

Physical Vapor Deposition

PVD

- Deposition of a material in the vapor phase onto a solid in a vacuum.

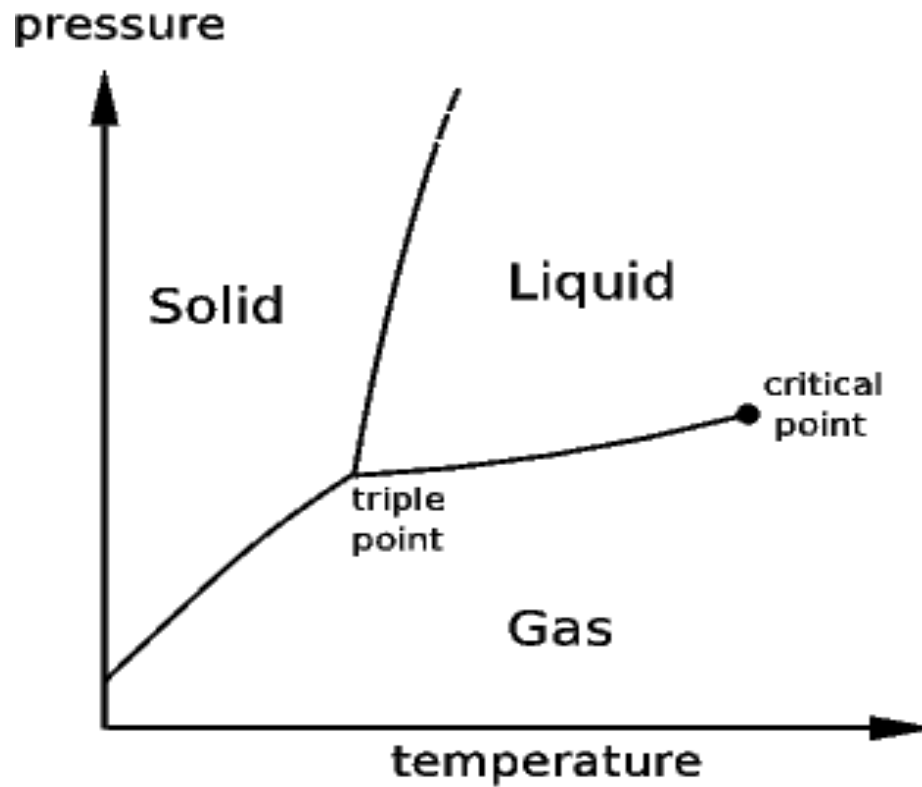
PVD Applications

- Optical coatings: Filters, Mirrors, Anti-reflection Films
- Semiconductors, Integrated Circuits, Solar Cells
- Cutting Tool Coatings
- Thermal, Diffusion Barriers
- Reflective, Decorative Coatings

Vapor Pressure

- The pressure of the vapor resulting from evaporation of a liquid or solid in a closed space. Vapor pressure increases with temperature.

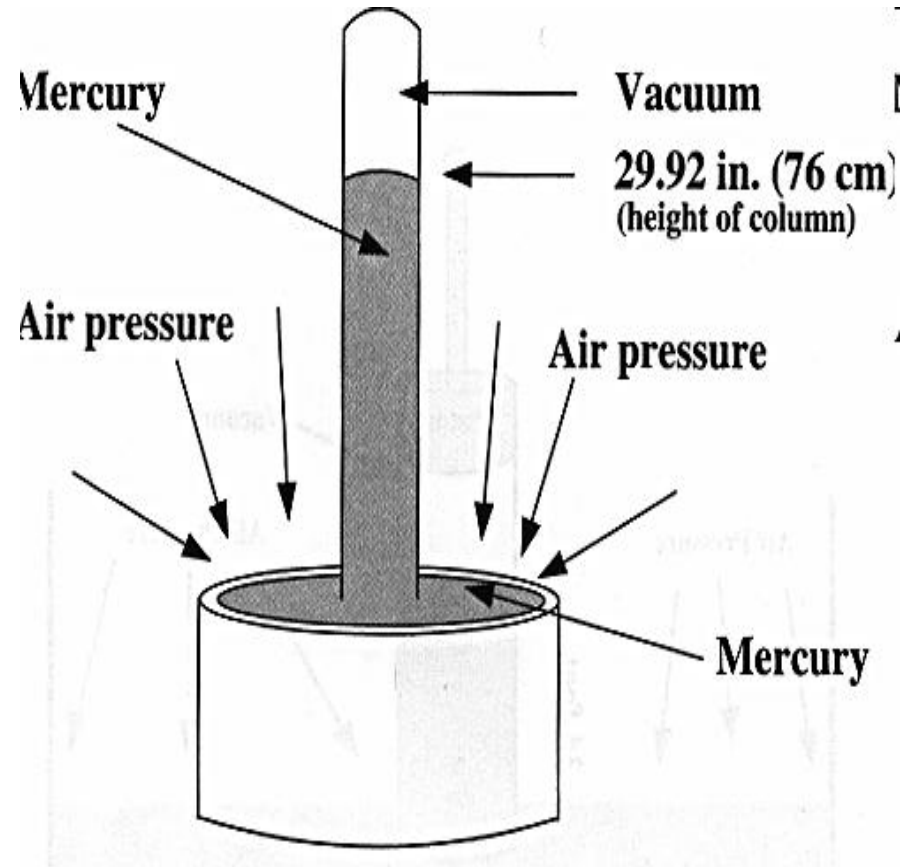
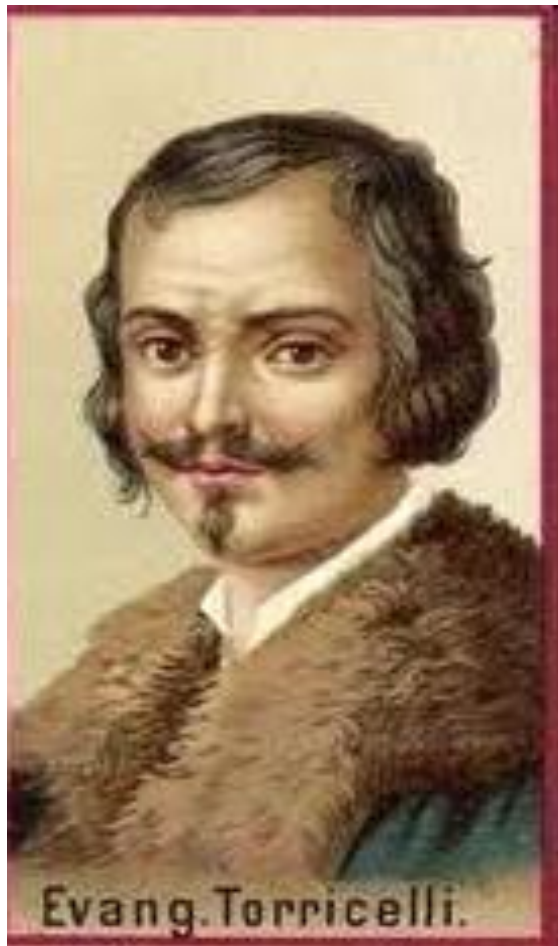
Phase Diagram



Vacuum

- History
- Units
- Pumps
- Measurement

Evangelista Torricelli



Vacuum Units

- Torr = 1 mm-Hg = 1.33 millibar
- Atmosphere = 760 Torr
29.9 in-Hg
1.01 bar
100 kPascal

Vacuum Ranges

LV - 760 to 10^{-3} Torr

HV - 10^{-3} to 10^{-8} Torr

UHV - 10^{-8} to 10^{-12} Torr

Vacuum in Space

- 200mi = 10^{-8} Torr
- 400mi = 10^{-10} Torr
- Deep space = 10^{-16} Torr

Mean Free Path (MFP)

