Tutorial 5 E3013 – Deposition Systems

1. You are required to sputter deposit Ag film over a silicon oxide layer on a silicon wafer substrate.

(i) Draw a schematic diagram of such a sputtering system with the anode and cathode clearly labelled. Identify the electrode in which the silicon wafer substrate is to be placed.
(ii) Discuss the effect of substrate bias voltage on the *step coverage* of the Ag film.
(iii) You want to increase your sputter deposition rate for a silver (Ag) electrical contact. You had been using Ar sputtering gas. Discuss how the following changes would help to *increase Ag deposition rate*:
- Switch sputtering gas to Kr (with a much heavier atomic mass unit than Ar).
- Increase the anode-cathode potential difference.
- Reduce the pressure in the chamber.

(iv) What changes should be made to the system if we need to sputter deposit a SiN film?

2. (a) Figure 2 shows a schematic diagram of a physical vapour system.

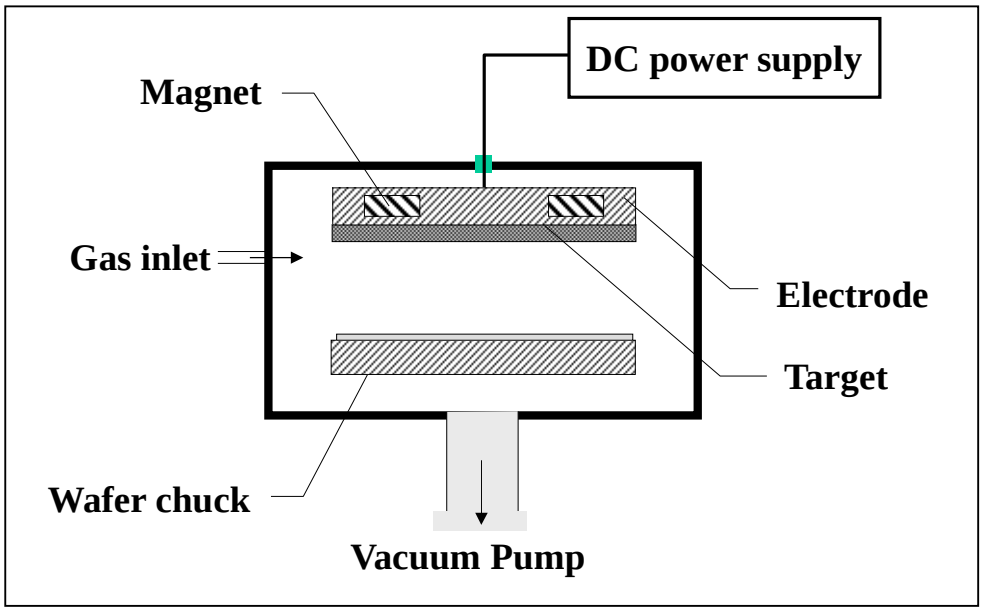

Figure 2 : A Physical Vapour Deposition System

(i) What is the name the physical vapour system?
(ii) Name the electrode in which the target was mounted.
(iii) Explain why magnets are deployed in the electrode.\
(iv) Name the gas used, explaining why such gas is deployed in such system
(v) Explain what modifications need to be implemented if this system is to be used for reactive ion etching of SiO_2 on a wafer?

(b) Explain how plasma is generated inside a vacuum system and list the various plasma reactions arising from the inelastic collisions of the electrons with the gas molecules.

3. In a PECVD system, a reaction gas is metered into a 30-litres chamber at flow rate of 50 sccm. The resulting steady-state pressure is 50 mtorr. Given that 1 torr litre/s = 78.9 sccm .

   (i) Define the residence time of the gas.
   (ii) Calculate the residence time of the gas.
   (iii) Determine the pumping speed of the vacuum pump.

4. Figure 3 shows the schematic of physical vapour deposition system.
   (i) What is the name of the deposition system?
   (ii) Why a RF generator instead of a dc power supply is being deployed in such deposition system?
   (iii) Name the chuck/electrode on which the substrate is placed.
   (iv) Name the gas used, explaining why such gas is deployed in such system
   (v) Explain what modifications need to be implemented if this system is to be used for reactive ion etching of SiO_2 on a wafer?
   (vi) Explain what modifications need to be implemented if this system is to be used for chemical vapour deposition of SiO_2 on a wafer?

