# Physical vapor deposition – Evaporation

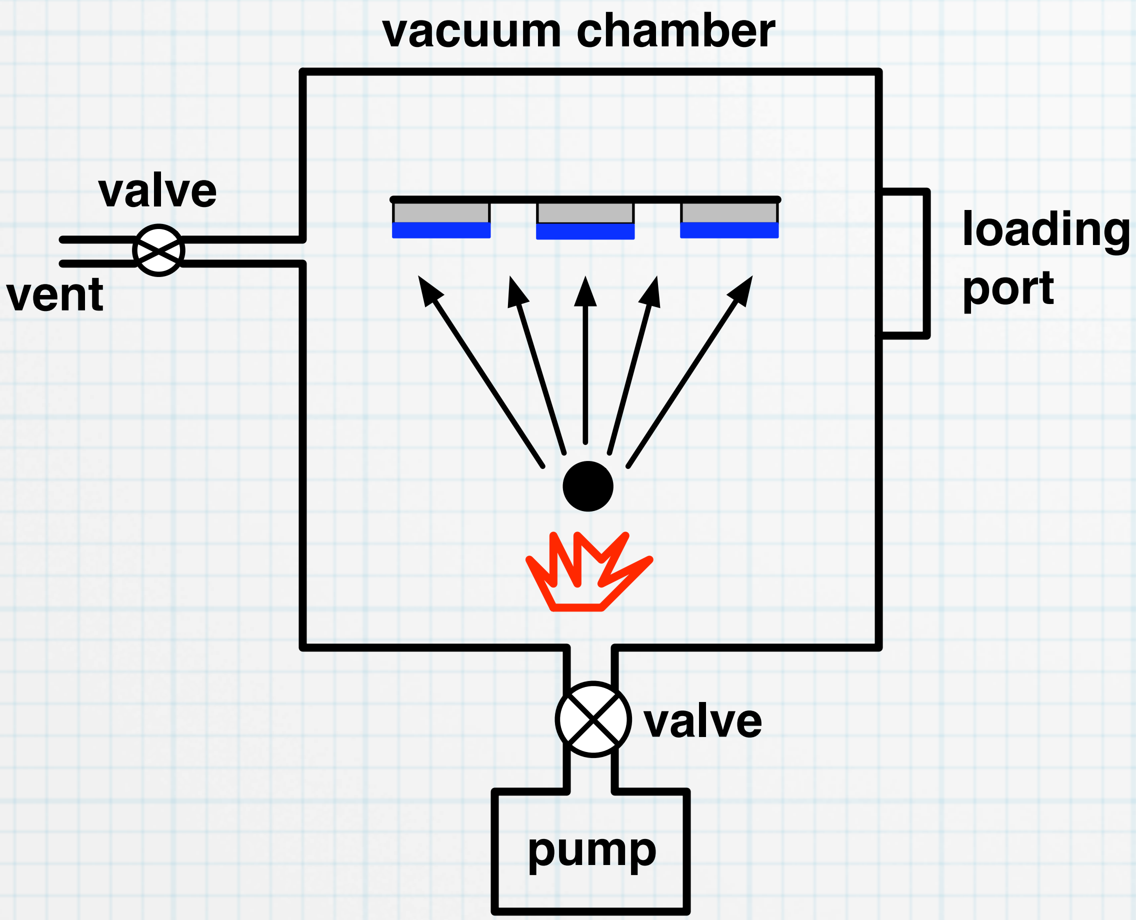
Used to deposit thin layers (thin films) of metal on a substrate.

Analogy: Water transporting from the hot shower to cooler surfaces like the mirror and windows. (The analogy breaks down in considering how the water gets from one place to the other. In the shower room, the movement is by diffusion through the air.)

Some metals films that are easily deposited by evaporation:

- aluminum
- chrome
- gold
- silver
- titanium

# Generic evaporation system




Basic vacuum chamber ($P \approx 10^{-6}$ Torr; $\lambda >>$ chamber dimensions.)

