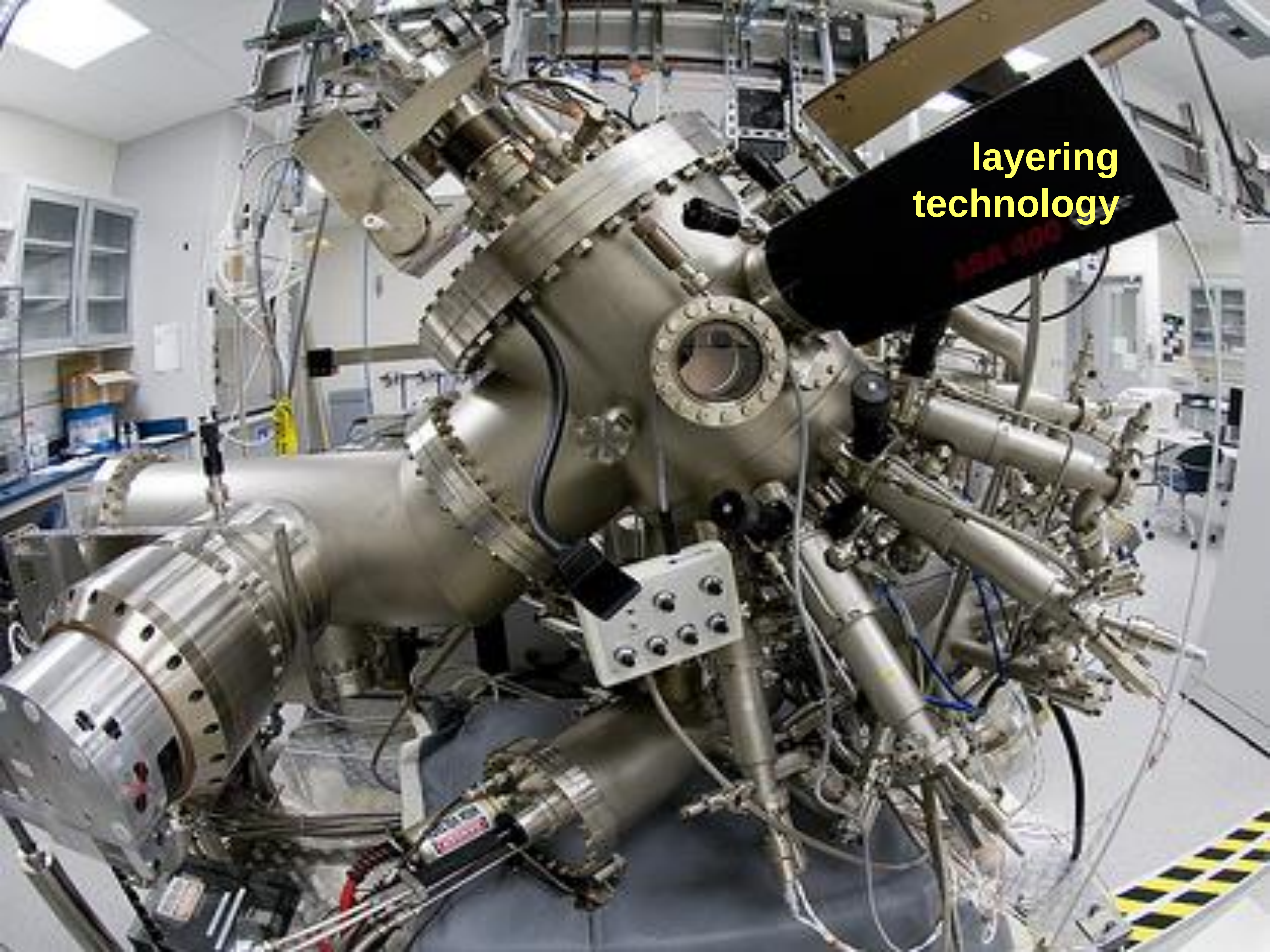
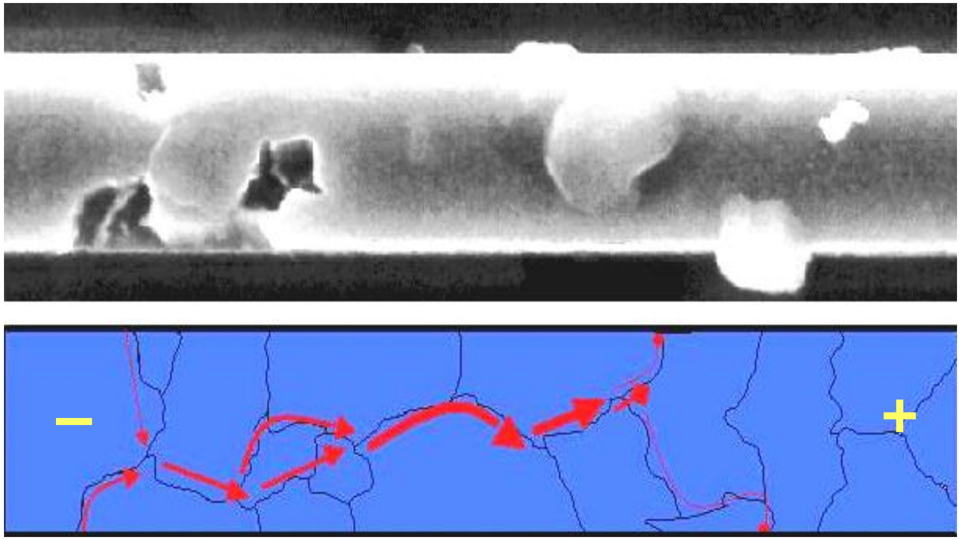


