Physical Vapor Deposition

Physical ejection of material (atoms, ions) and condensation and nucleation on top of material to be coated

Physical ejection by

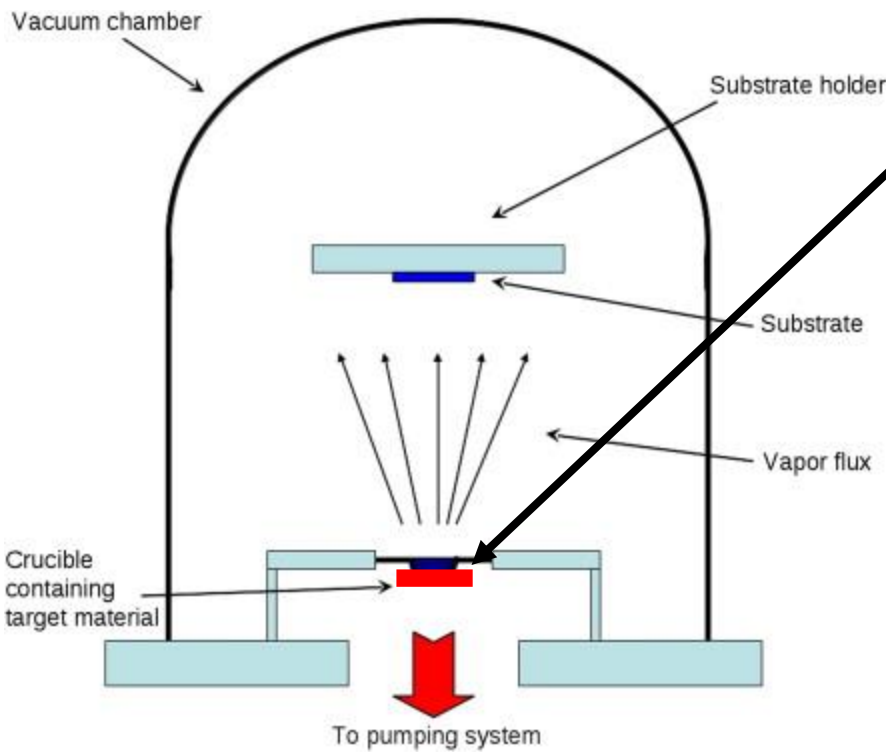
- Heating – Thermal, E-beam
- Sputtering – RF, DC
- Ion implantation

Chemical reaction is possible by maintaining reactive gas atmosphere

Applications

1. This process is widely used to produce decorative coatings on **plastic parts those are resembling shiny metal**.
2. Many automobile parts are plastic with a PVD coating of aluminium.
3. A lacquer coating is applied over the decorative coating to provide corrosion protection.
4. This process is also used to apply relatively **thick (1mm) coatings** of heat resistant materials on jet engine parts, A special alloy of chromium, aluminium and yttrium is used for this type of coating.

Thermal Evaporation



Heating by
- Direct resistive heating
- In-direct Resistive heating
- Induction heating
- Laser Ablation

Evaporated material in vapor form is condensed on top of substrate (surface to be coated)
Vacuum is maintained to avoid unnecessary reactions

1-100 µm thick coating

Eg. Metal evaporated in vacuum leads to metal coating,
Metal evaporated with particular oxygen atmosphere leads to metal oxide coating (Reactive Thermal Evaporation)

Thermal Evaporation

- Requirement – coating materials should have low melting point, high vapor pressure in given temperature e.g. Al, Au can be coated
- W, Ti cannot be coated → higher melting point (low vapor pressure)
- Purity ==> source materials purity and vacuum

Advantages

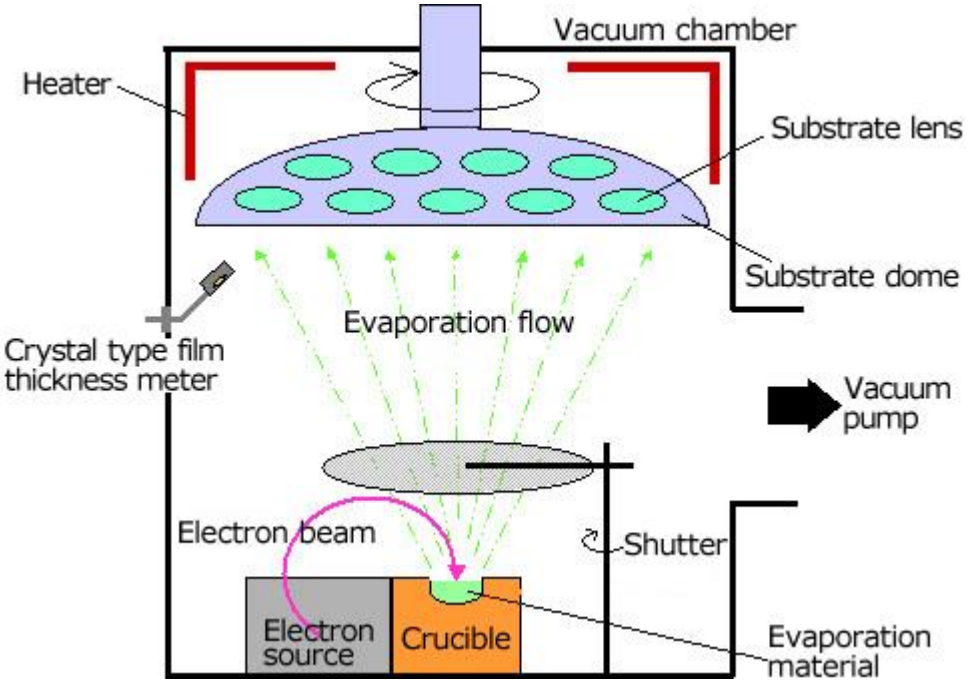
Simple and cheap, excellent purity, less surface damage on the substrate