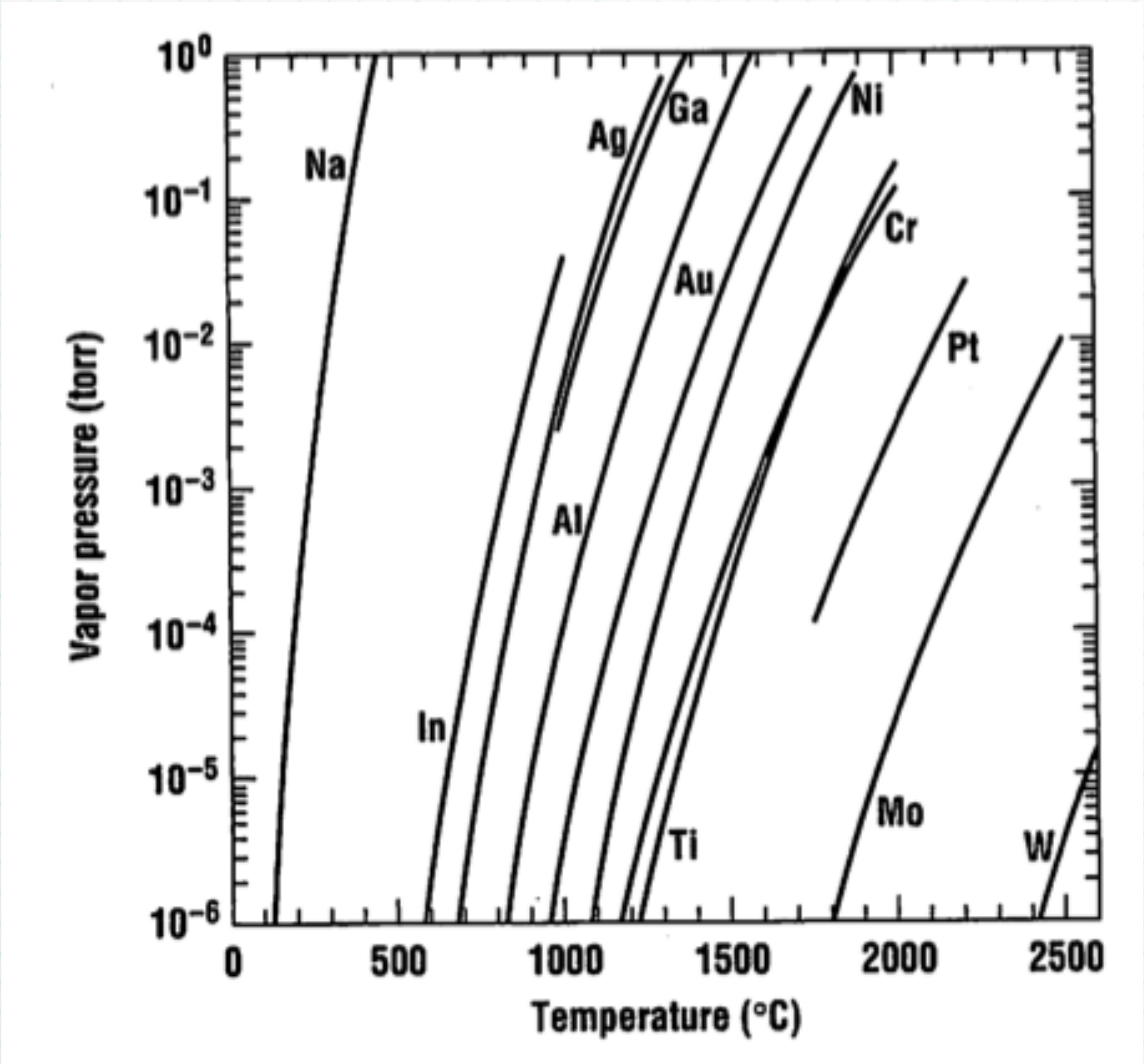
Substrates are loaded, facing down.

A source of the metal to be evaporated is located below the wafers.

The source is heated to the point where it will evaporate.

The vapor condenses on the cool substrates (and chamber walls).

