Thin-Film Deposition

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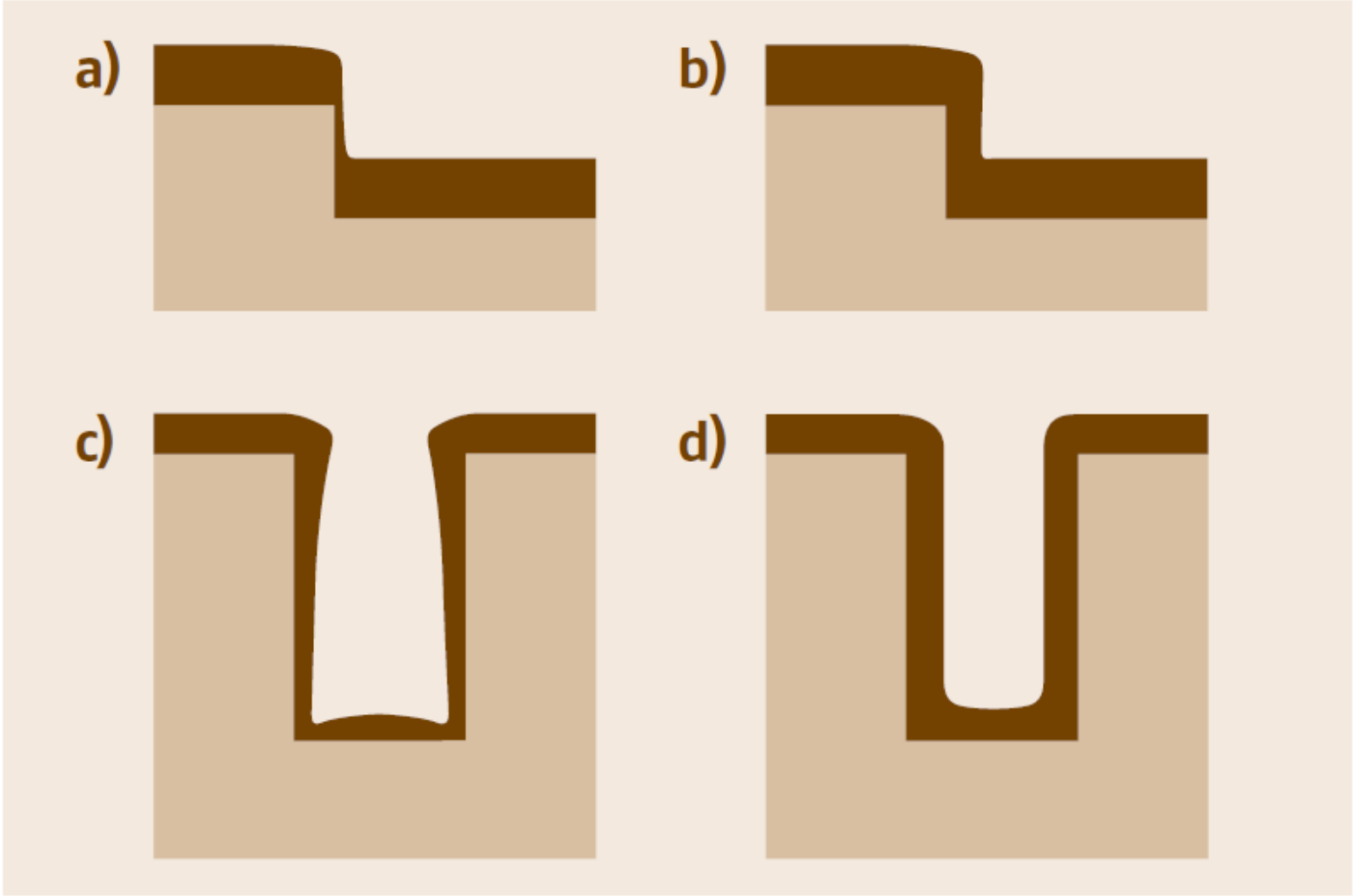
Thin-Film Deposition and Doping