Average distance between collisions for a gas molecule

Pressure (Torr)	MFP (Inches)
10^{-2}	0.2
10^{-3}	2
10^{-4}	20
10^{-5}	200

Vacuum Pumps

- Transfer Pumps
- Entrapment (Capture) Pumps

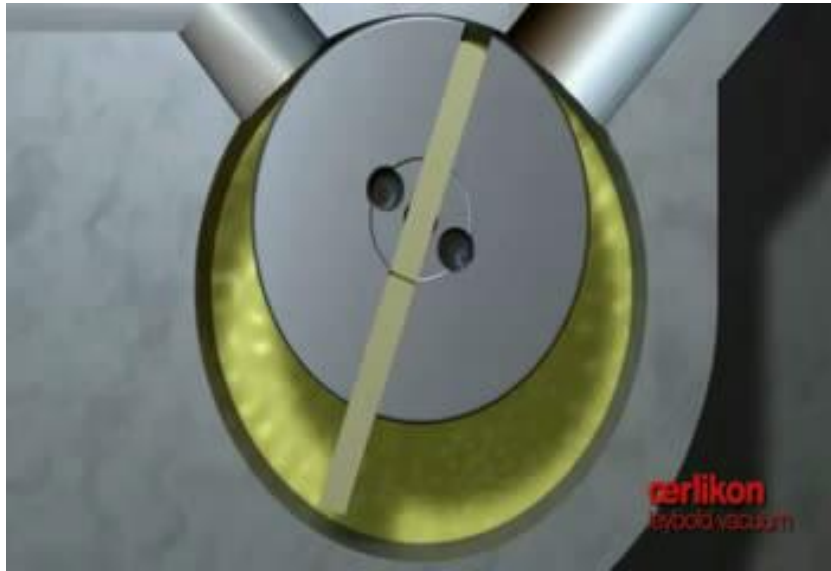
Transfer Pumps

Positive Displacement

10^{-2} Torr

Rotary Vane

Scroll



Transfer Pumps

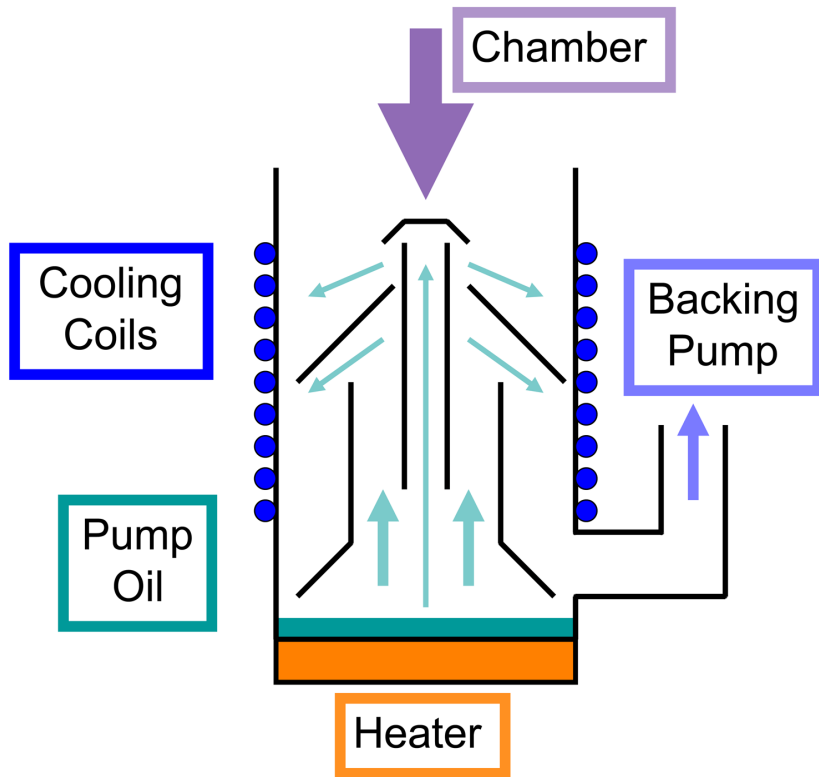
Momentum Transfer

Diffusion

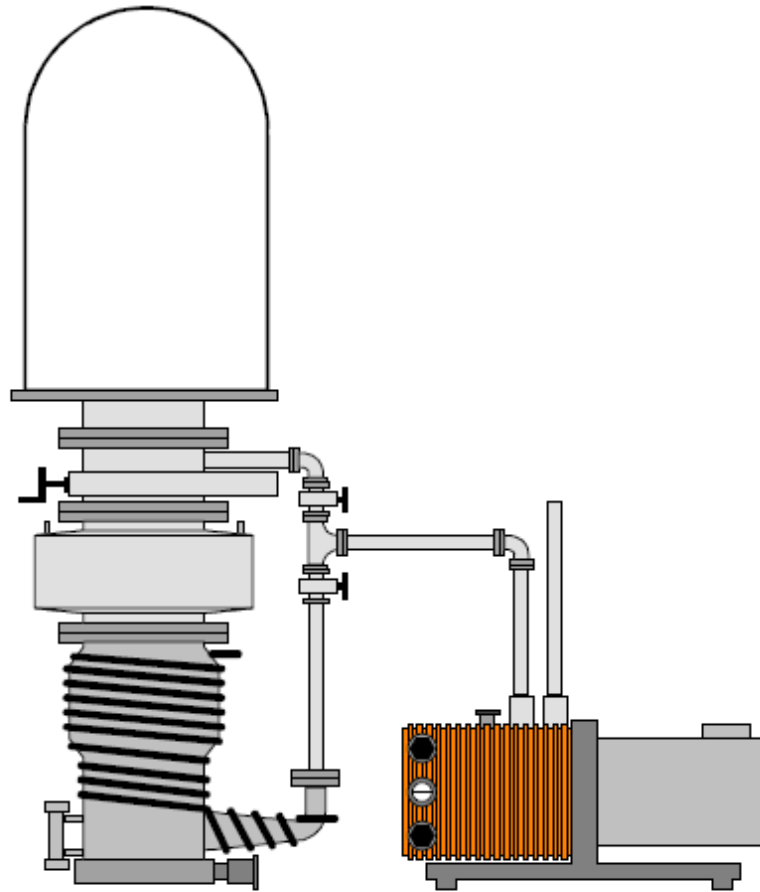
Turbomolecular

Diffusion Pump

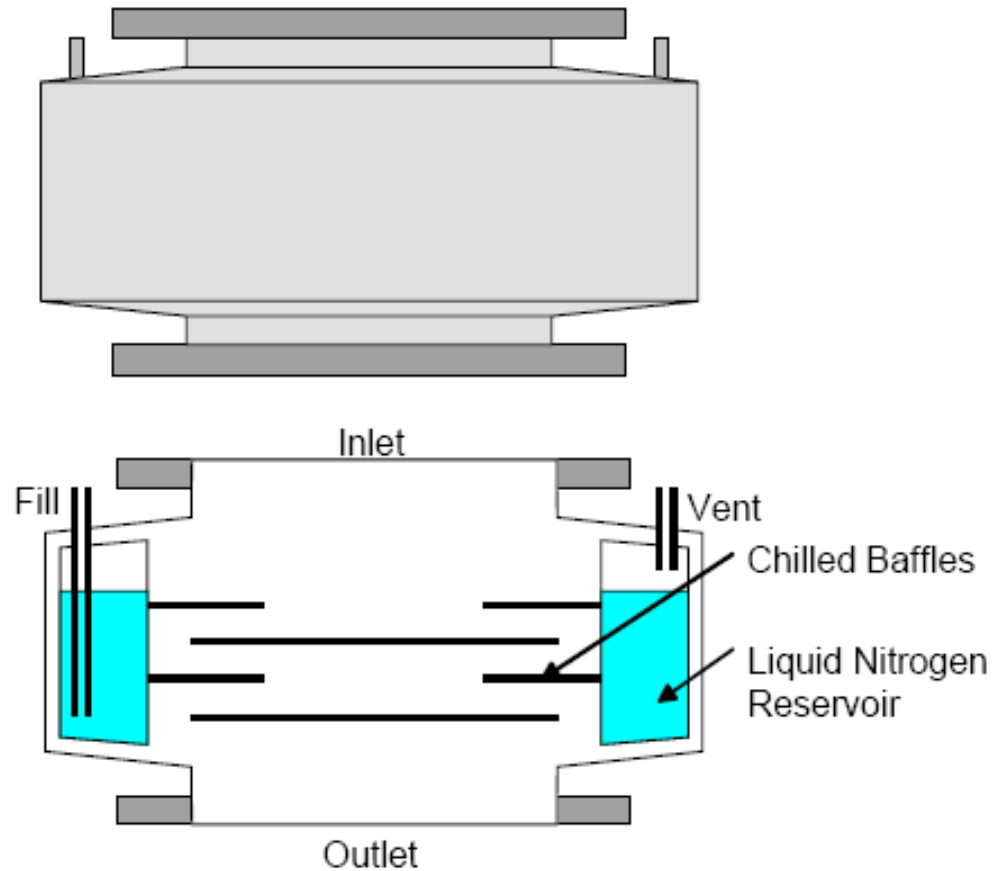
10^{-7} Torr



Diffusion Pump System

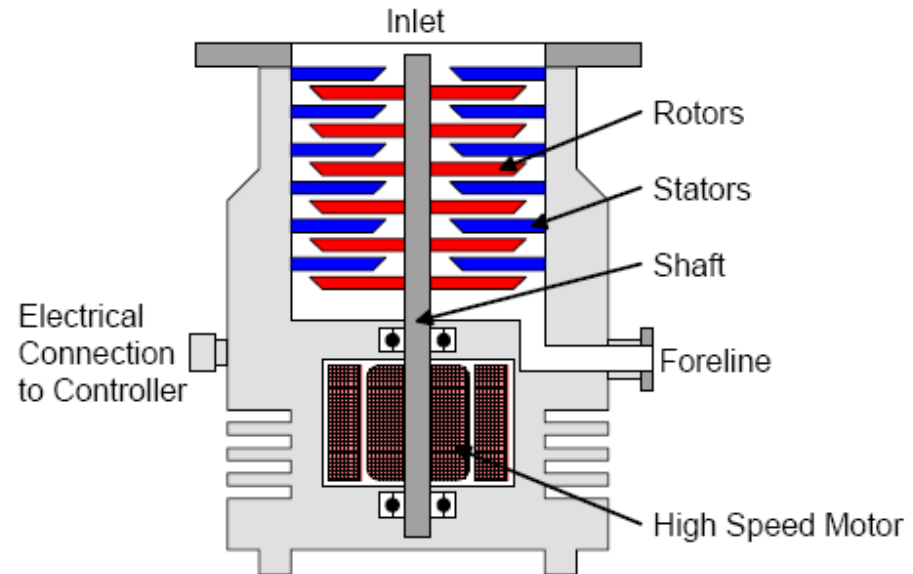


Cold Trap/Cryotrap

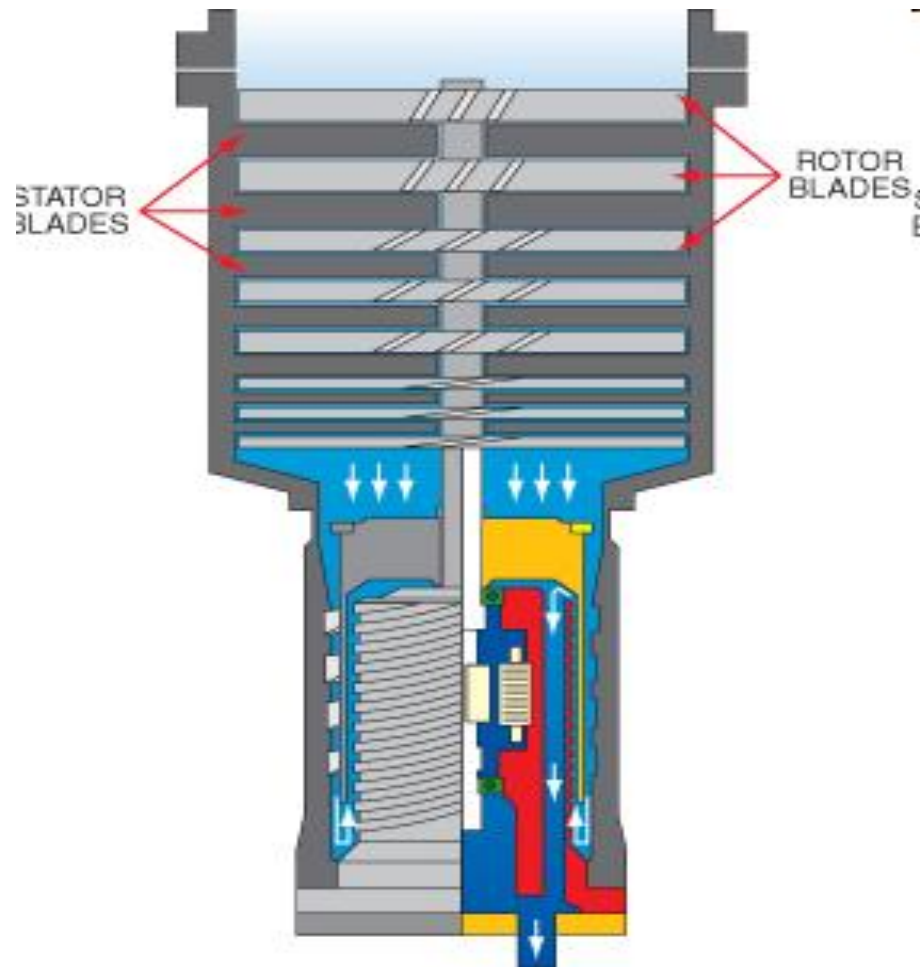