# Vapor pressure curves

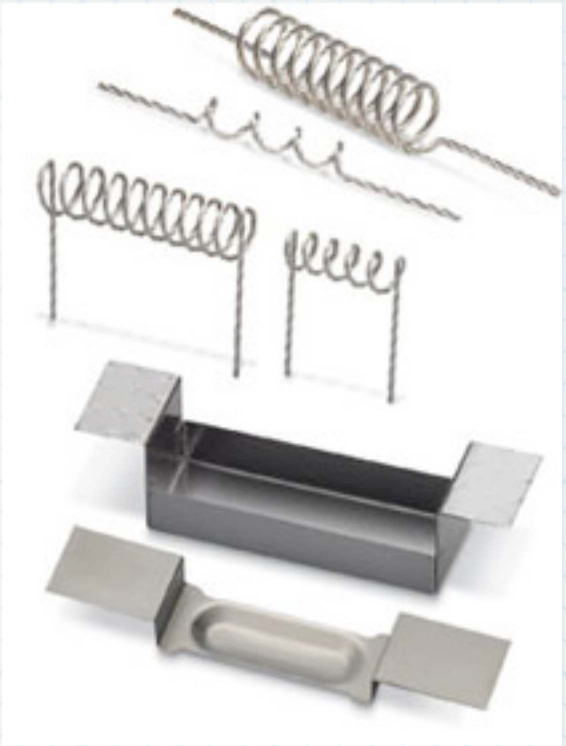


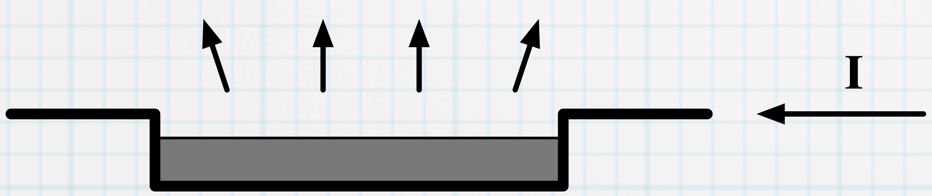

In order to be able to evaporate a material effectively, it must have a high *vapor pressure* at a reasonable temperature. (Recall that pressure is equivalent to flux.)

# Heating the source

It is necessary to heat the source material to temperatures ranging from a few hundred degrees to well over one thousand degrees.  The method of heating must be compatible with a high-vacuum environment.

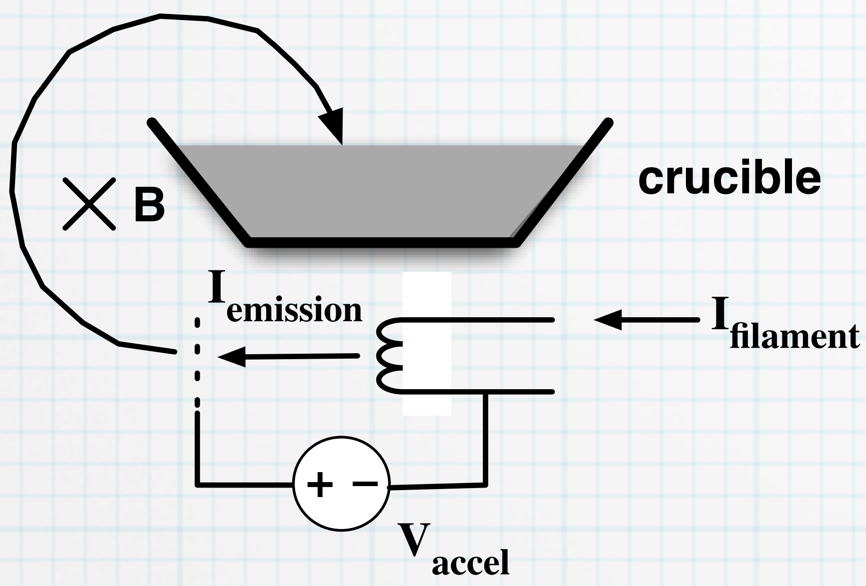
The simplest methods employs what is known as <u>thermal evaporation</u>.  The metal to be evaporated is loaded into a wire basket or a metal "boat" – usually made of tantalum.  A large current passes through the holder, heating it resistively.  At sufficiently high temperature, the source material will begin to evaporate.






Thermal evaporation is a very simple process and is easy to implement.  However, it can be difficult to control the rate of evaporation.  Also, the source needs to be replenished frequently and the boats don't last very long.