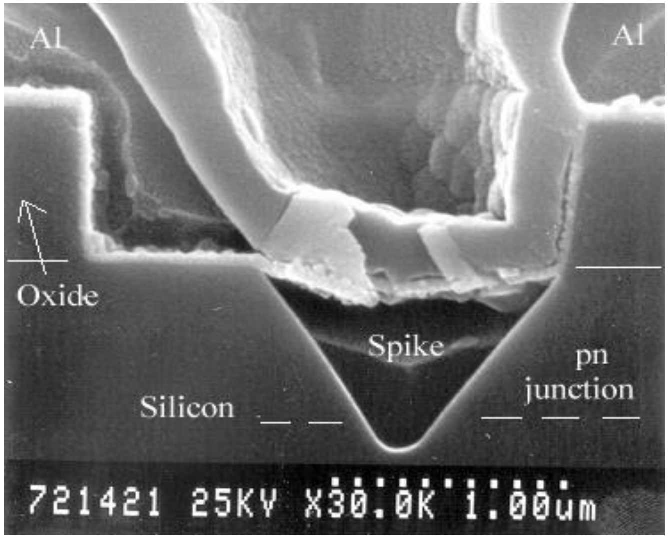
layering
technology

conductors (current paths, gate layer, shield)

- **Al** – simple etch technology / low stability (+ 1-2% Si; 0,5-4% Cu)



electromigration (local overheating)