Following is a list of a few typical applications for the deposited and/or doped materials used in micro/nanofabrication

- Mechanical structure
- Electrical isolation
- Electrical connection
- Sensing or actuating
- Mask for etching and doping.
- Support or mold during deposition of other materials (sacrificial materials)
- Passivation

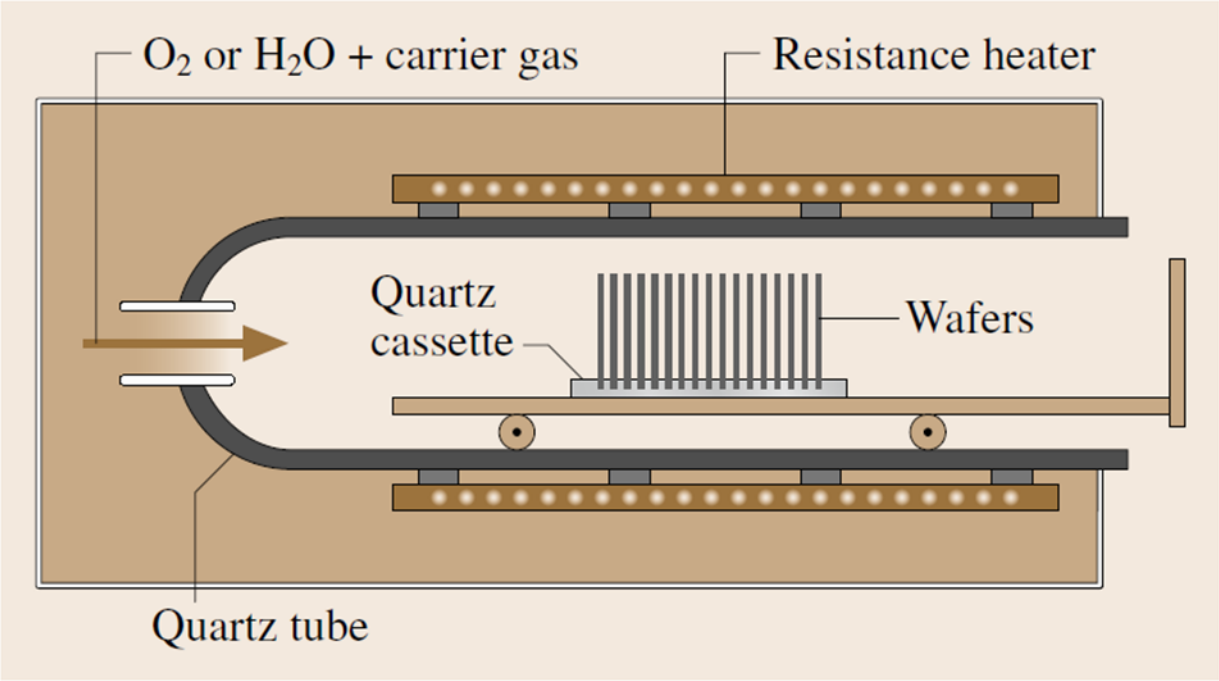
(a)poor step coverage
(b)good step coverage
(c)nonconformal layer
(d)conformal layer



Oxidation

Oxidation of silicon is a process used to obtain a thin film of SiO_2 with excellent quality (very low density of defects) and thickness homogeneity.

The oxidation process is typically carried out at temperatures in the range of 900–1200 ◦C in the presence of O_2 (dry oxidation) or H_2O (wet oxidation)