# Electron-beam heating (e-beam evaporation)




The source material is placed in a crucible (usually made of graphite).

A filament underneath the crucible is heated by running a large current through it (≈ 100 A).

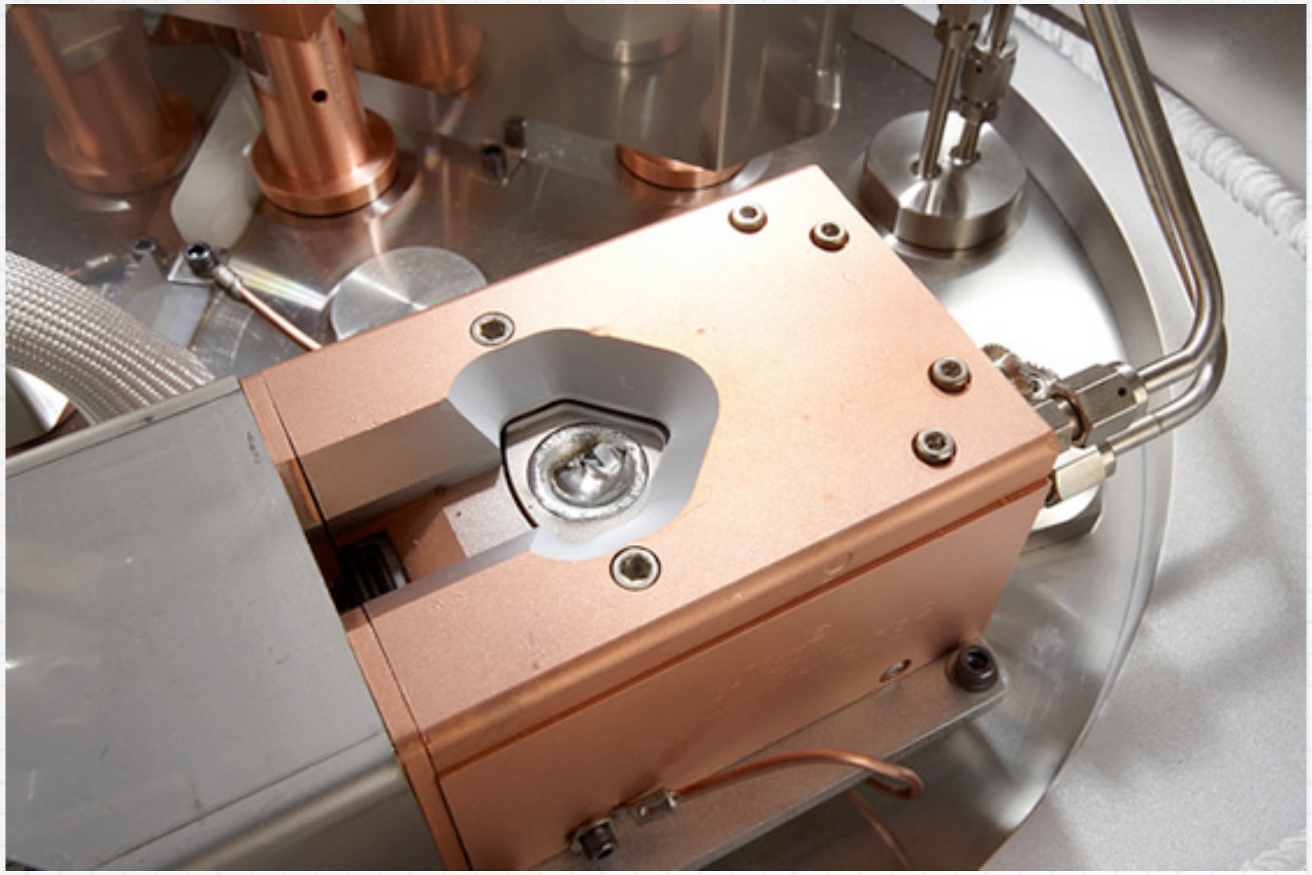
Some electrons in the hot filament will have enough energy that they can escape, leading to an emission current of a few mA. (Thermionic emission.)