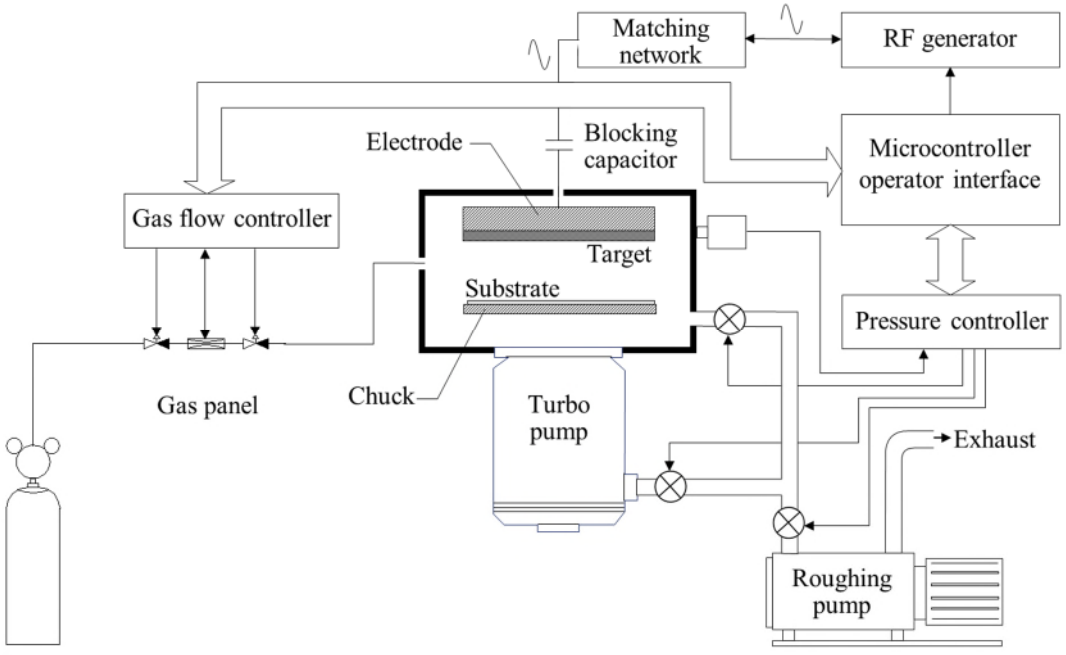

Figure 3 : A Physical Vapour Deposition System

5. Compare and contrast the thermal evaporation to that of the sputtering technique used for the metallization of integrated circuits.

6. You are about to grow a film by CVD and want good process control. Briefly explain the advantages of film growth in the regime that is limited by *gas transport* (as opposed to reaction limited).

7. Name the CVD system shown in Figure 4

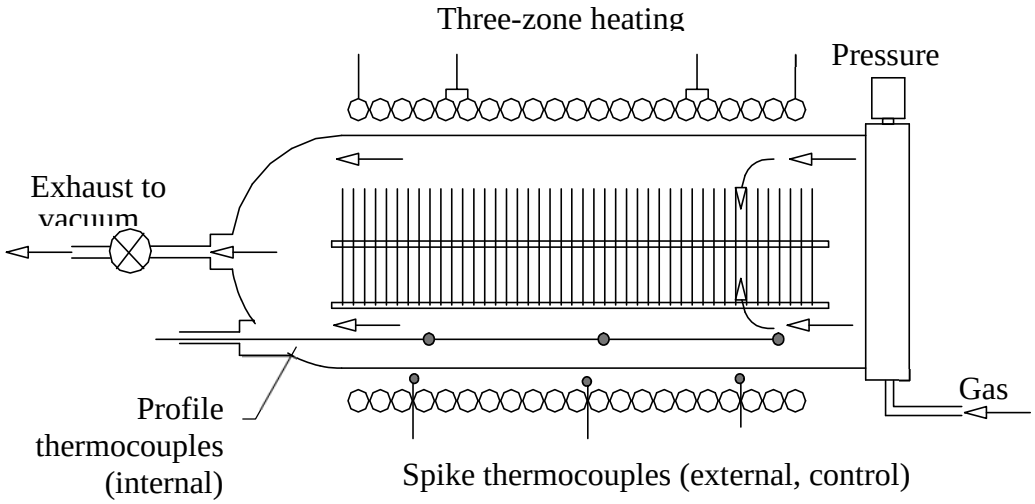

Figure 4 : A typical CVD System

(i) Under what mechanism is the system operating under? Explain why.
(ii) Why the wafers are stacked vertically and not horizontal as in some other system?
(iii) What gases are required for deposition of silicon nitride?

8.

(a) The thin film deposition for the horizontal CVD reactor is usually carried out in the gas phase mass transport limited regime. Why? Give 2 reasons.

(b) In a different experimental run, the total pressure of a CVD method was lowered from 760 torr to 1 torr
(i) Sketch the growth velocity vs 1/T graph for both pressures.
(ii) Explain the differences between the plots.
(iii) Describe the usefulness of the CVD mode operating at 1 torr (with respect to film growth).

(c) As an engineer, you have been tasked with forming thin films of Mo-Ti alloy for electronic applications. You have access to three equipment – a thermal evaporator, an e-beam evaporator and a sputtering machine. Both the evaporators can allow for co-evaporation.

(i) What equipment would you utilise for deposition the Mo-Ti alloy thin film? Explain the reasons for choosing the equipment and eliminating the alternatives.

(ii) List the advantages and limitation of the e-beam evaporation.

(iii) What is sputter yield? List the 3 parameters that affect sputter yield.