EBB 212/3

CHEMICAL SYNTHESIS OF CERAMIC POWDER (PART 3)

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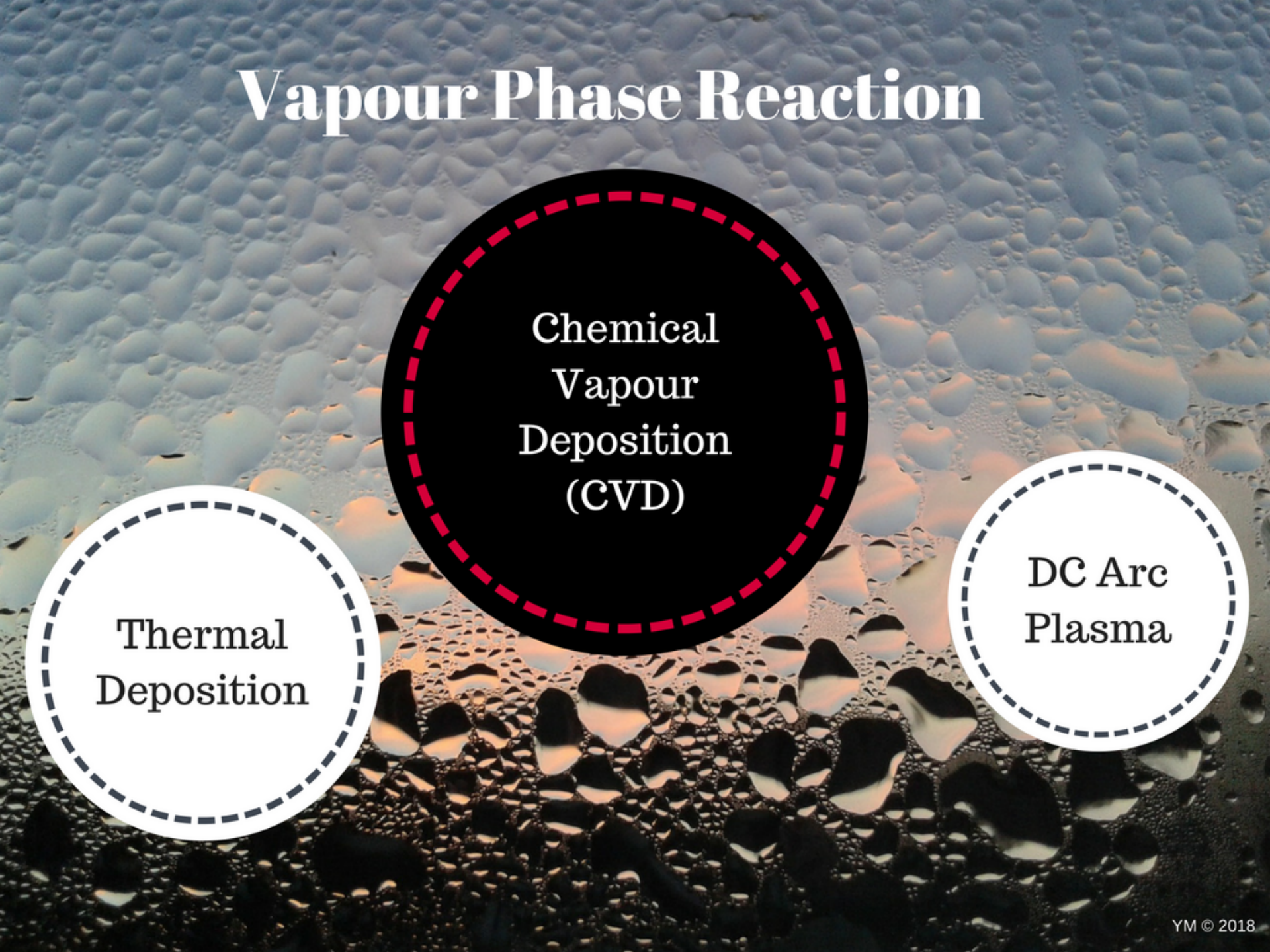
Vapour Phase Reaction



Chemical Vapour Deposition (CVD)

The formation of soot due to incomplete oxidation of firewood is probably the oldest example of deposition using CVD

Chemical Vapour Deposition (CVD)

By definition...

CVD involves the dissociation and/or chemical reactions of gaseous reactants in an activated (heat, light, plasma) environment, followed by the formation of a stable solid product

What is CVD?