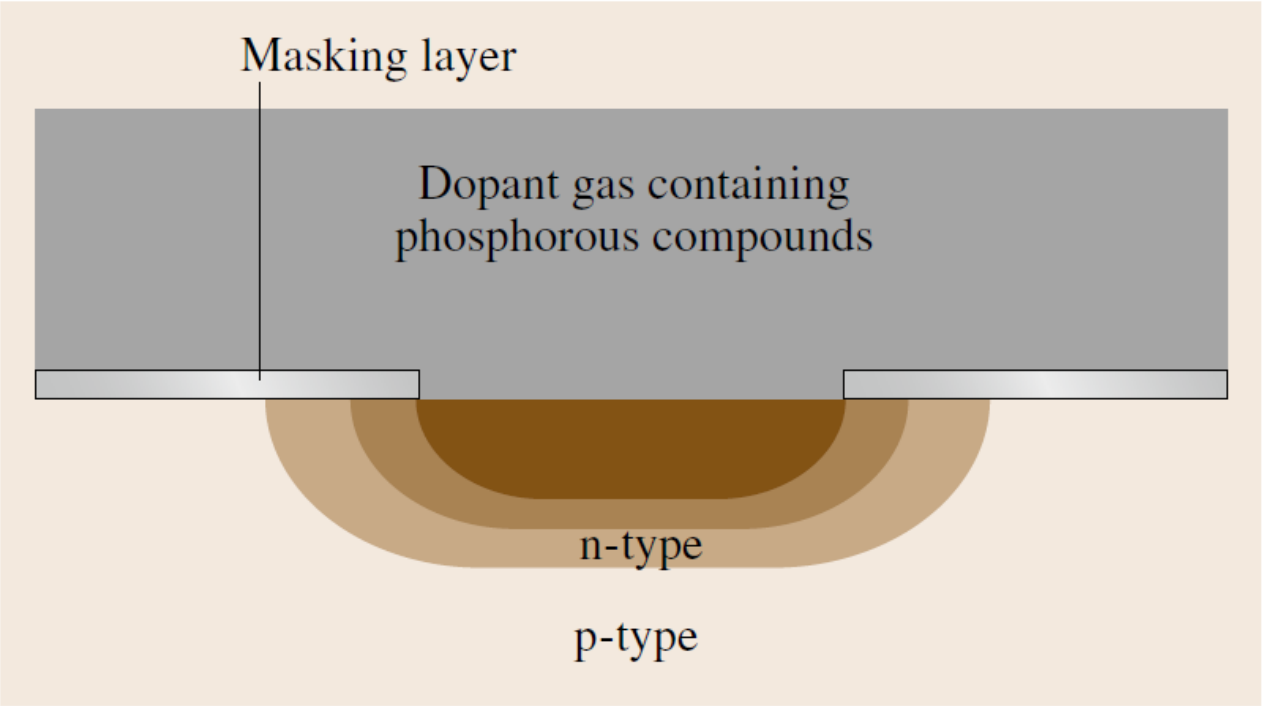
$$Si_{(solid)} + O_{2\,(gas)} \Rightarrow SiO_{2\,(solid)}$$

$$Si_{(solid)} + 2H_2O_{(steam)} \Rightarrow SiO_{2\,(solid)} + 2H_{2\,(gas)}$$

Doping

The introduction of certain impurities in a semiconductor can change its electrical, chemical, and even mechanical properties

Typical impurities or dopants used in silicon include boron (to form p-type regions) and phosphorous or arsenic (to form n-type regions).



Chemical Vapour Deposition (CVD)

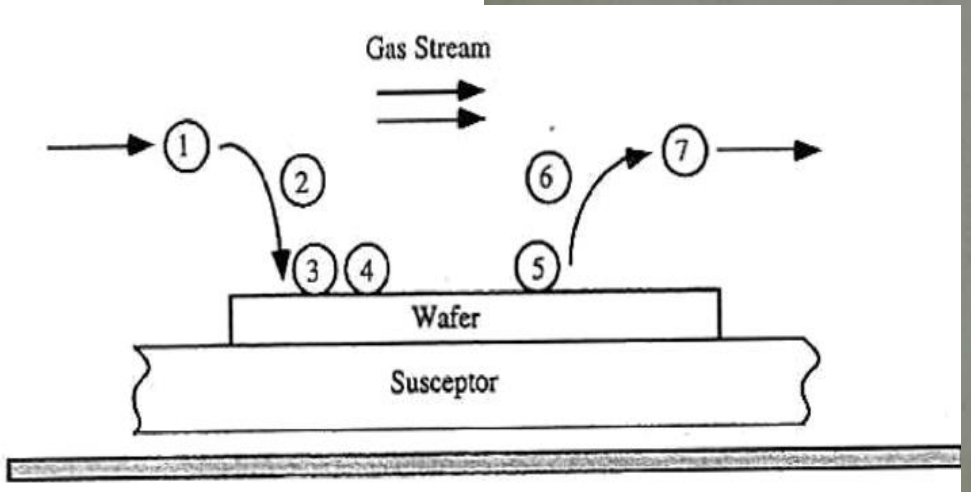
- Chemical Vapour Deposition (CVD) is a chemical process used to produce high purity, high performance solid materials.