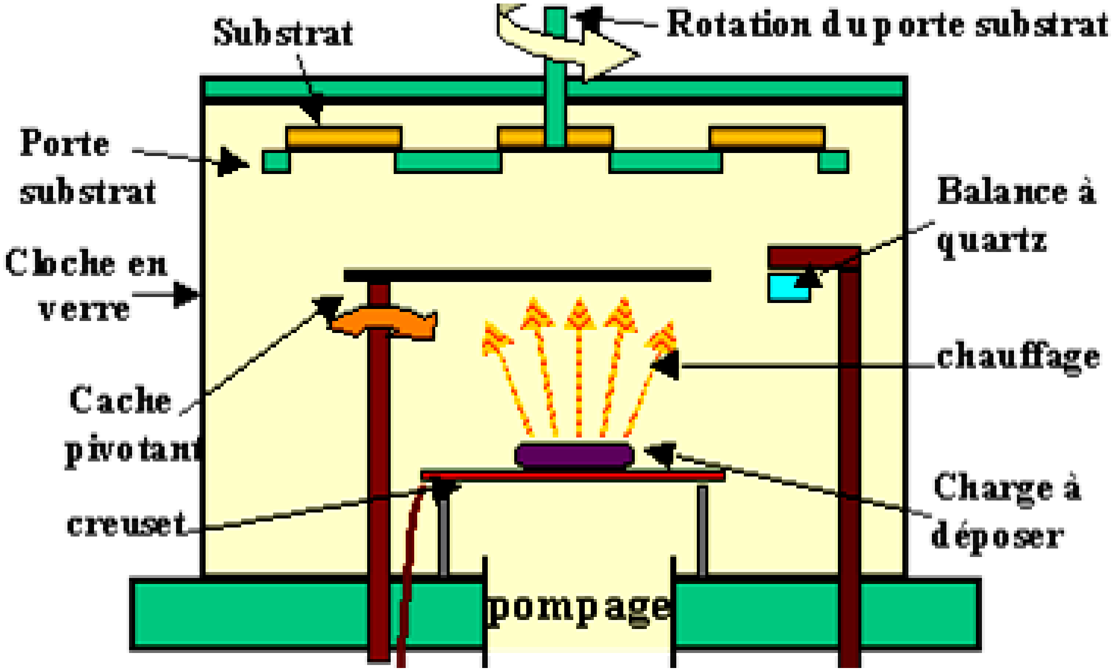
spikes (eutectic Al+Si 577 °C)

- **Cu** – good conductivity / hard etching; corrosion
- **Au** – good conductivity / too soft → shielding

- **Ti,Ta** – stable, good adhesion / low conductivity → barrier layers
- **TiN** – adhesive layer, antireflex
- **n-Si** high doped – good thermal stability, compatible with Si