Disadvantages

Limited to materials with low melting point, filament limits the materials that can be deposited (temperature)

E-beam evaporation

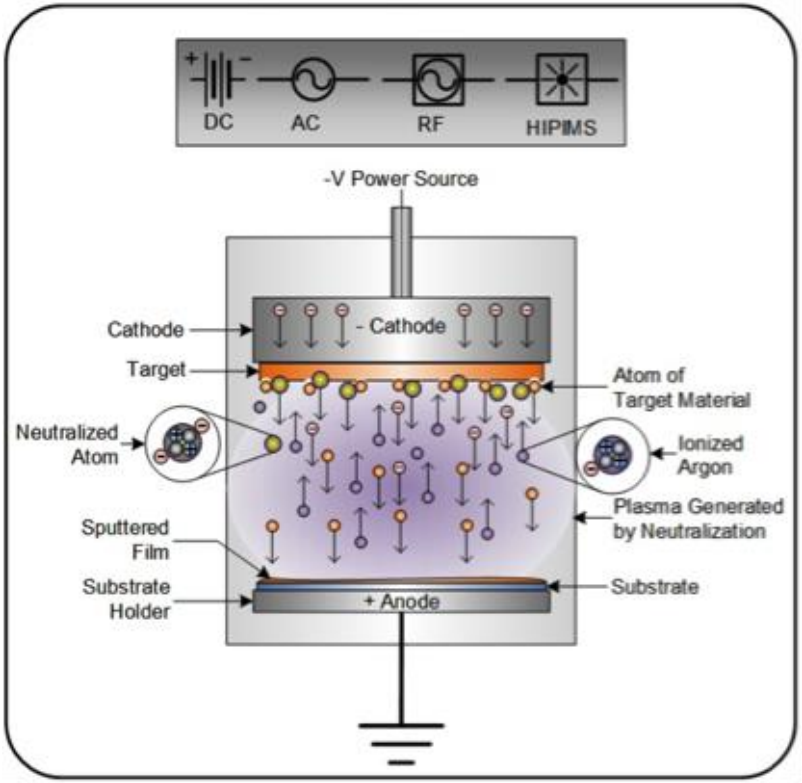
- Target anode is bombarded with electron beam – charge tungsten filament under high vacuum
- Atoms transformed to gaseous phase due to the electron beam and deposited on top of heated substrate (materials to be coated)



Advantages – higher deposition rate
Disadvantages – Filament degradation due to non uniform evaporation of the material

Sputtering

A popular **method for adhering thin films on to a substrate**. Sputtering is done by bombarding a target material with a charged gas (typically argon) which releases atoms in the target that coats the nearby substrate.
It all takes place inside vacuum chamber under low pressure.



Applications

- Sputtering is used extensively in the semiconductor industry to deposit thin films of various materials in integrated circuit processing.
- Thin anti reflection coatings on glass for optical applications are also deposited by sputtering.
- An important advantage of sputter deposition is that even materials with very high melting points are easily sputtered.
- Deposited films have a composition close to that of the source material.

Ion Implantation Method

1.A third variation of the **PVD process is ion implantation** .

2.Metal is evaporated thermally and plasma is established to ionize the evaporating species

3.Evaporant ions bombard the substrate with energy

4.They physically implant into the **substrate to produce an extremely strong coating bond.**

5.Sputter and ion plated coatings are used in **design for very thin films for electrical, optical and wear-resistant applications**.

6.The wear properties of tools are **widely enhanced by hard thin film coatings.**

Ion Implantation

1. The common systems in use are ion implantation, laser treatment and electron beam treatment.

2. In ion implantation ions of specific element with sufficient energy are impinged on the surface of a material with sufficient energy.