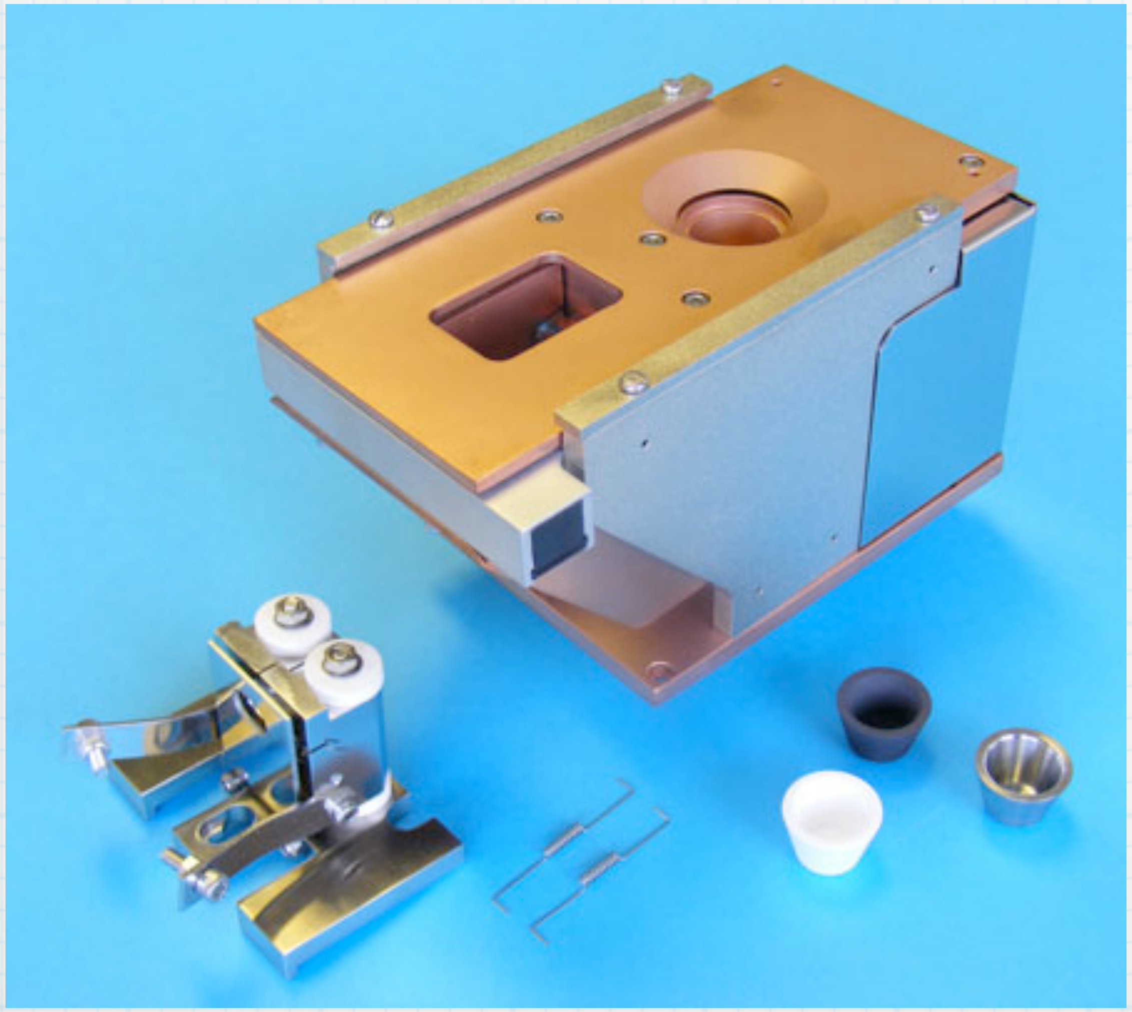
e-beam heating provides several advantages:

- small spot size that can be swept
- good control over emission current
- large reservoir of source material.

The emitted electrons are accelerated, ($V_{accel}$ ≈ 10 kV.)

and then twisted by a magnetic field, slamming them into the source material, heating it up to evaporation temperatures.






EB 900 Series


Planetary E-Beam Evaporating System(Metal)