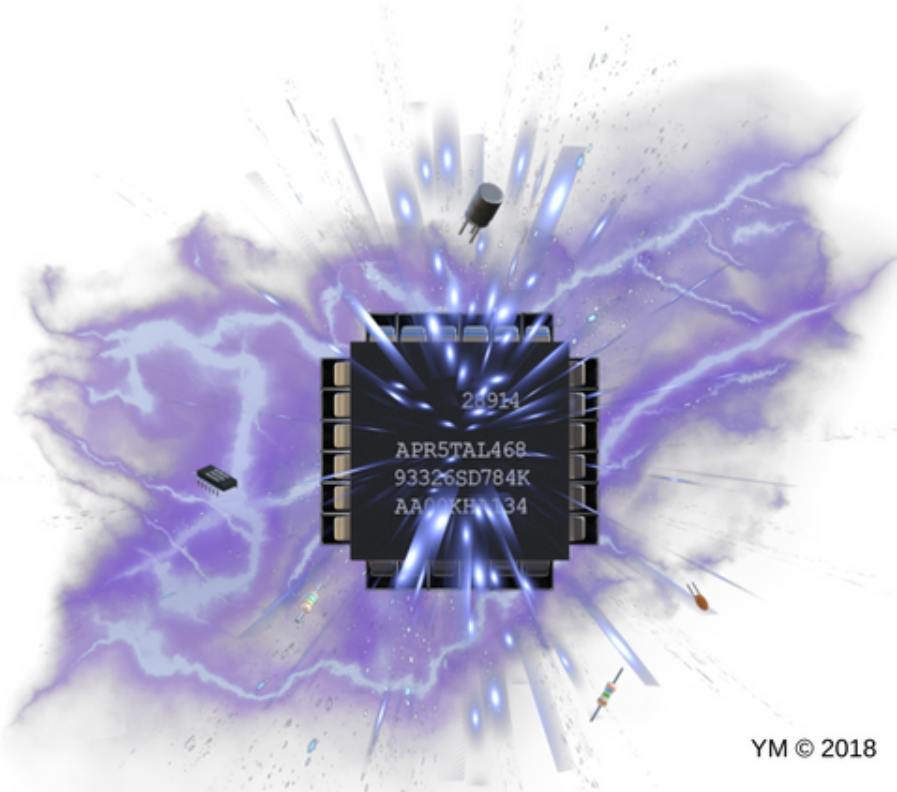
Solid material is obtained as a coating, a powder, or as single crystals

Example for Solid-Vapor Reaction

Chemical Vapour Deposition (CVD)

Chemical process used to produce:
high purity
high performance solid materials

Often used in
semiconductor industries
to produce thin film



Types of CVD

CVD's are classified into 2 types on the basis of operating pressure.

Atmospheric Pressure CVD

Low Pressure CVD

Plasma Enhanced CVD

Thermal CVD

Photochemical Vapour Deposition

Basic Concept

Production of powder particle through: Homogeneous or heterogeneous nucleation on supplied nuclei.

**Nuclei : point where the crystal start to growth during solidification.*

Reaction typically carried out by passing the reactants into a chamber (often through a burner tube with a gas flame).

Basic Concept

Reactants for vapour phase reaction...

Volatiles gases

Volatiles liquids

Wide variety of alternative heat source such as plasmas and lasers.

PROCESS

Vapour

Powder

Bulk crystals

Thin film

Whiskers

Substrate

PROCESS

1. Wafer (substrate) exposed to one or more volatile reactants (precursors)

2. Selected reactant materials is diffused in a *carrier gas that flow over the hot substrate surface

3. heat from the hot substrate surface prompt chemical reactions between the reactant and carrier gas

4. volatile by-products are also produced- removed by gas flow through the reaction chamber