Turbomolecular Pump

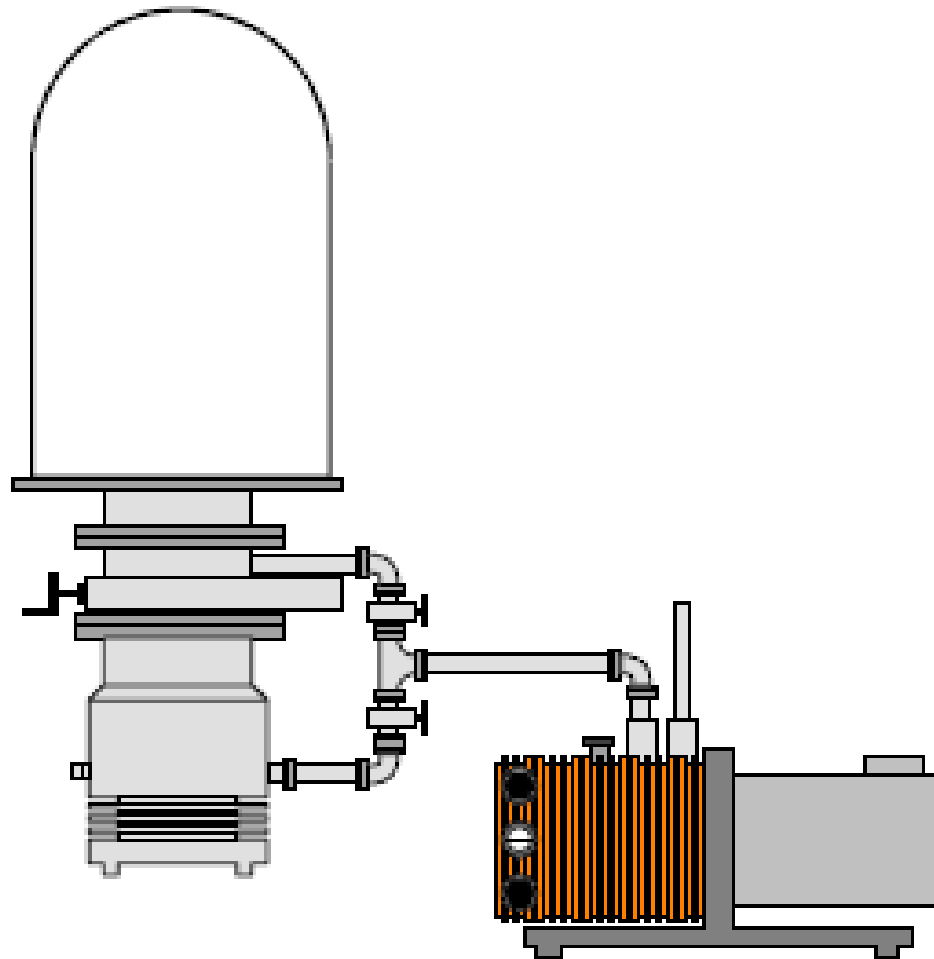
10^{-10} Torr



Turbodrag Pump



Turbopump System



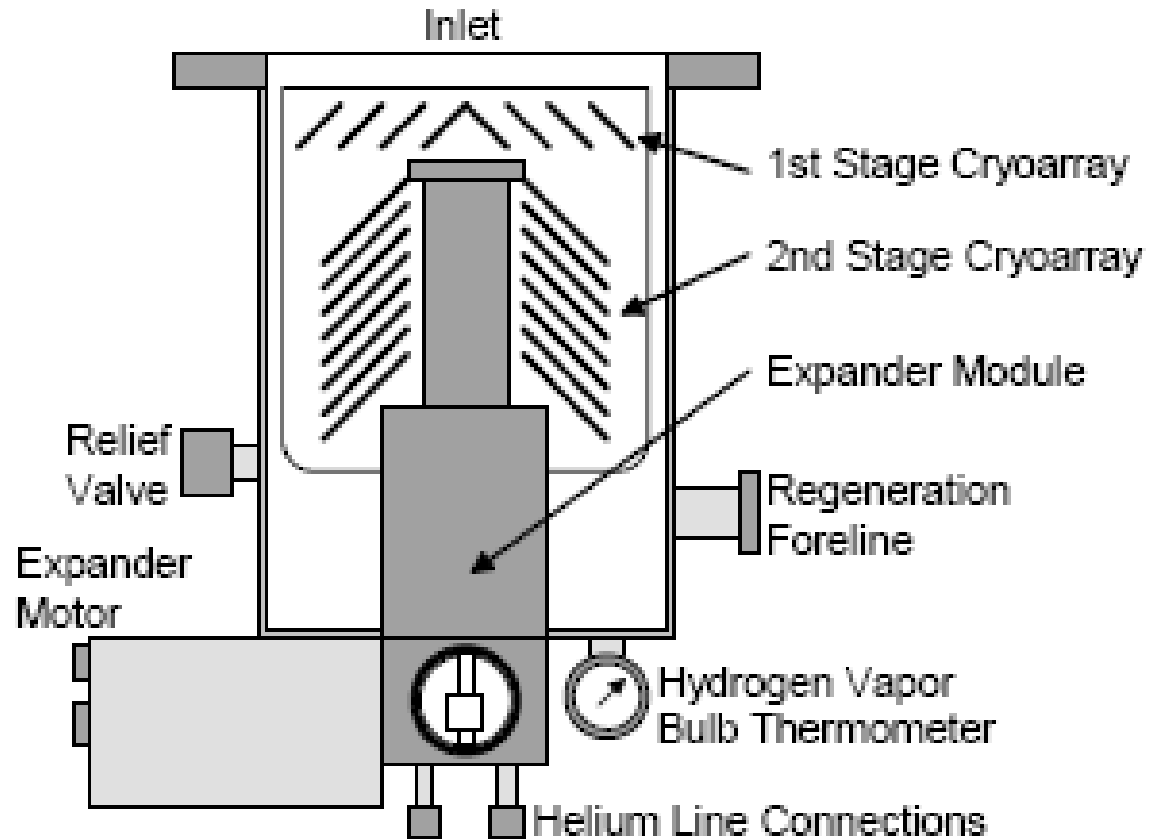
Entrapment (Capture) Pumps

Cryopump

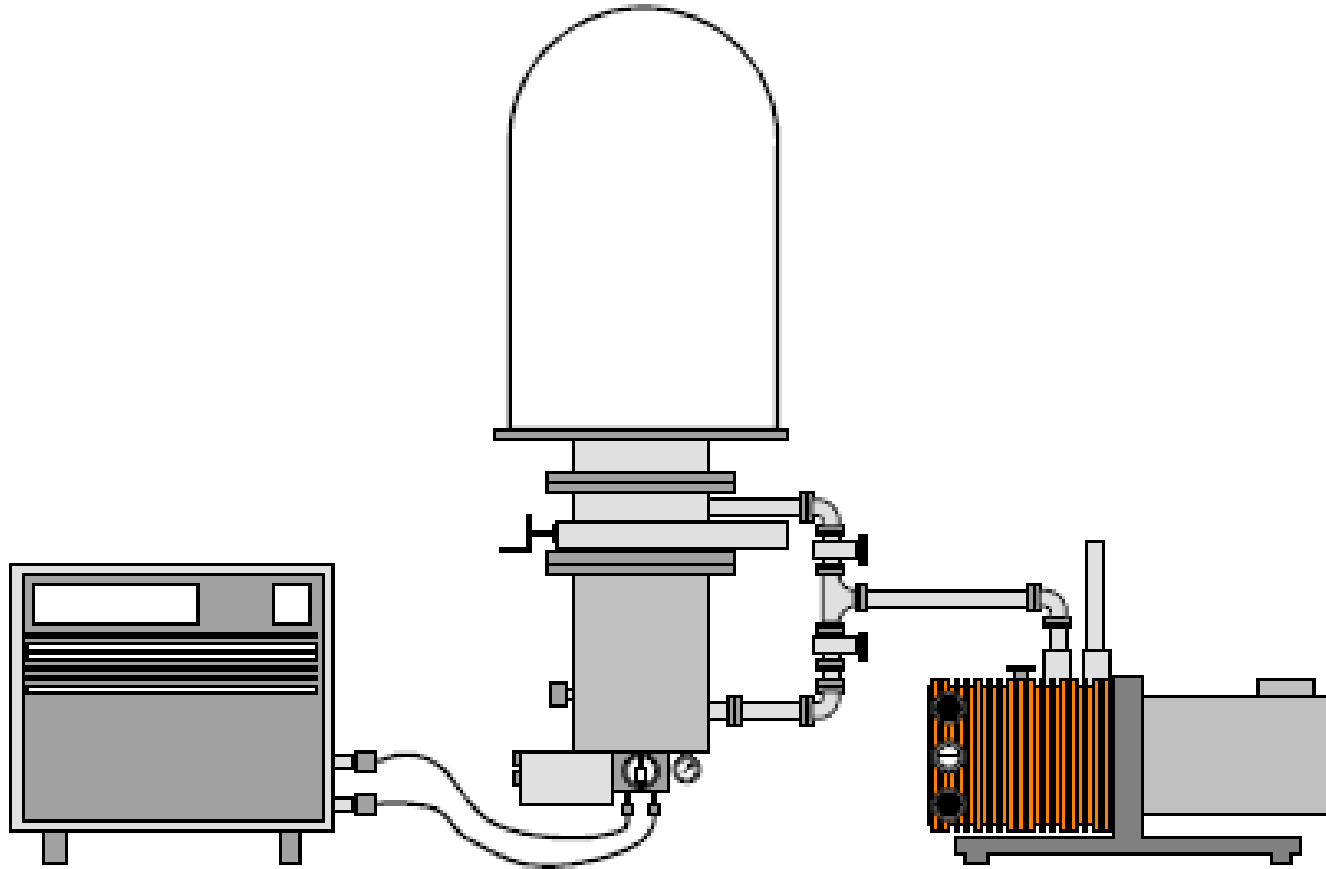
Sputter Ion Pump

Cryopump

10^{-9} Torr

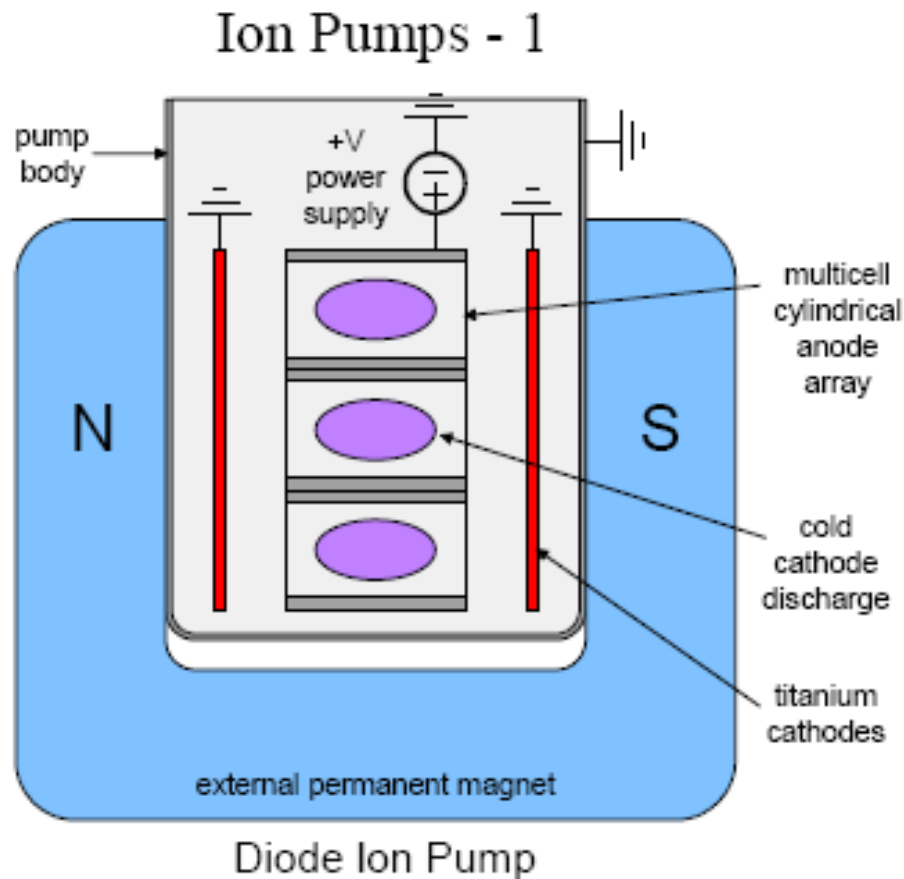


Cryopump System



Sputter Ion Pump

10^{-11} Torr



Vacuum Gauges

- Bourdon
- Manometer
- Capacitance manometer (Baratron)
- Thermocouple
- Ionization
 - Cold Cathode (Penning, Magnetron)
 - Hot Cathode (Bayard-Alpert)

Bourdon Gauge

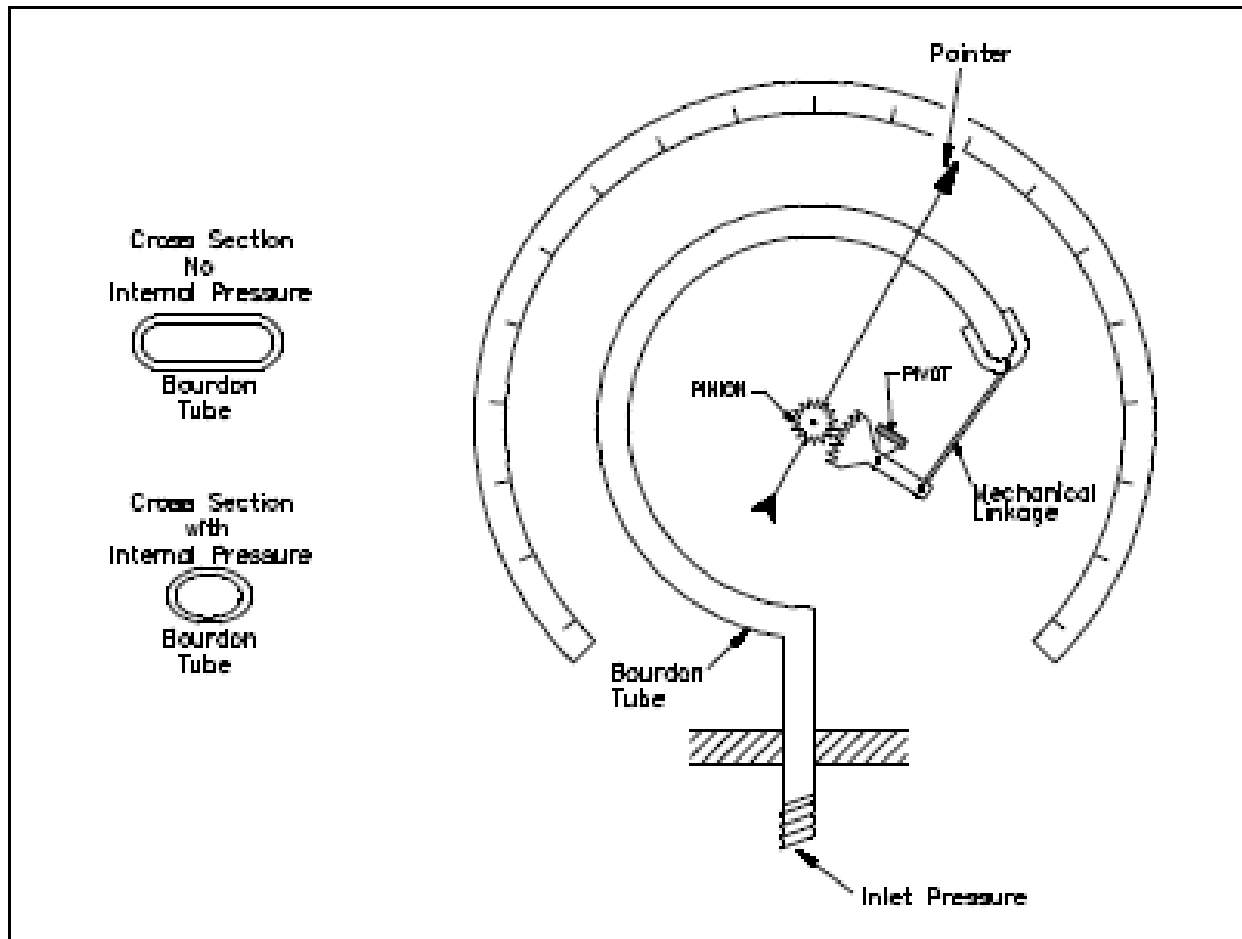
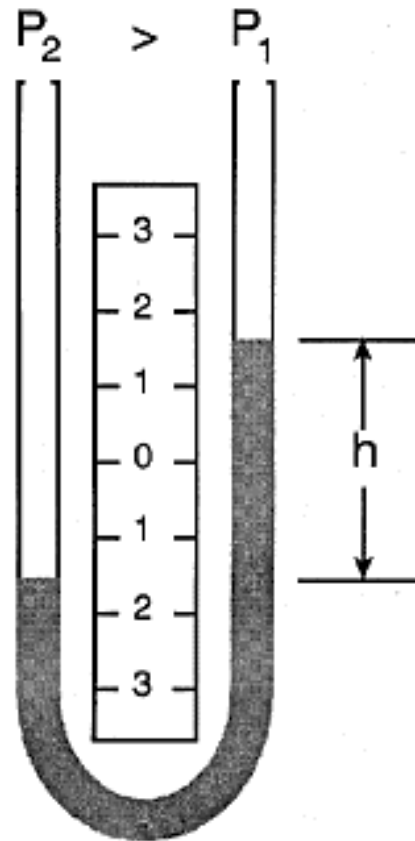