- In a typical CVD process, the substrate is exposed to one or more volatile precursors which react and decompose on the substrate surface to produce the desired deposit.

- During this process, volatile by-products are also produced, which are removed by gas flow through the reaction chamber.

Chemical Vapour Deposition (CVD)

1. Transport of reactants by forced convection to the deposition region
2. Transport of reactants by diffusion from the main gas stream to the substrate surface.
3. Adsorption of reactants in the wafer (substrate) surface.
4. Chemical decomposition and other surface reactions take place.
5. Desorption of by-products from the surface
6. Transport of by-products by diffusion
7. Transport of by-products by forced convection away from the deposition region.



CVD Classification

CVD’s are classified into two types on the basis of Operating Pressure.

1. Atmospheric Pressure CVD

2.Low Pressure CVD

- Plasma Enhanced CVD
- Photochemical Vapour Deposition
- Thermal CVD

Atmospheric Pressure CVD

- **CASE 1 : HIGH TEMPERATURE**
- This process is used to deposit Silicon and compound films or hard metallurgical coatings like Titanium Carbide and Titanium Nitride.
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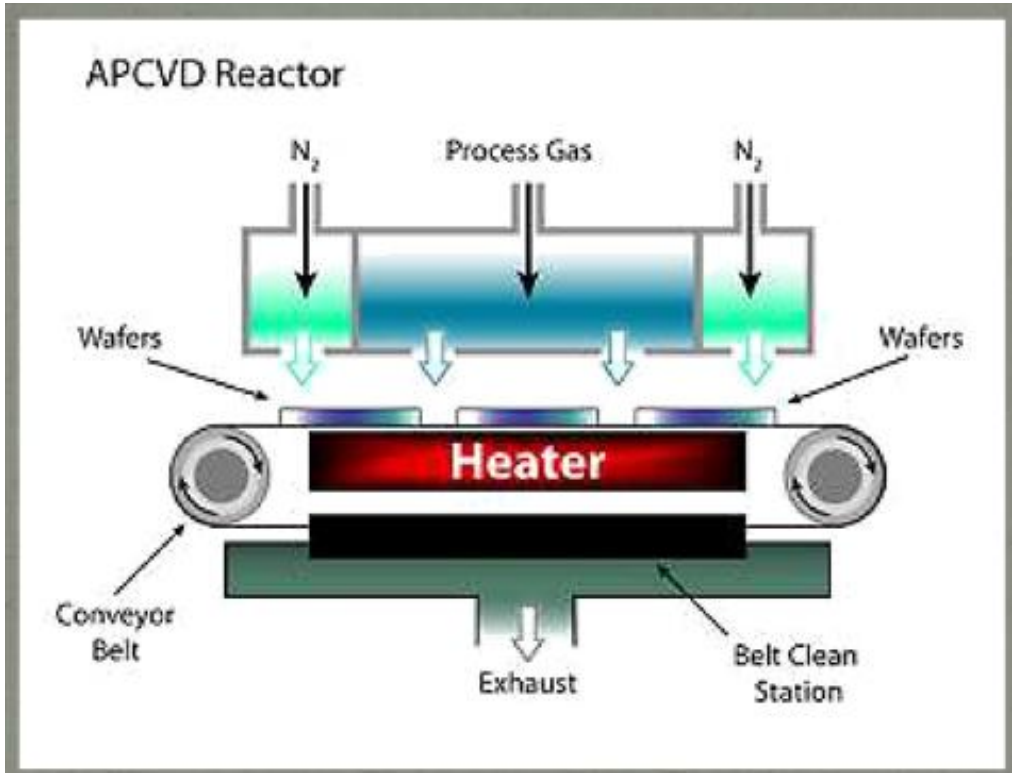
- **CASE 2 : LOW TEMPERATURE**
- Many insulating film layers such as Silicon dioxide need to be deposited at low temperatures for effective deposition.