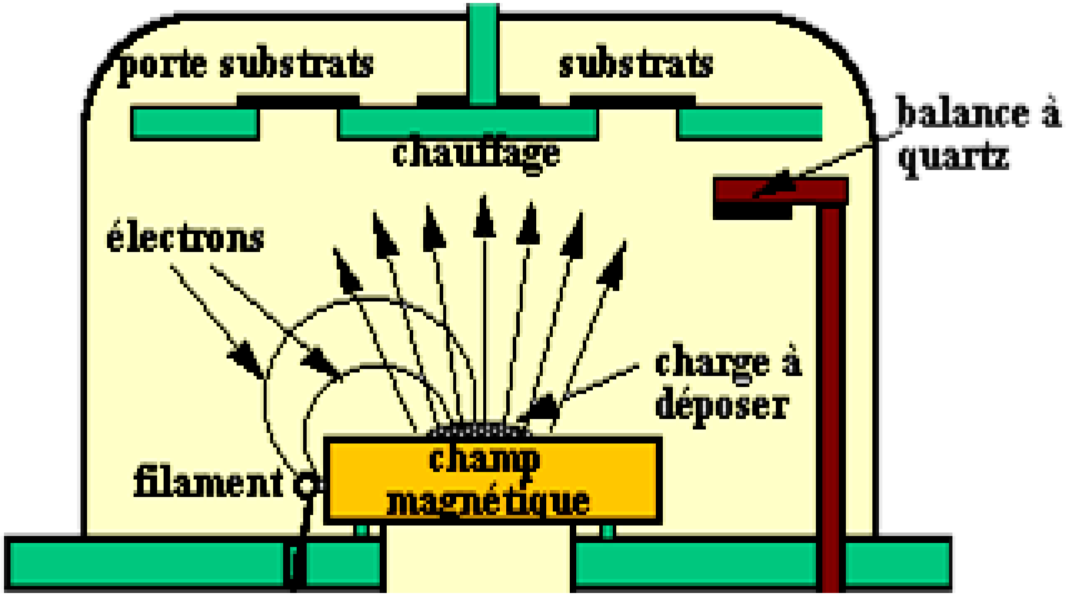
multilayers: Ti / TiN-Pd / Pt-Cu-Au

Physical Vapour Deposition



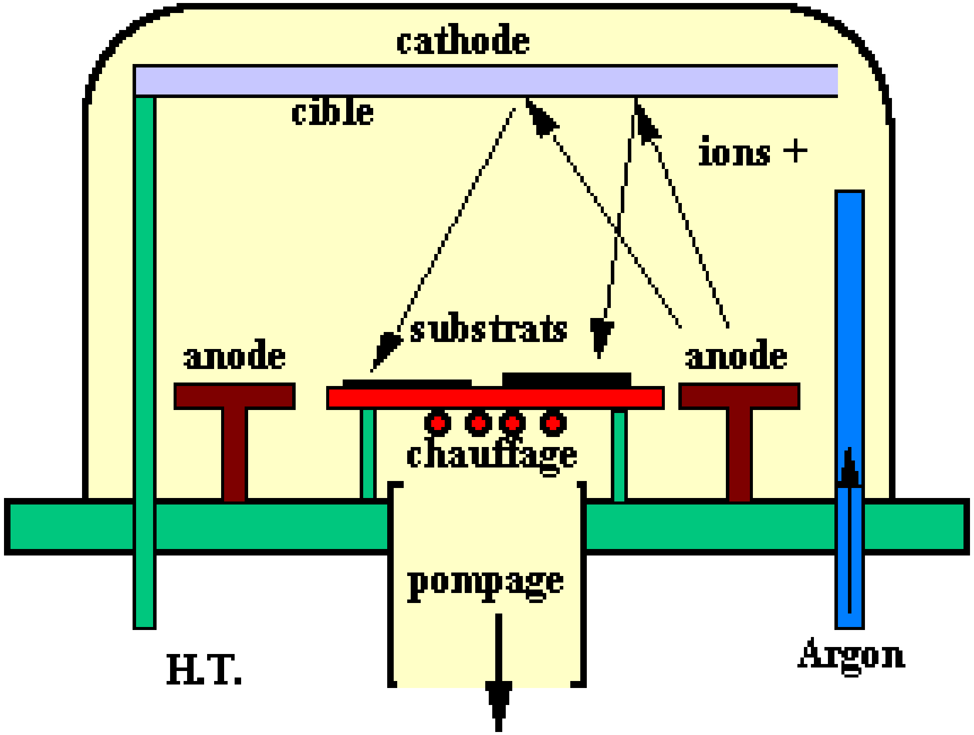
- filament (W,Ta,Mo) – up to **1800 C**
- **Au**, Ag, Al, Sn, **Ge, In, Ga**, **Cr**, **CdS, PbS**, CaF_2
- 1-20 Å/sec → 0,05-5 µm

