advantages and disadvantages of using HIPIMS for thin film deposition? How can the

disadvantages be improved?

25. Explain how the grain size affects the optical, electrical, magnetic, and mechanical properties of thin films.
26. What are “dry etching” and “wet etching”, and what are their advantages and disadvantages?
27. Describe the advantages and disadvantages of thermal CVD, atmospheric-pressure CVD and low-pressure CVD.
28. Please provide two examples of applying plasma technology in the semiconductor industry and briefly explain their mechanisms.
29. Please provide two examples of applying plasma technology in preparing antibacterial surfaces with descriptions of experimental steps.
30. Please give an example of applying plasma technology in agriculture and briefly explain its mechanisms.
31. An Al film was deposited at a rate of 1 $\mu\text{m}/\text{min}$ in vacuum at 25 $^{\circ}\text{C}$, and it was estimated that the oxygen content of the film was 0.001. What was the partial pressure of oxygen in the system?
Al: 27, 2.7 g/cm^3 , O:16, 1.429 g/L @25 $^{\circ}\text{C}$
Molar gas constant: 8.314 $\text{J}/(\text{K}\cdot\text{mol})$, 0.082 $\text{L}\cdot\text{atm}/(\text{K}\cdot\text{mol})$
The vapor pressure of liquid Al is given by
$$\log P(\text{torr}) = -15993/T + 12.409 - 0.999 \log T - 3.52 \times 10^{-6} T$$
32. Plasma are often used to clean surface. Two of the common surface contaminants are water and hydrocarbons(oil).
 - (1) Consider a 0.1 μm thick water layer on a glass substrate that must be removed prior to the deposition of an optical coating. What plasma composition and experimental arrangement would you recommend to remove the water?
 - (2) Steel sheet contains a 1 μm thick oil layer. Suggest a plasma-based cleaning process to degrease this metal.
 - (3) Typical cleaning gases have an ionization energy of 5 eV per ion. Explain the electronic and chemical mechanisms involved in your process for cleaning steel.
33. Find the stoichiometric formula for the following films:

(1) PECVD silicon nitride containing 20 at.% H with a Si/N ratio of 1.2.

(2) LPCVD silicon nitride containing 6 at.% H with a Si/N ratio of 0.8.

H:1, Si: 28, N: 14

34. If trench filling is like sintering, roughly estimate the time required for copper to fill a trench that is 0.25 μm wide and 2 μm long at a temperature 500 $^{\circ}\text{C}$. Make any assumption you wish.

Cu: atomic number: 29, standard atomic weight: 63.546 u, m.p.: 1085 $^{\circ}\text{C}$, density(@20 $^{\circ}\text{C}$): 8.935 g/cm^3 , when liquid (at m.p.): 8.02 g/cm^3 , heat of fusion: 13.26 kJ/mol, crystal structure: fcc, lattice constant(fcc @20 $^{\circ}\text{C}$) $a = 361.50 \text{ pm}$, thermal expansion(@25 $^{\circ}\text{C}$): 16.5 $\mu\text{m}/(\text{m}\cdot\text{K})$, thermal conductivity: 401 $\text{W}/(\text{m}\cdot\text{K})$

35. What are the advantages and disadvantages of having electrons (1) inside or (2) outside plasma-etching reactors?

36. An FCC film is deposited on the (100) plane of a single-crystal FCC substrate. It is determined that the angle between the [100] directions in the film and substrate is 63.4 $^{\circ}$. What are the Miller indices of the plane lying in the film surface?

37. A tungsten evaporation source is rated at 1000 W and operates at 120 V. If the filament heater wire is 20 cm long and 0.75 mm in diameter estimate the temperature (T) the source will reach when powered. Compare your answer with an alternative estimate of the temperature assuming all of the input electrical power dissipated is thermally radiated from the filament surface.

38. A parallel plate plasma reactor with 60 cm diameter electrodes contains argon at a pressure of 20Pa. The electron temperature is 2 eV while the ion and neutral temperature is 0.03 eV. If the plasma density is $10^{16}/\text{m}^3$, calculate: (a) The mean electron velocity. (b) The electron mobility. (c) The degree of ionization.

39. In a DC planar magnetron sputtering system at 1000 V, the cathode-anode spacing is 10 cm. What magnetic field should be applied to trap electrons within 0.5 cm of the target?

40. Select any film material (e.g. semiconductor, oxide, nitride, carbide, metal alloy) that has been deposited or grown by both PVD and CVD methods. Try to compare the resultant structure, stoichiometries, and properties.