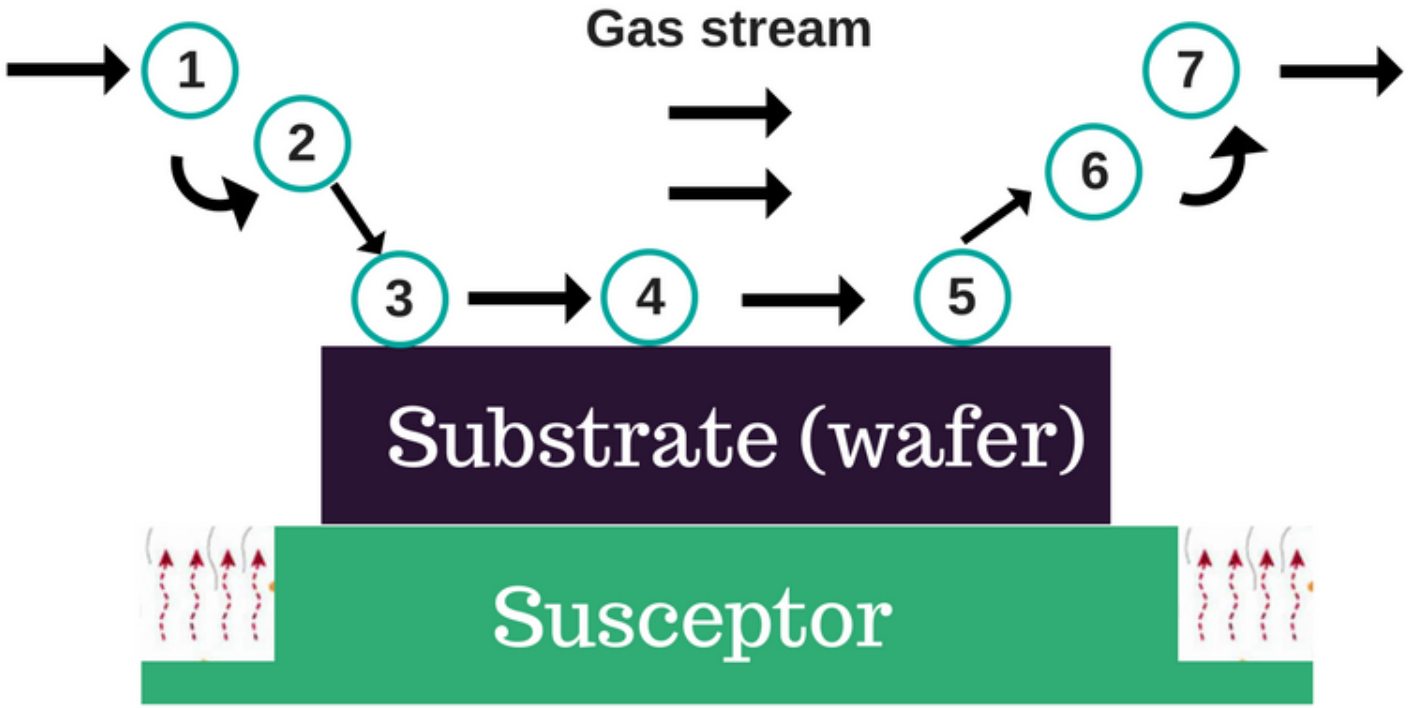
5. Desired deposit produced

*Carrier gas include O2, NO2, CO2 and H2.

Steps involved in CVD

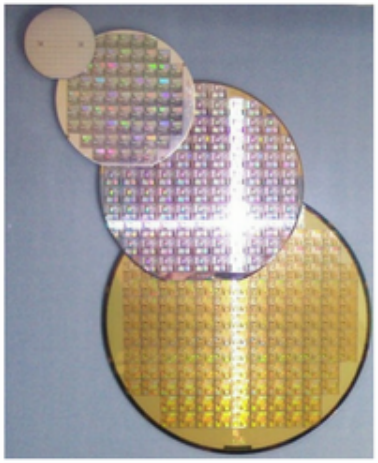
1. Transport of reactants by forced convection to the deposition region
2. Transport of reactants by diffusion from the main gas stream to the substrate surface
3. Adsorption of reactants on the wafer (substrate) surface
4. Chemical decomposition and other surface reactions take place
5. Desorption of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