Atmospheric Pressure CVD

- **Aluminium oxide films are deposited by this method from aluminium trichloride, argon and oxygen gas mixtures at temperatures ranging from 800-1000 degree Celsius**
- **The films have low chlorine content, which continue to decrease with increasing temperature.**
- **Analysis of the film growth rate on the substrates revealed that, the growth takes place only by diffusion from 800 to 950 degree Celsius and only by gas phase reaction at 1000 degree Celsius.**

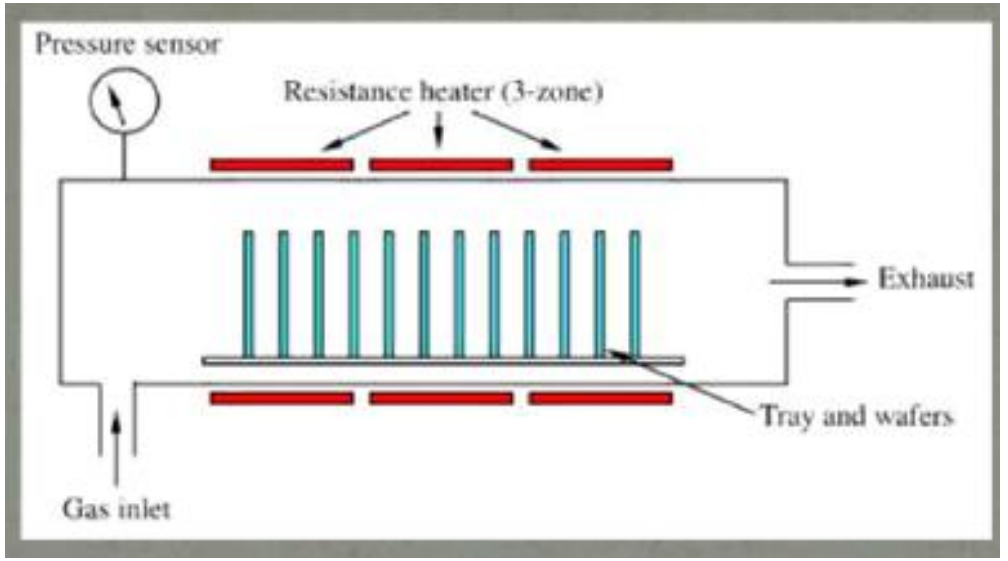


Limitations of APCVD

- Film thickness uniformity cannot be maintained.
- Large number of pinhole defects can occur.
- Wafer (Substrate) throughput is low due to low deposition rate.
- The deposits get contaminated very easily since it takes place at atmospheric pressure.
- Maintaining stochiometry is extremely difficult.

Low Pressure CVD

- The deposition of Silicon carbide thin film is performed using low pressure CVD of Dichlorosilane / Acetylene / Hydrogen reaction system.
- The Silicon carbide film deposited at three different temperatures has three different properties.
- This technique permits either horizontal or vertical loading of the wafers into the furnace and accommodates a large number of wafers for processing.
- The process results in the deposition of compounds with excellent purity and uniformity.
- However the technique requires higher temperatures, and the deposition rate is low.



1023 K	AMORPHOUS
1073 K	MICROCRYSTALLINE
1173 K	PREFERENTIALLYORIENTED