Figure 2 Bourdon Tube

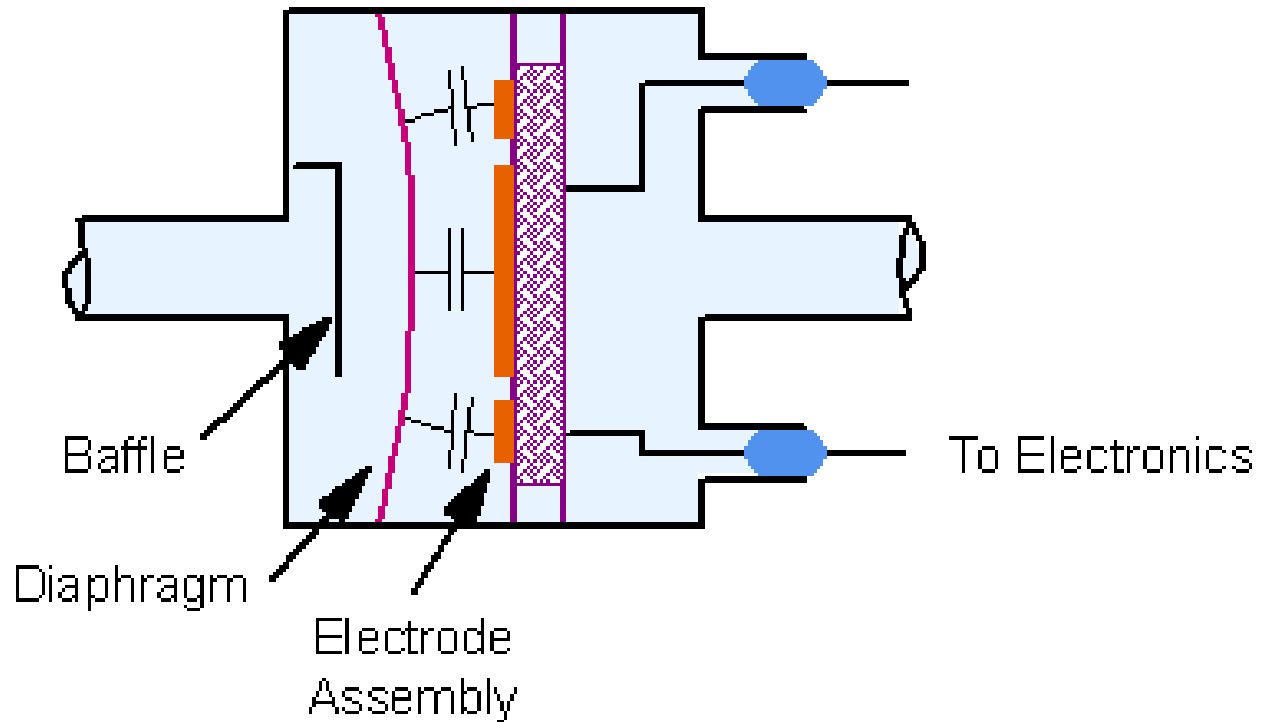
Manometer



McLeod Gauge

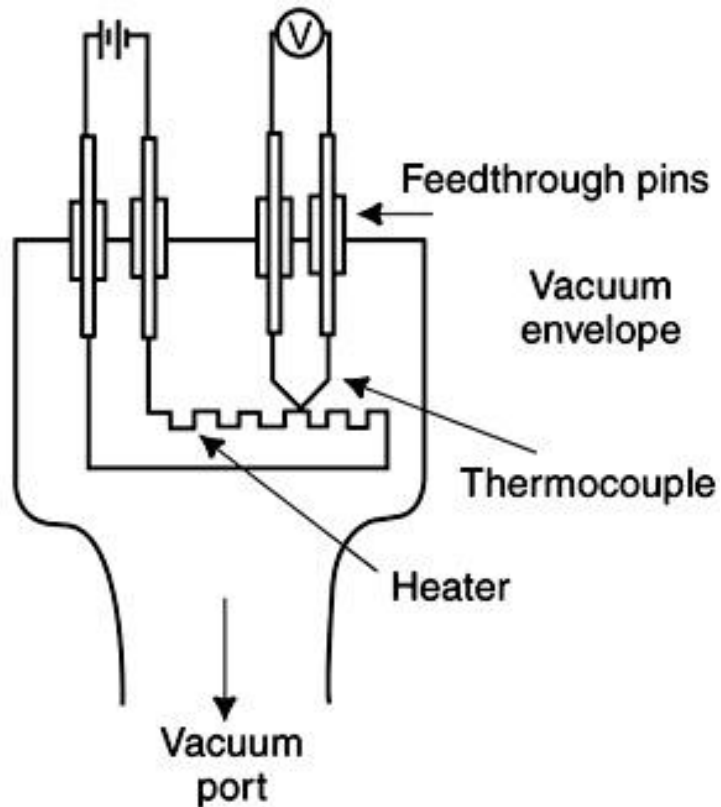


Capacitance Manometer Baratron



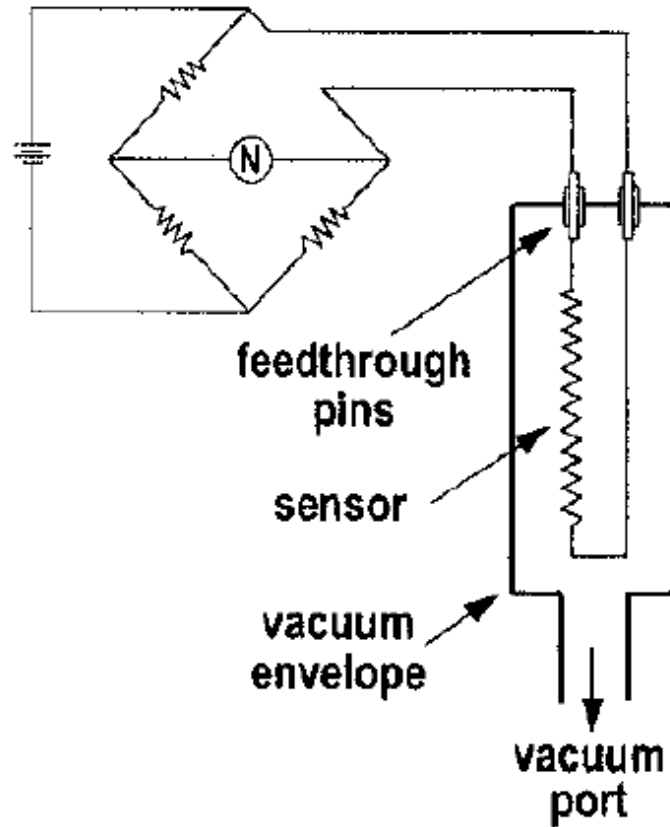
Thermocouple

Atmosphere to 10^{-4} Torr



Pirani Gauge

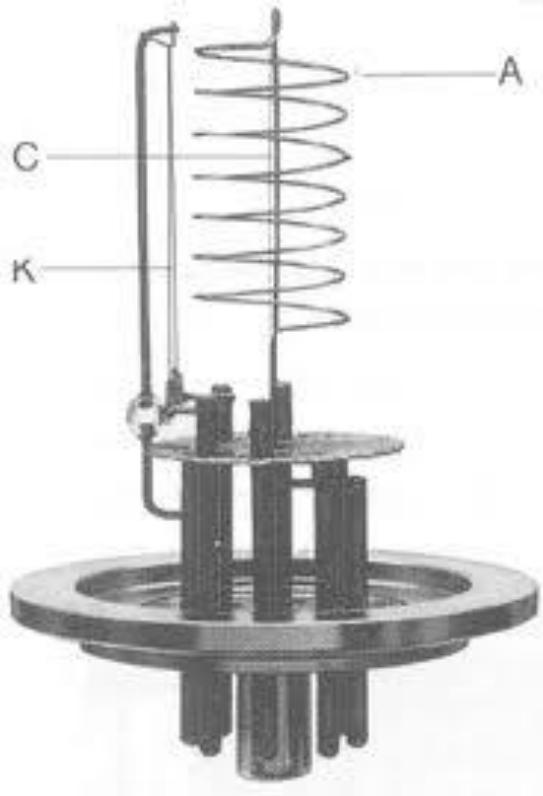
0.5 Torr - 10^{-4} Torr.



Ionization Gauge

Hot Cathode (Bayard-Alpert)