Physical Vapour Deposition



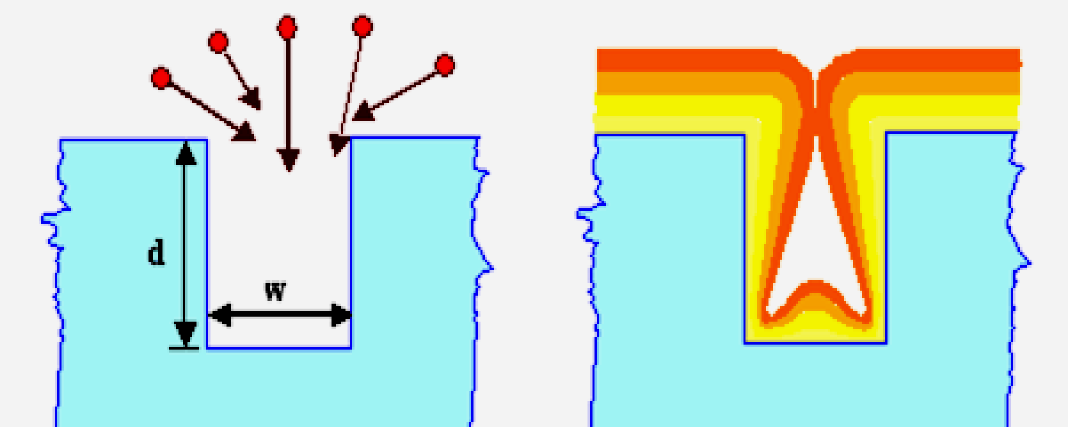
- electron beam → fast temperature rise up to 3000 C
- + Ni, Pr, Ir, Rh, **Ti, V, Zr, W**, **Ta**, **Al2O3, SiO_2**, **TiO2**, **ZrO2**
- 10-100 Å/sec
- X-ray emission

Physical Vapour Deposition



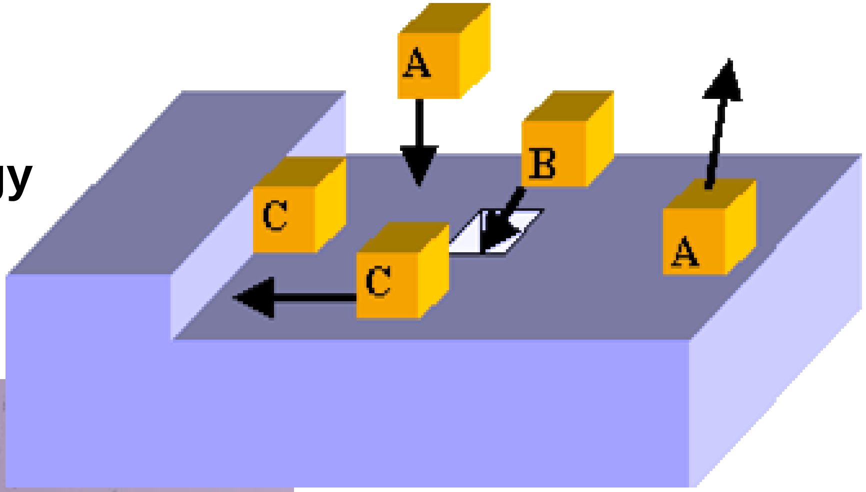
- accelerated Ar$^+$ ions → material drops = **sputtering**
- > adhesion + uniformity
- >> deposition rate
- **layer removal** → hard to control