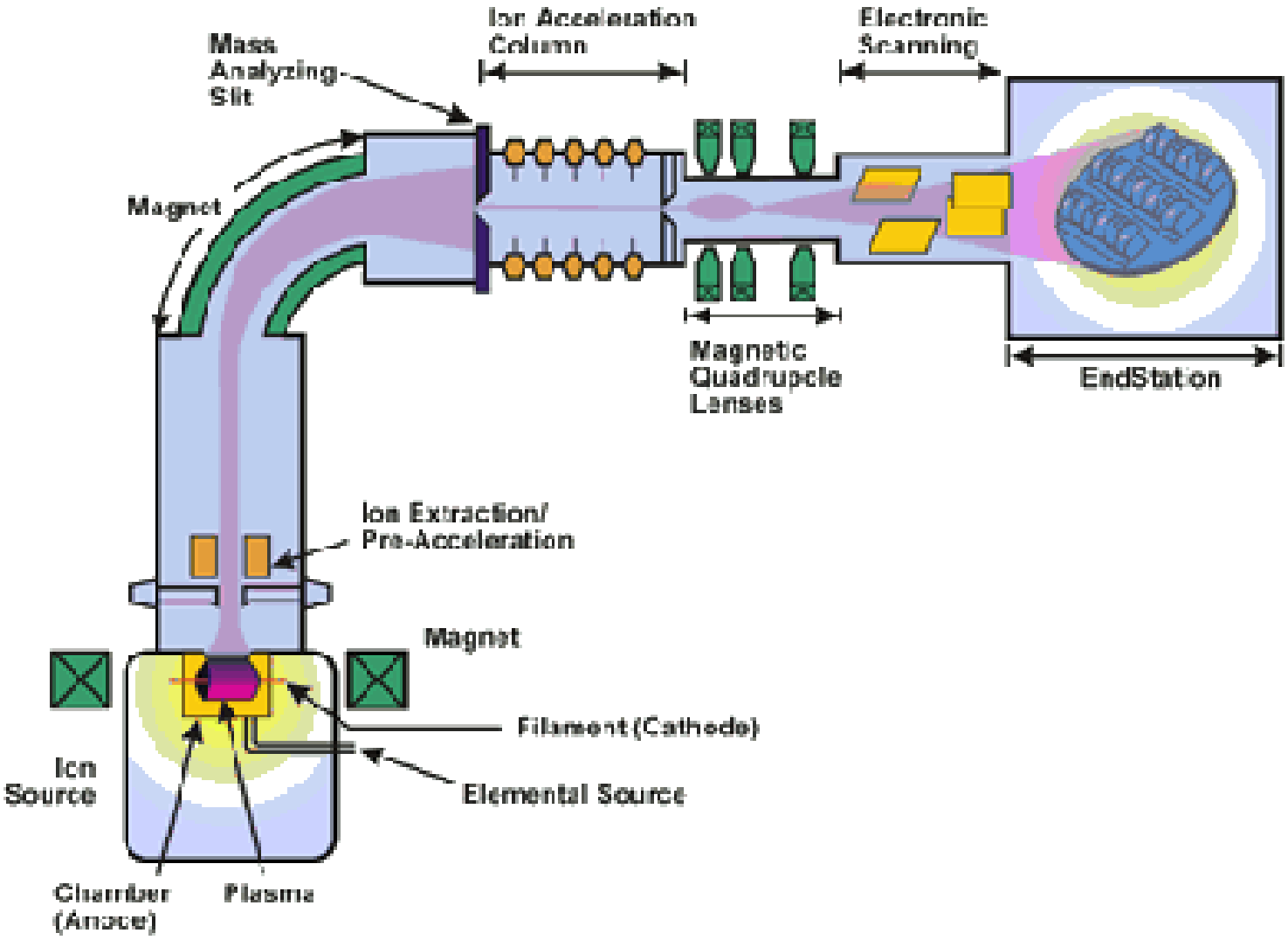
3. The ions so impinged are embedded into the atomic lattice of substrate. This process is performed in a vacuum chamber.

4. Usually ion gun produce the ions. It is done by passing the gas through an electron beam or plasma. The gas atoms on collision with the electron beam or with the species in plasma become ions.

5. The ions are accelerated by an applied magnetic field. These ions impinge on the work surface. The surface of the metal is hardened by creating atomic defects or misfits by the impinged ions.

6. The depth of implantation is usually about 0.1μm. However, the sphere of influence is much deeper, may be a micrometer.

Ion Implantation



PVD applications

Coating	Hardness (HV)	Colour
Titanium nitride	2900	gold
Zirconium nitride	2800	gold
Titanium aluminum nitride	2600	brown
Titanium carbonitride	4000	silver
Chromium nitride	2500	silver
Amorphous diamond like carbon	1000 – 5000	black