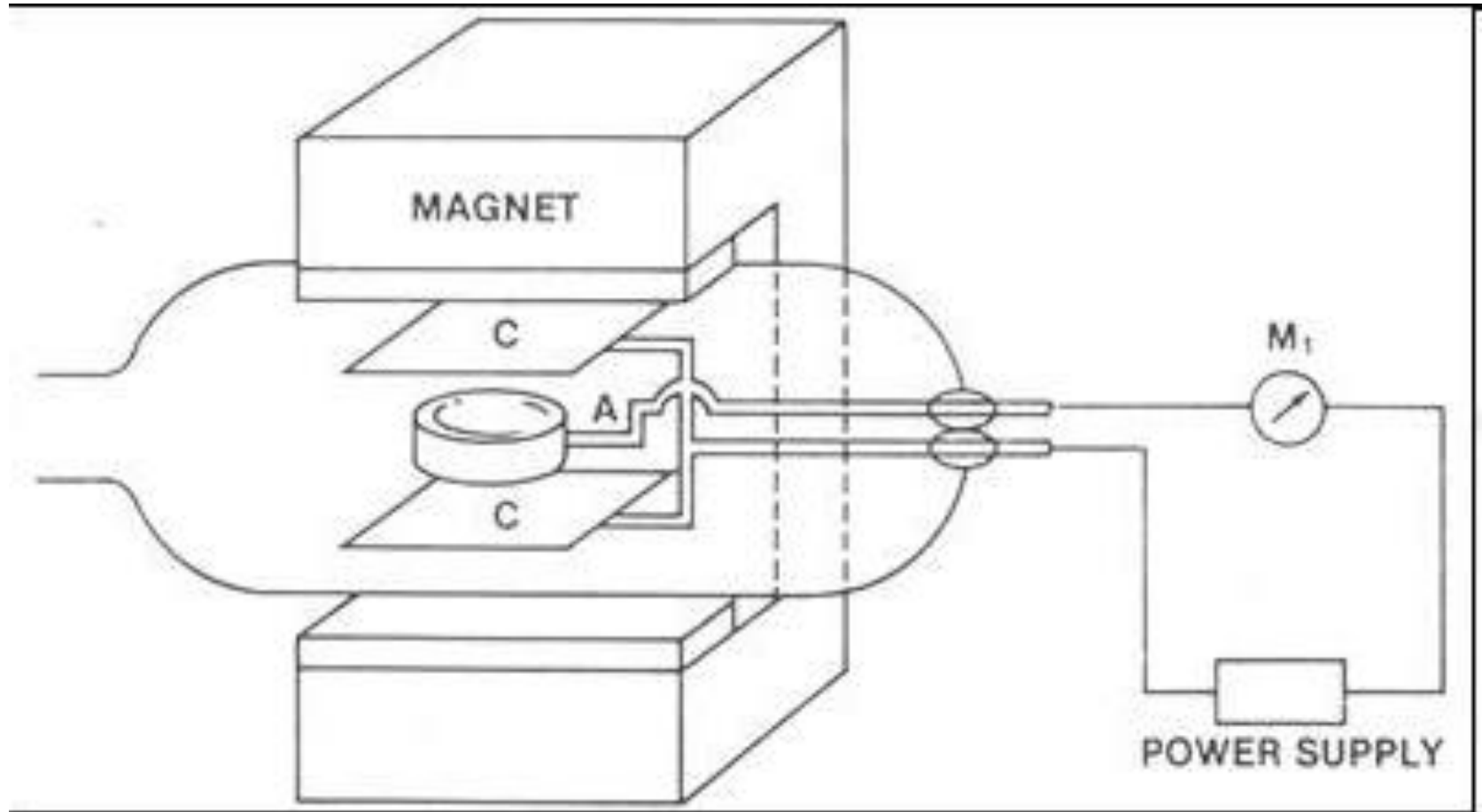
$10^{-3} - 10^{-10}$ Torr



Ionization Gauge

Cold Cathode

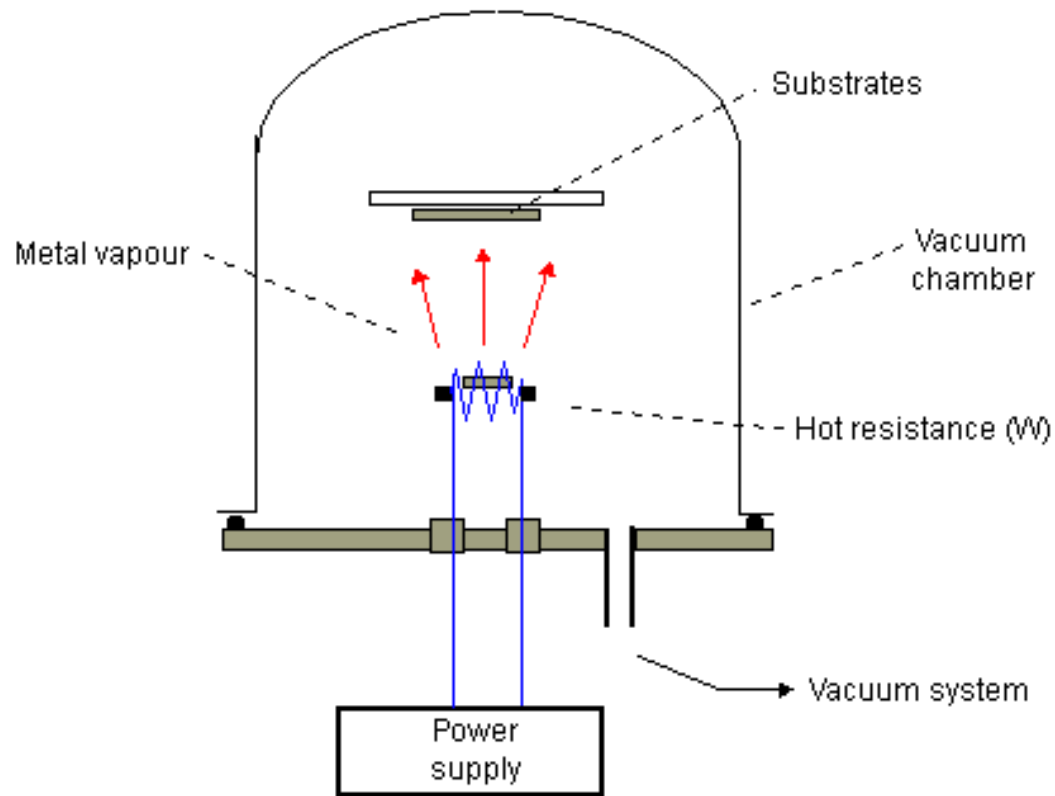
$10^{-3} - 10^{-12}$ Torr



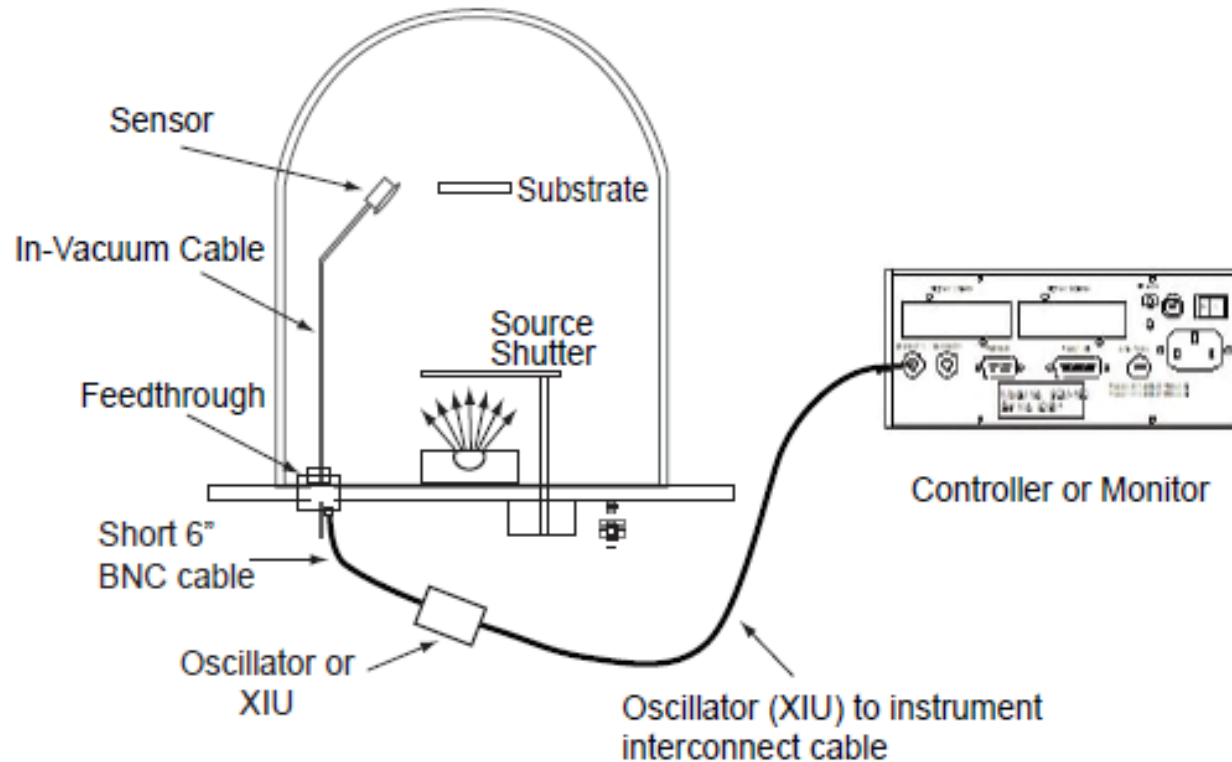
Vapor Source

- Thermal Evaporation
 - Resistive Heating
 - E-Beam Heating
 - Laser Ablation
 - Cathodic Arc
- Sputtering
- Ion Beam Deposition