Physical Vapour Deposition



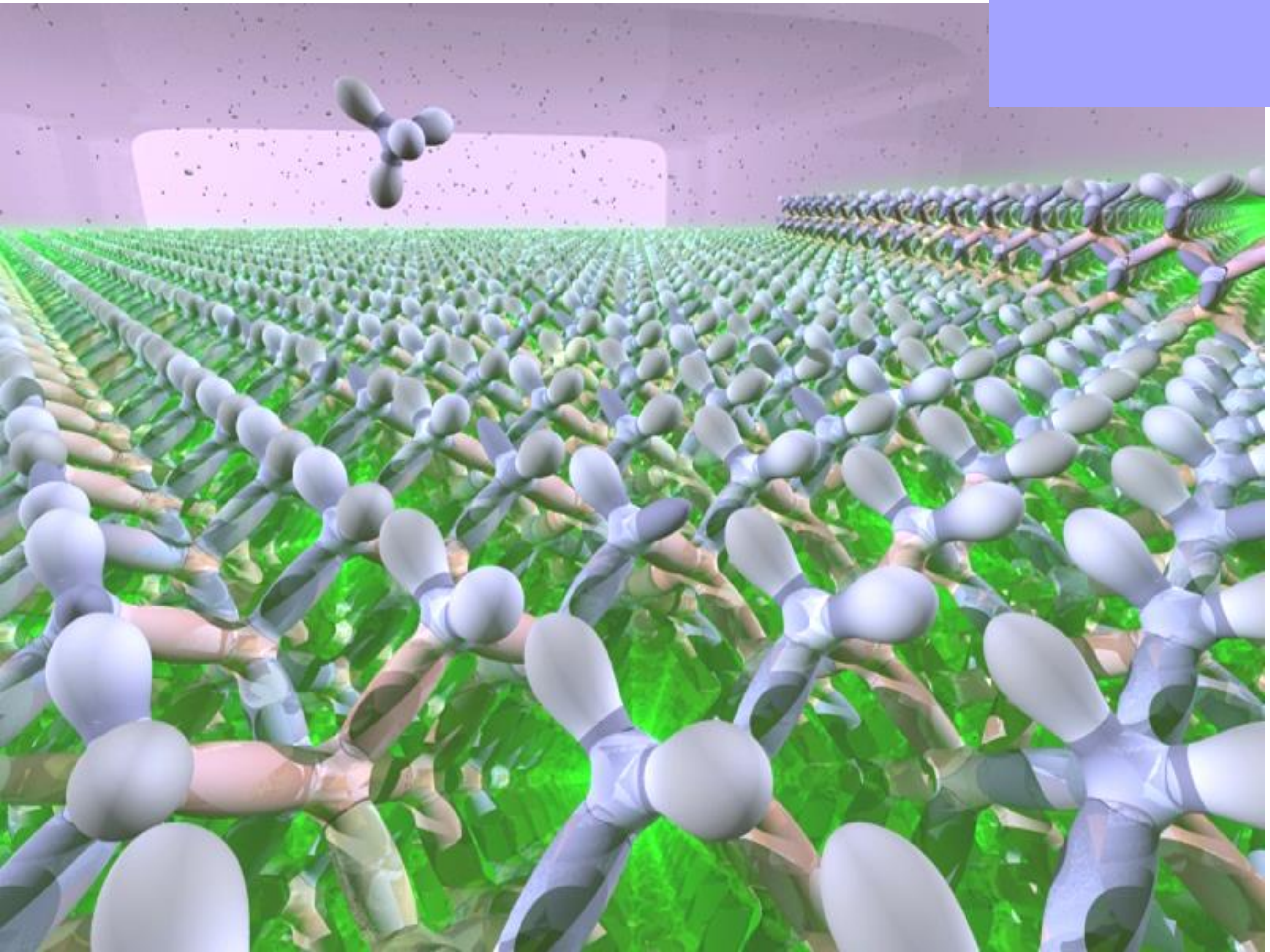
imperfect hole filling

crystalline layers = **epitaxy**