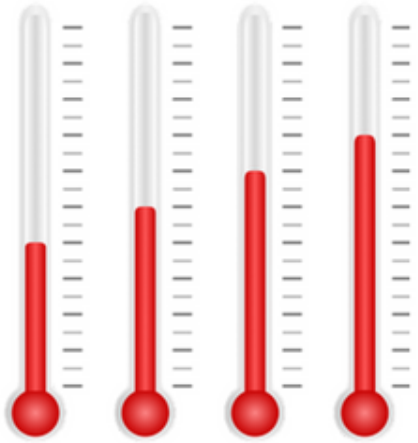
Steps involved in CVD



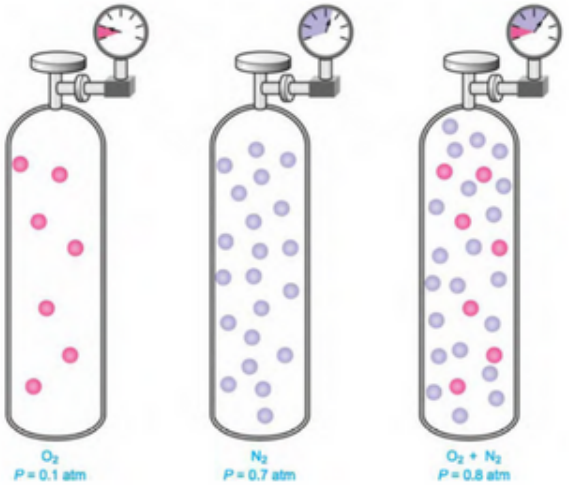
Materials with different properties can be grown by varying the experimental conditions:

Substrate material

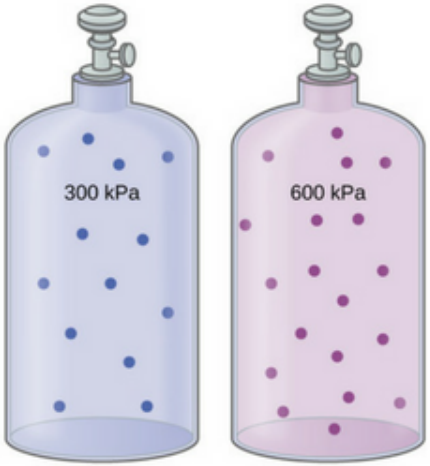




Substrate temperature



composition of the reaction gas mixture



total pressure gas flows

Advantages & Disadvantages of CVD

Versatile – can deposit any element or compound

High Purity (~99.99%)

High Density – (~100% of theoretical)

Material formation well below Tm

Coating deposited conformal and near net shape

Economical in production

Expensive starting materials (reactants)

Easily oxidized (particularly when producing non oxide powder)

SiO_2

$SiH_4 + O_2 \rightarrow SiO_2 + 2H_2$ at $400 - 500^oC$

Si_3N_4

$3SiH_4 + 4NH_3 \rightarrow Si_3N_4 + 12H_2$ at $700 - 900^o$ C

$3SiCl_4 + 4NH_3 \rightarrow Si_3N_4 + 12HCl$ at 850^o C

$3SiH_2Cl_2 + 4NH_3 \rightarrow Si_3N_4 + 6HCl + 6H_2$ at $650 - 750^oC$

Distance in the direction of gas flow

Pressure

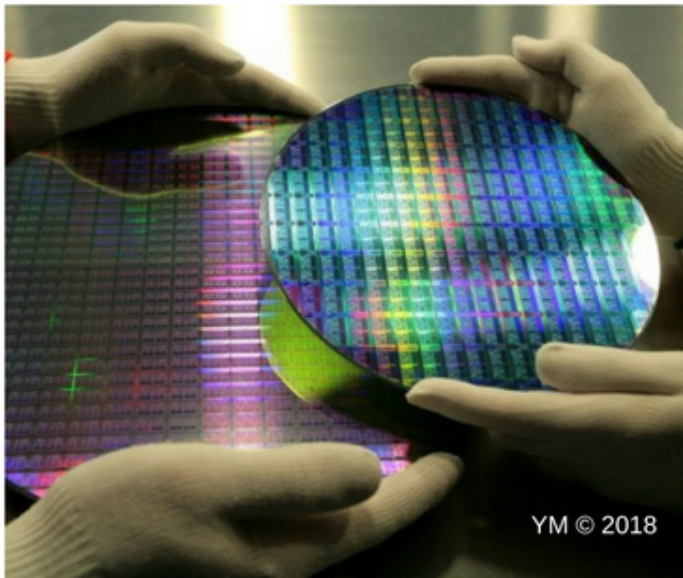
Temperature

Velocity of carrier gas

Better performance can be achieved by either increasing T and gas flow or by reducing pressure and gas velocity

However, increase in T ➡ adverse effect on the substrate due to incompatible CTE of the deposit and substrate

Reducing gas velocity ➡ non-uniformity of the deposition



Applications of CVD

Optical Fibres for telecommunication

Synthetic diamond

Novel powders production

Applications of CVD

Gallium arsenide is used in some photovoltaic devices

Integrated circuits, sensors and optoelectronic devices.

Coatings for wear resistance, corrosion resistance, high temperature protection, erosion protection and combinations thereof