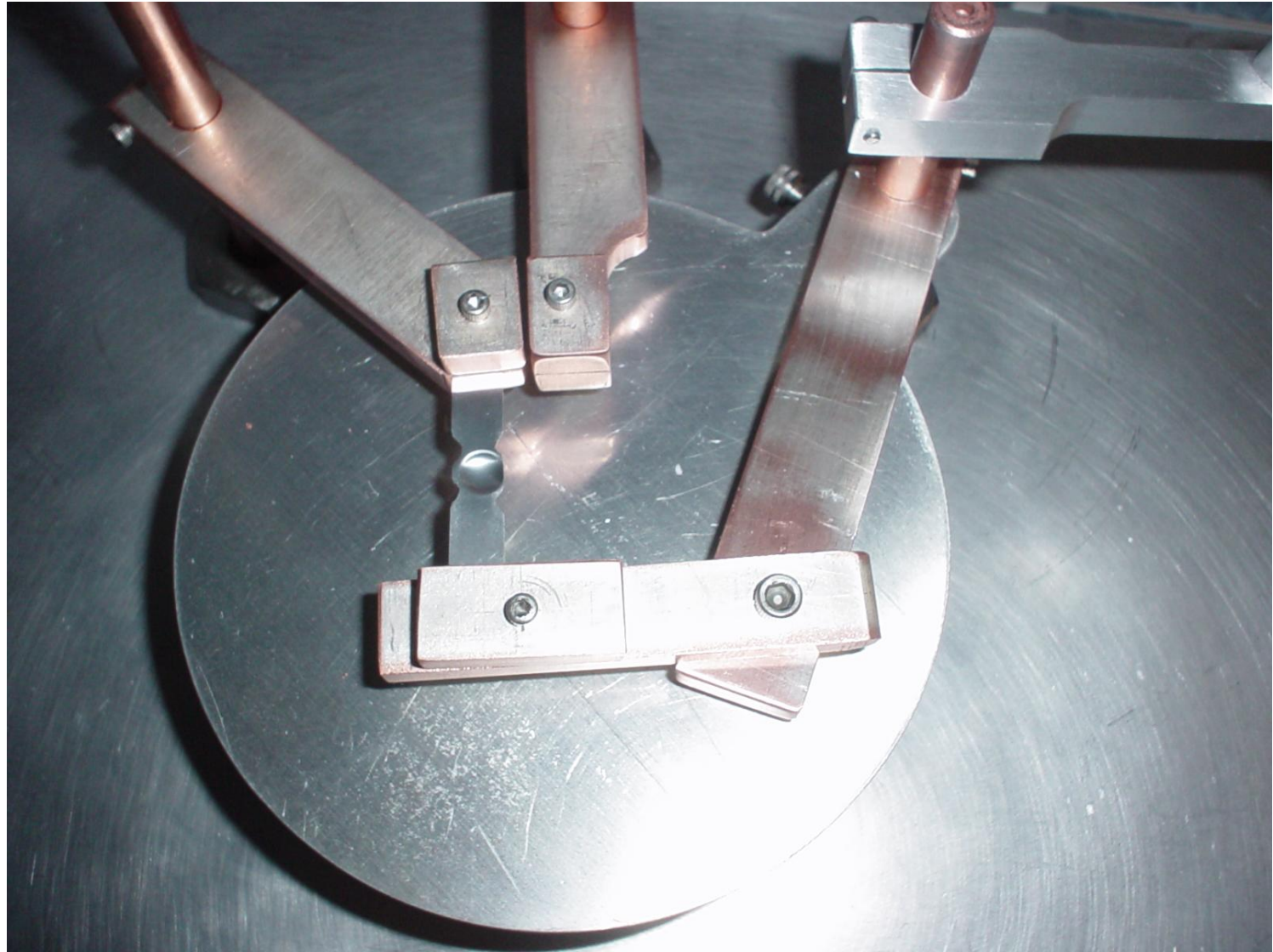
Resistive Heating

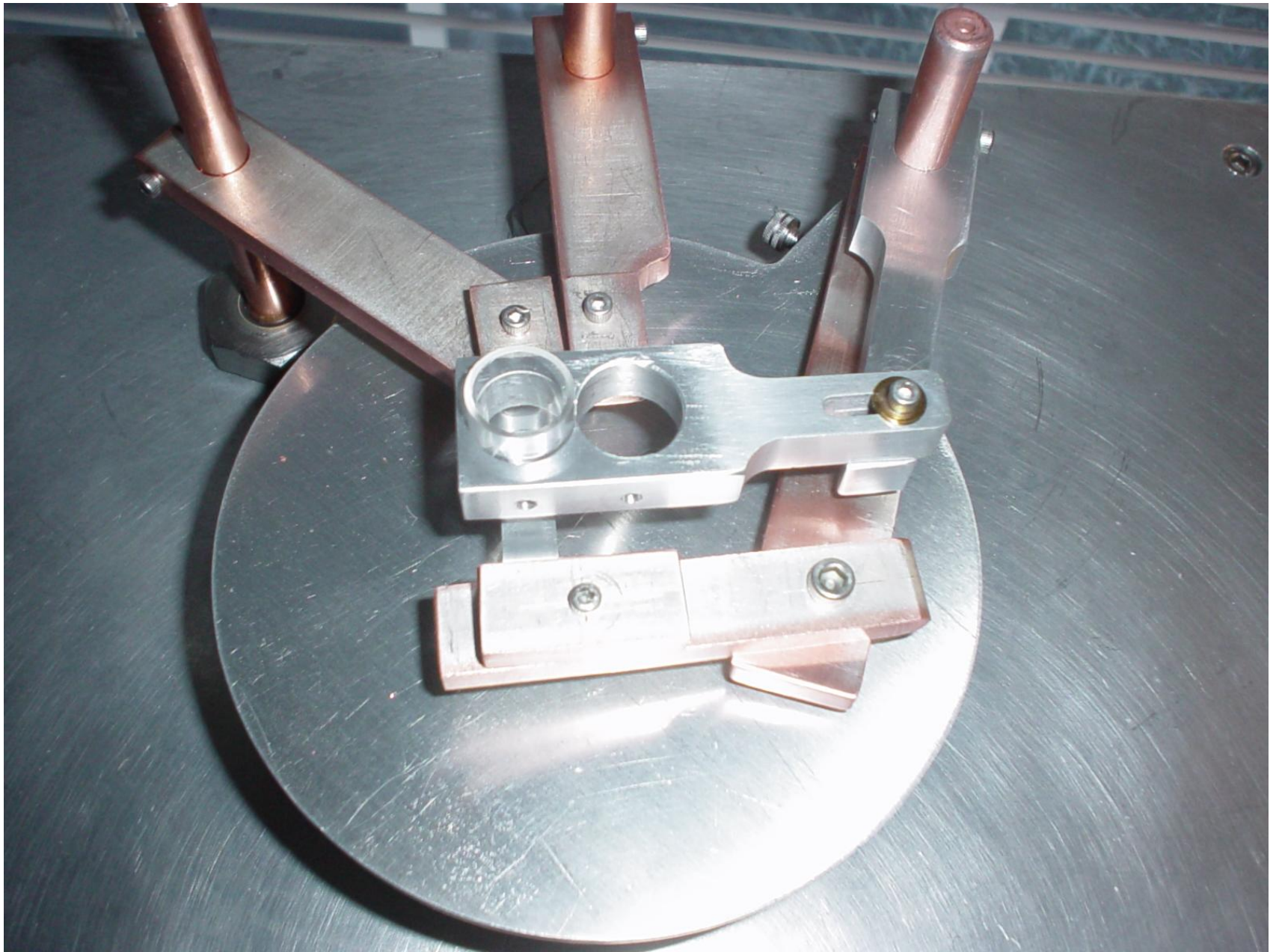


Deposition Monitor

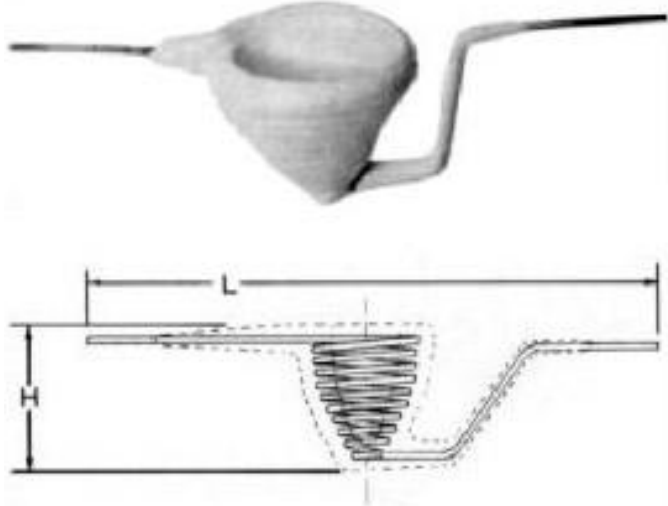






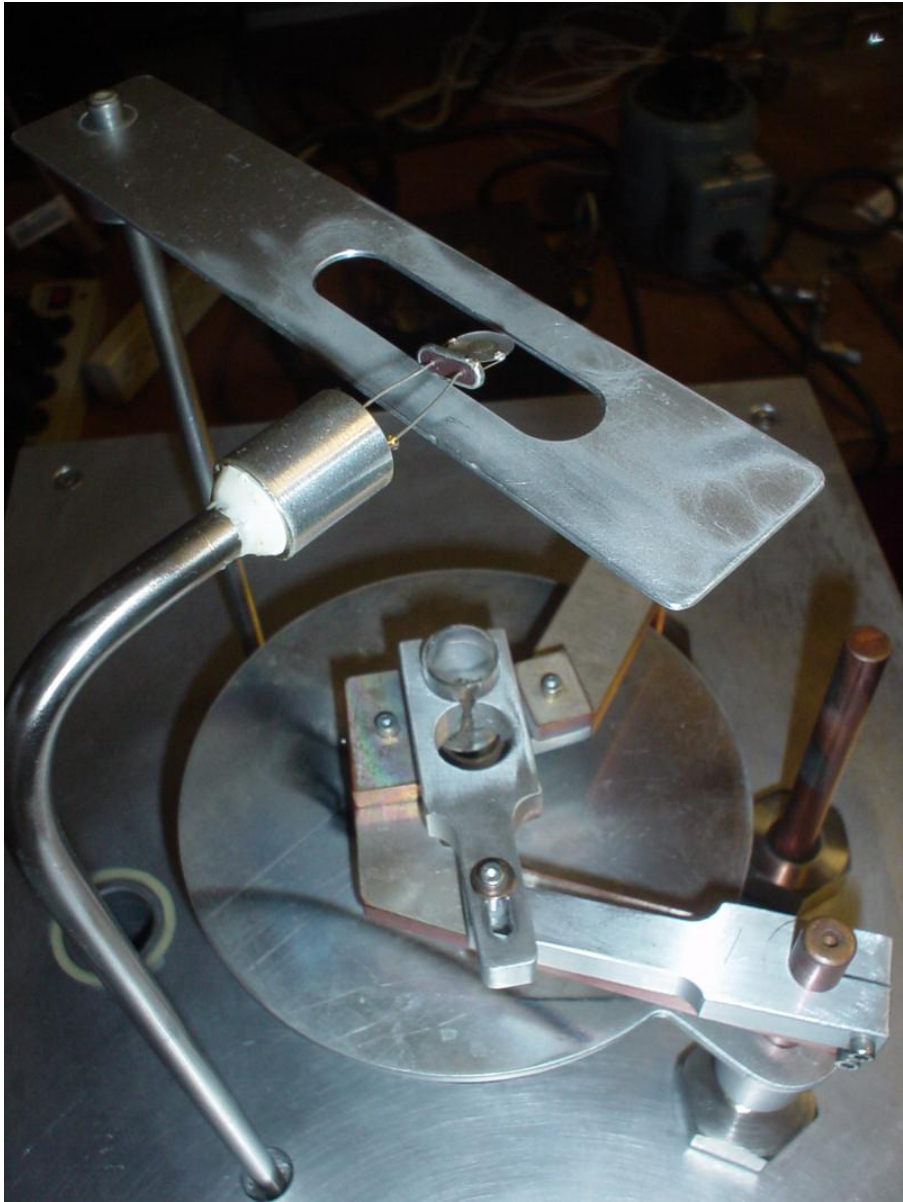


Evaporation Baskets and Boats



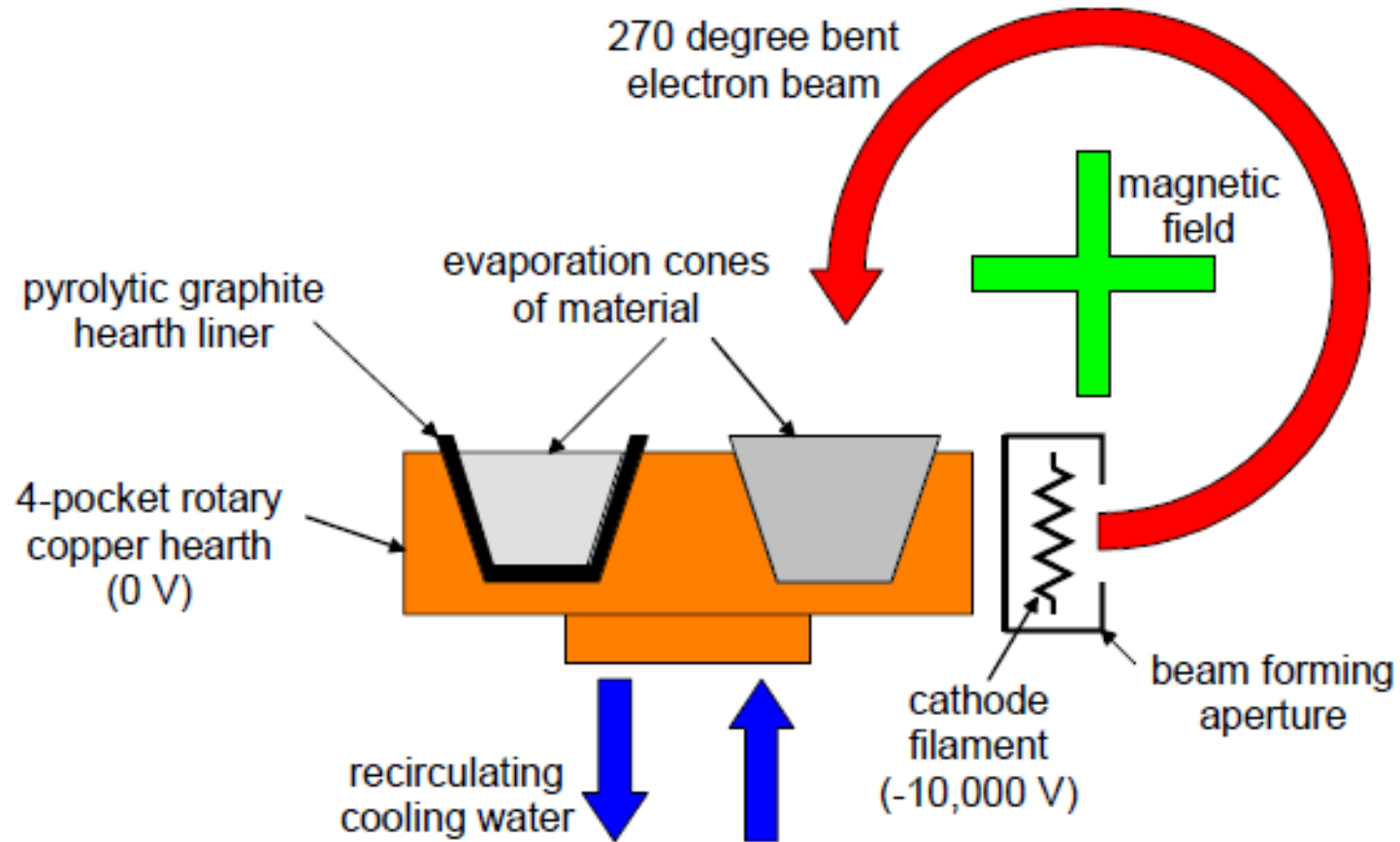




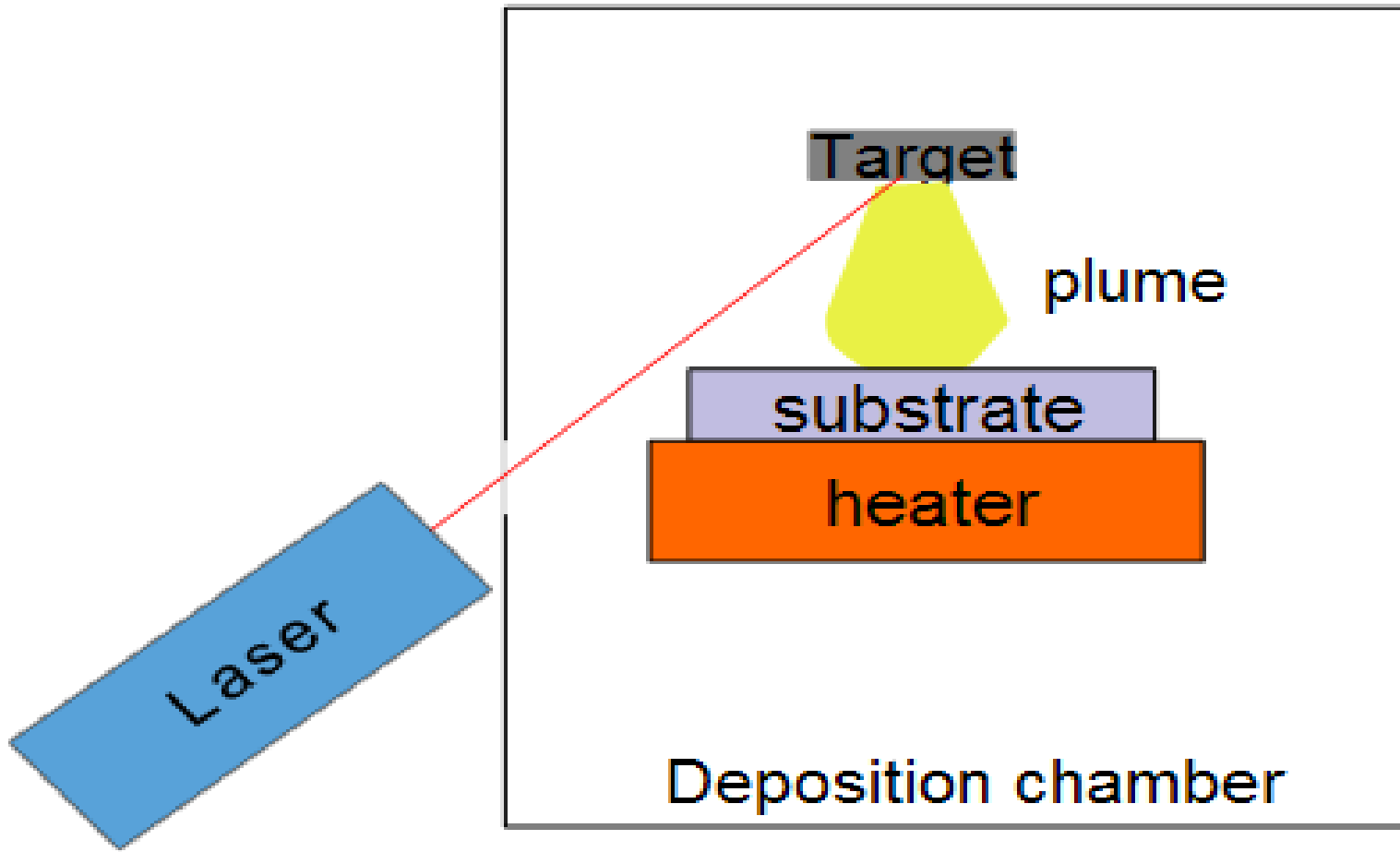




Electron Beam Evaporation Source



Laser Ablation

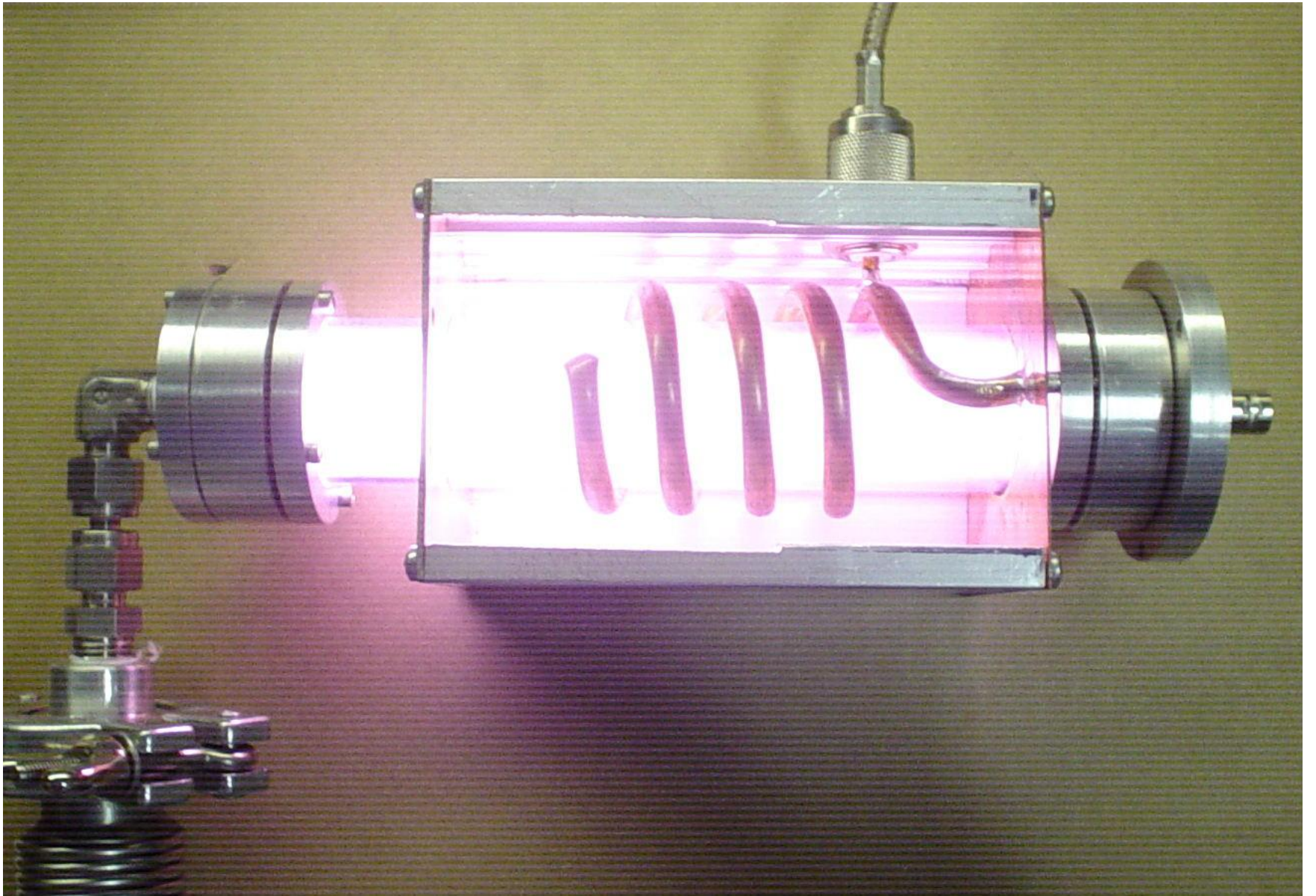


Sputtering

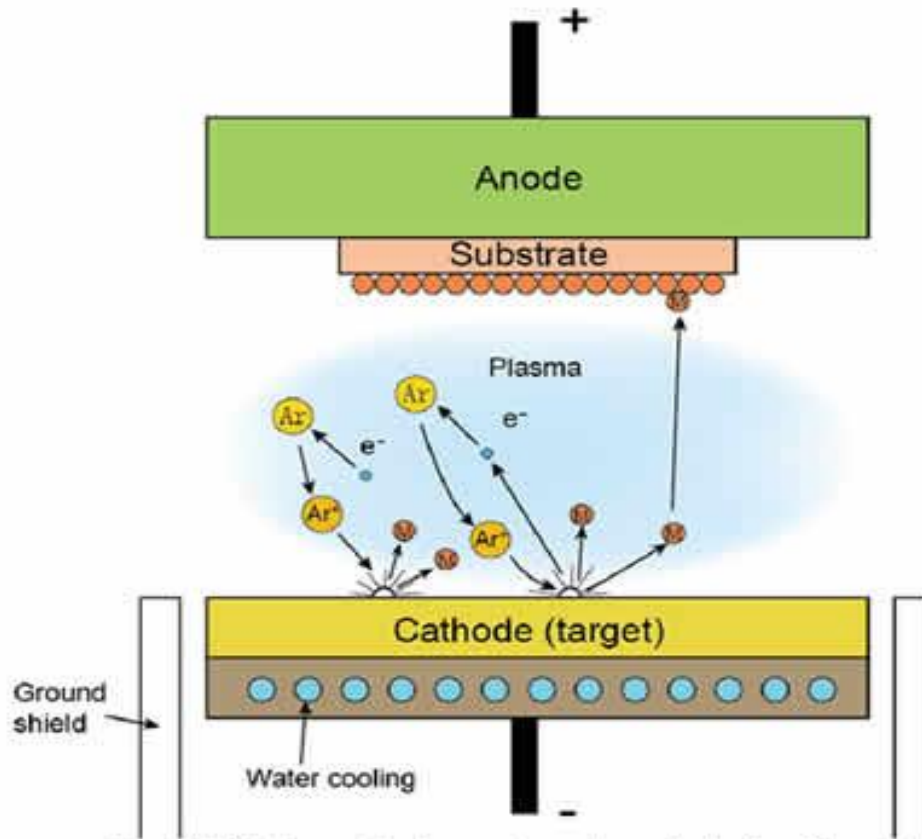
- Sputtering is the removal of atomized material from a solid due to energetic bombardment of its surface layers by ions or neutral particles.

Plasma

- Fourth state of matter
- Disassociated free radicals, ions, electrons and unexcited molecules.

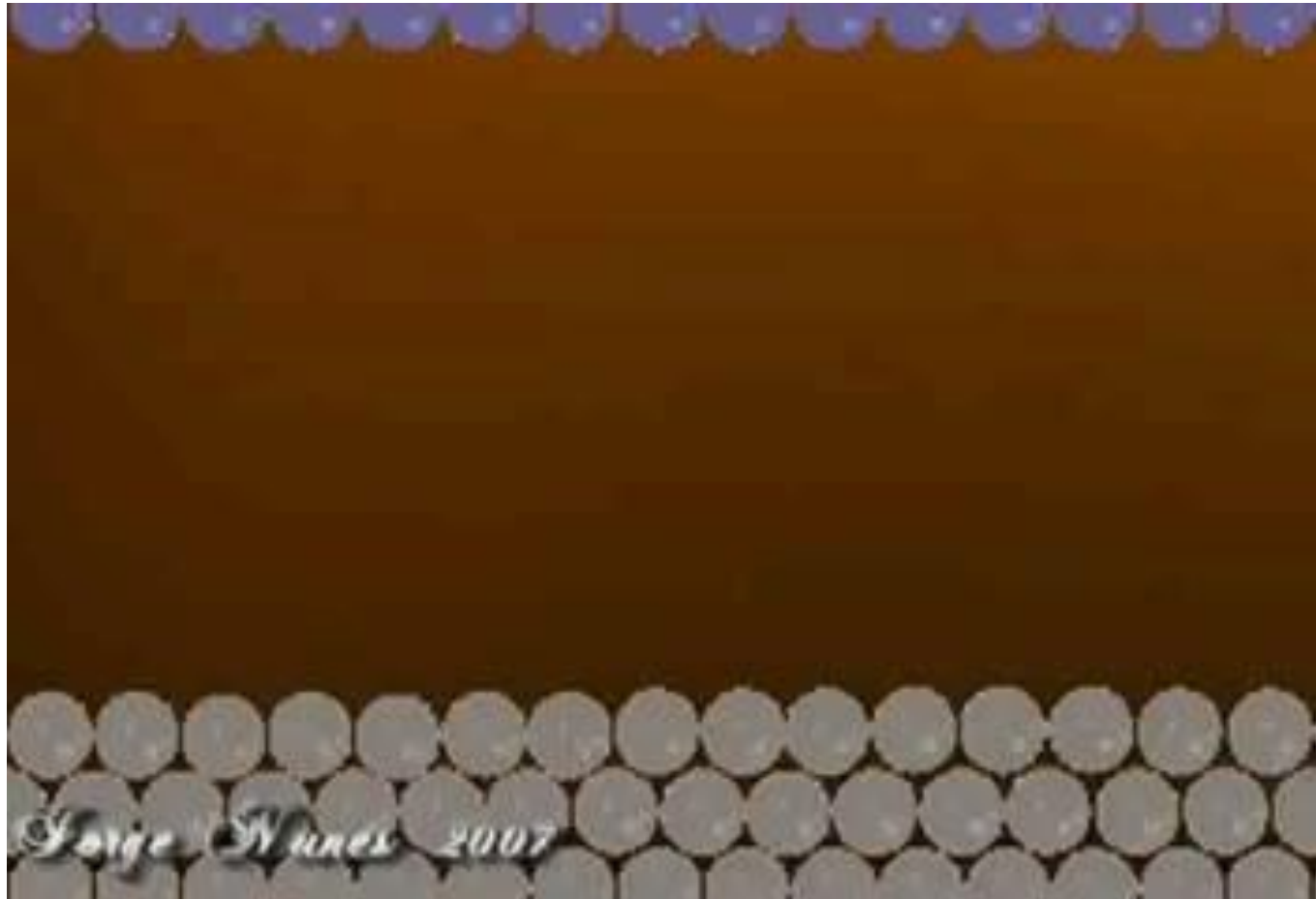


Sputtering

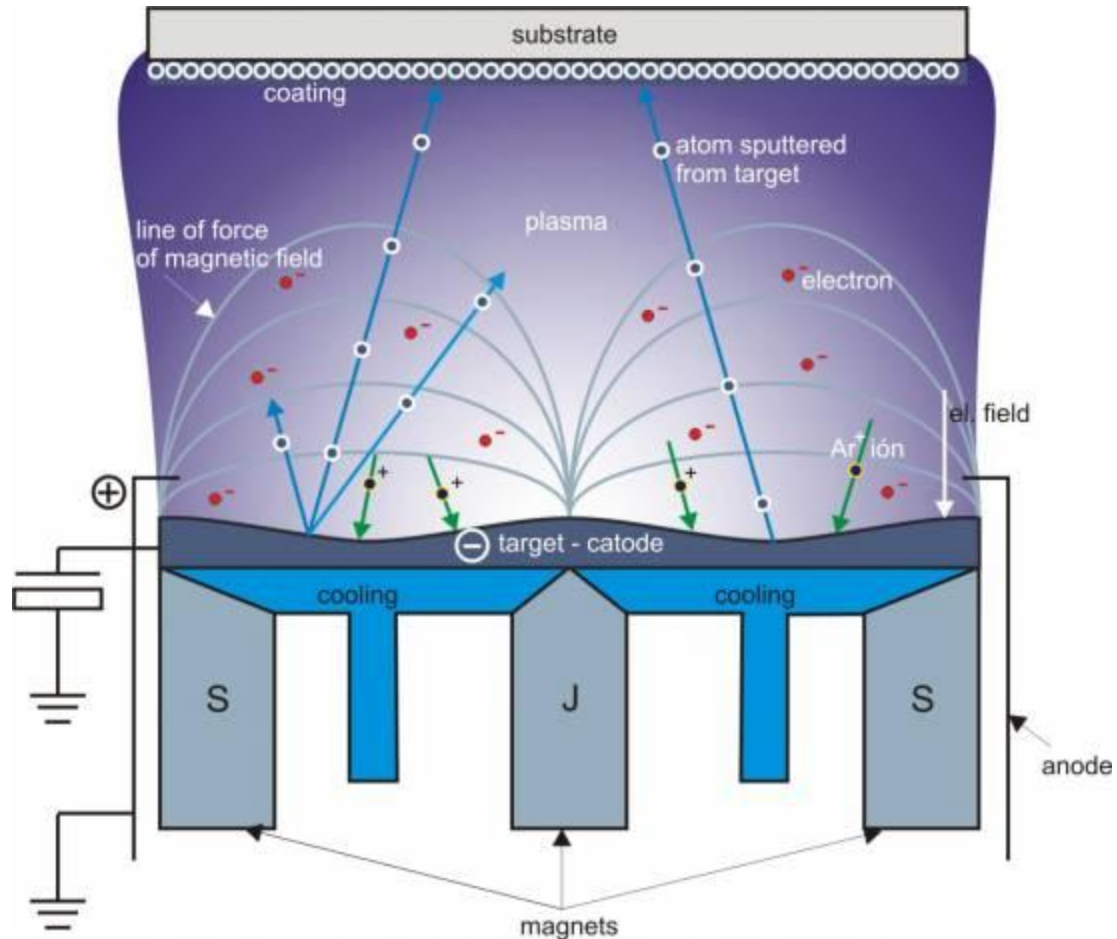


In a DC diode sputtering system, Argon is ionized by a strong potential difference, and these ions are accelerated to a target. After impact, target atoms are released and travel to the substrate, where they form layers of atoms in the thin-film

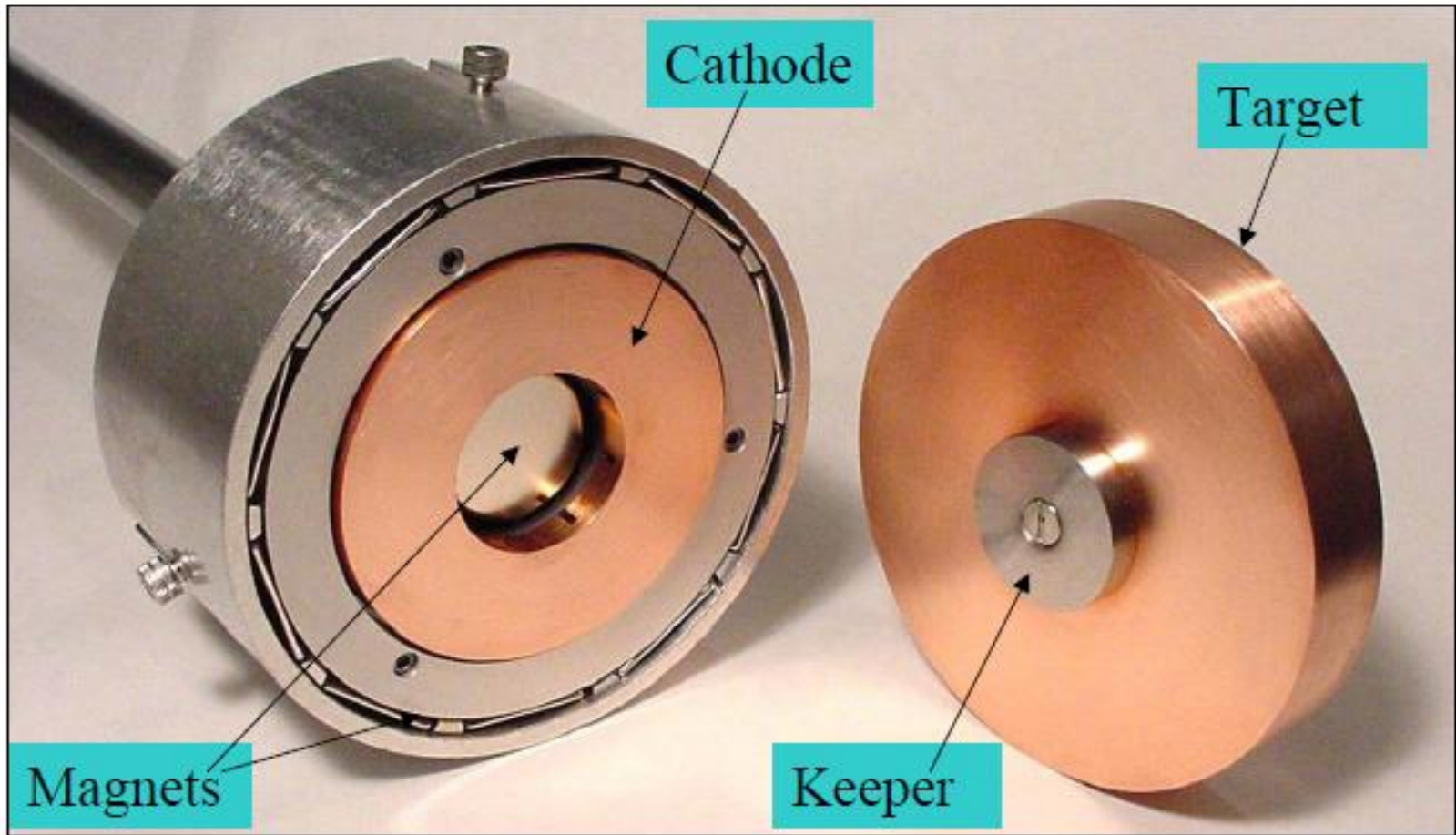
Sputtering

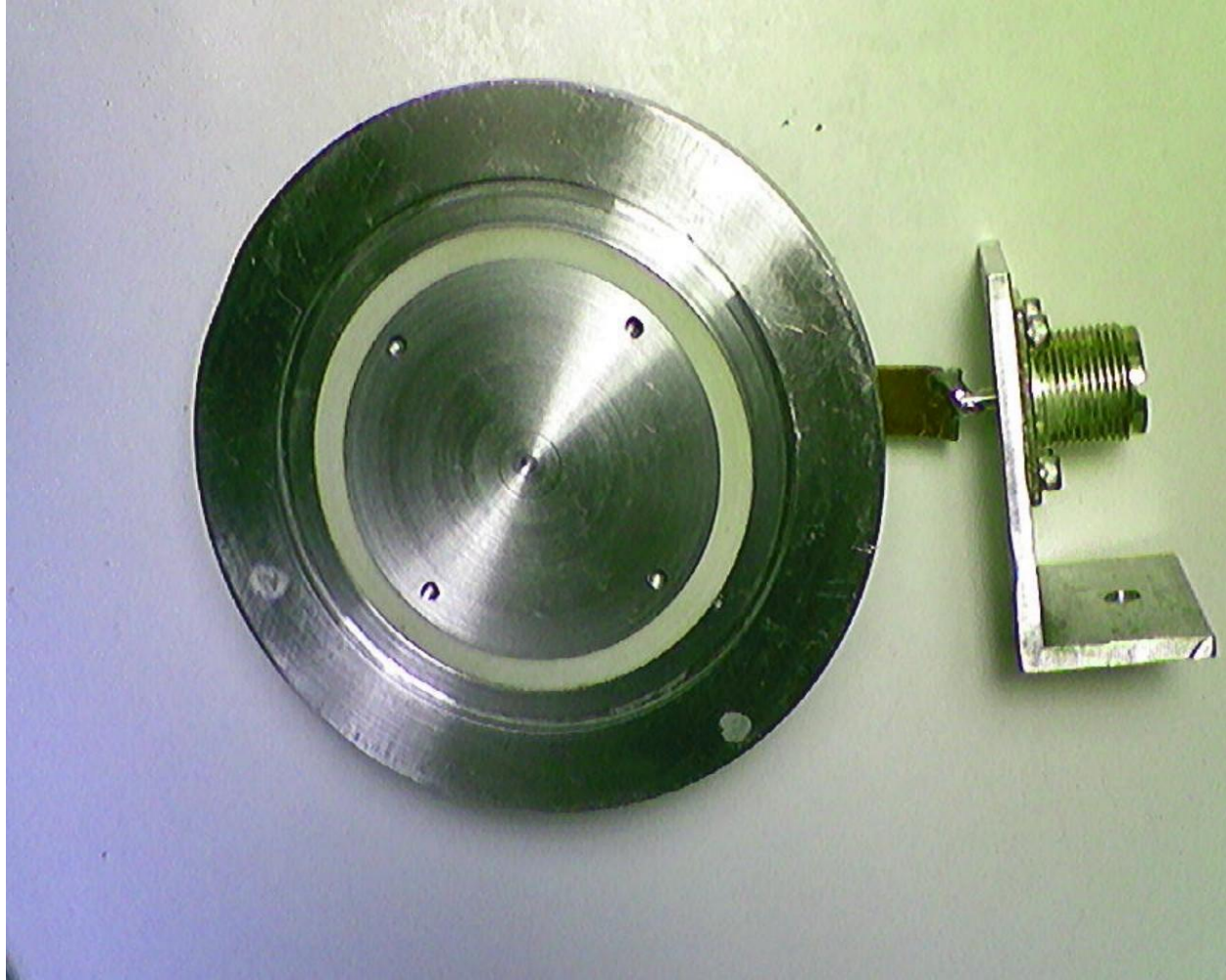


Planar Magnetron



Magnetron









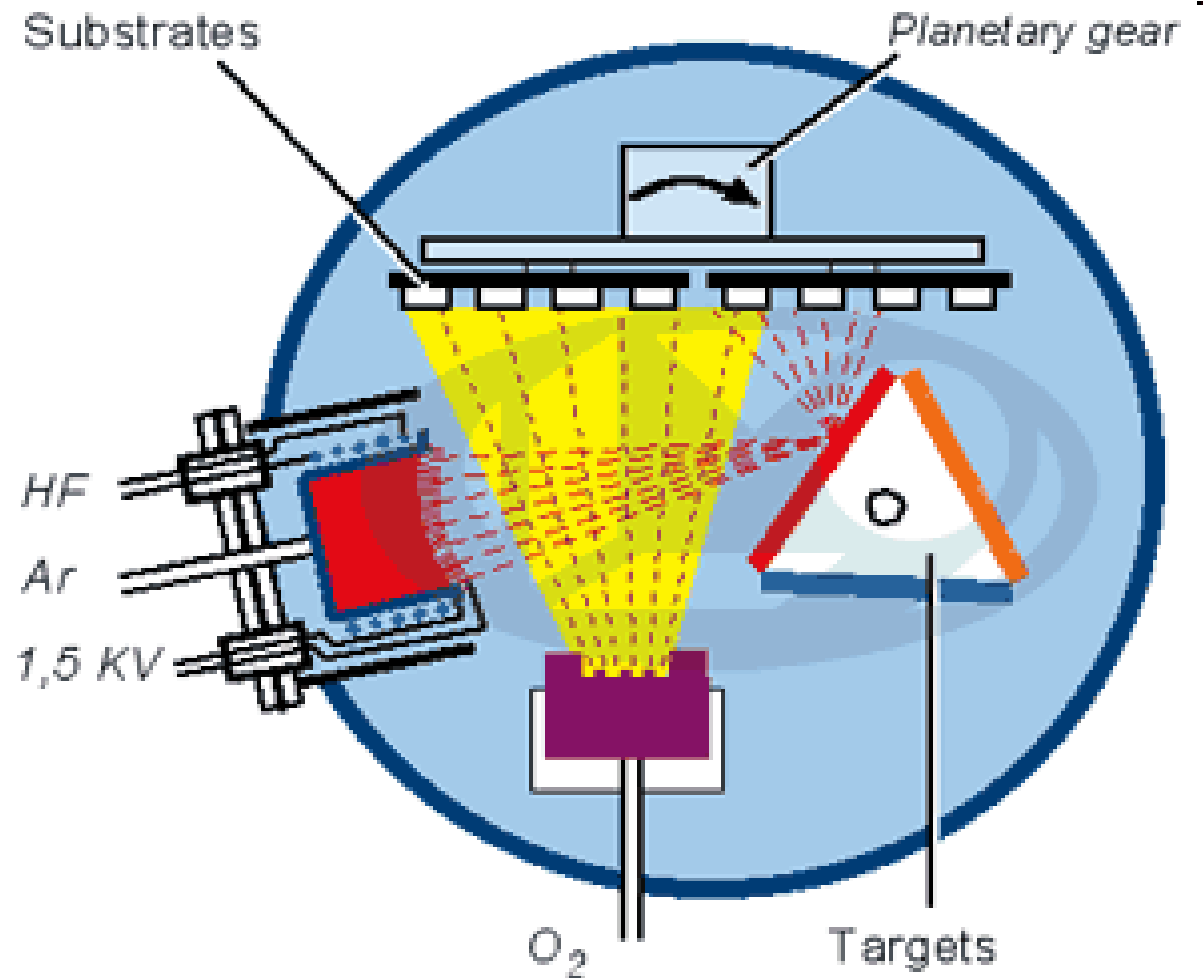
Planar Magnetrons



Magnetron Sputtering

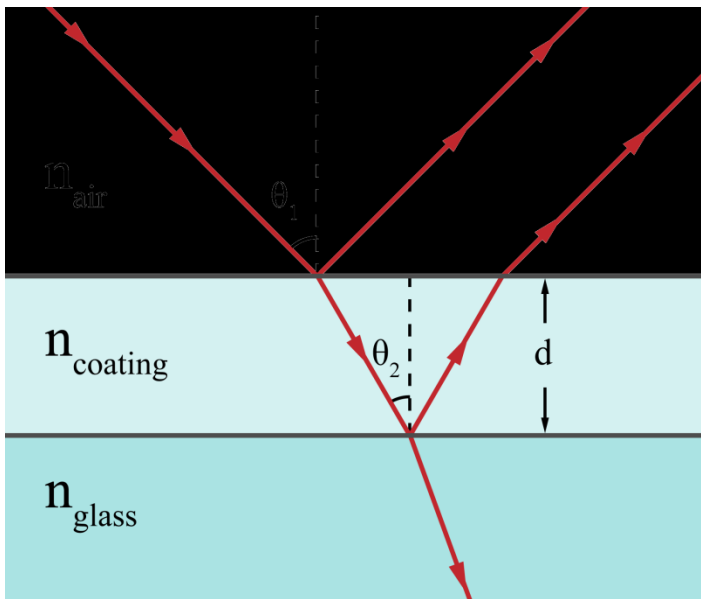
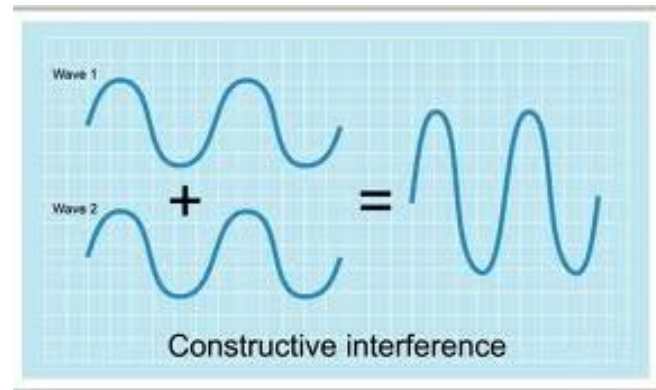
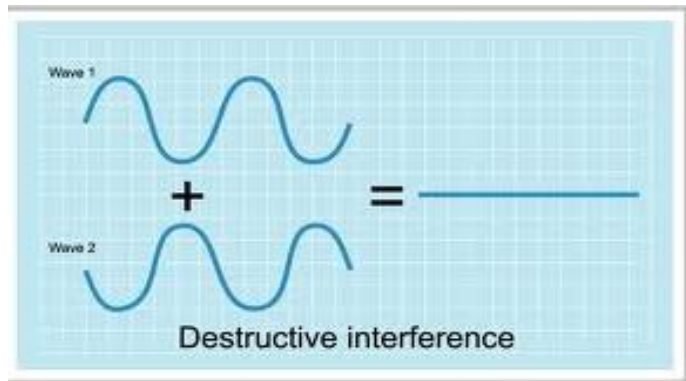


Ion Beam Deposition



Thin Film Metrology

Interferometry



Ceramic Coatings

- Titanium Nitride (500°C)
- Titanium Aluminum Nitride (800°C)
- Titanium Carbide
- Aluminum Oxide
- Chromium Nitride
- Zirconium Nitride
- Zirconium Oxide – Thermal Barrier Coat
- MCrAlY (M=Co, Ni or Co/Ni) – Bond Coat