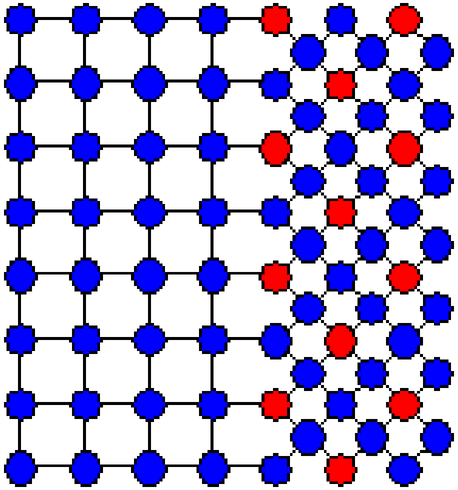


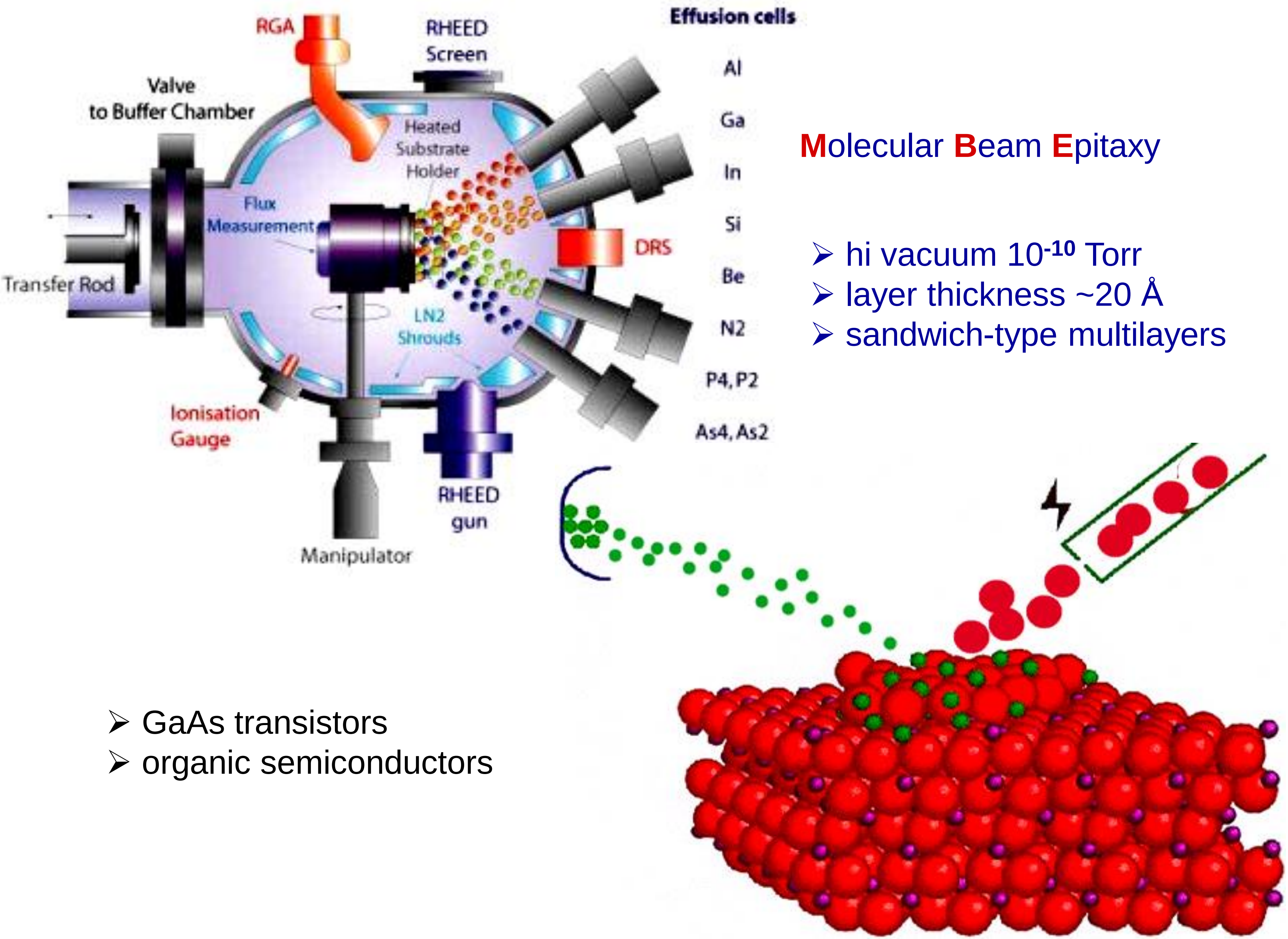
sufficient atom **energy**

crystalline sub-layer is a template



koherent
heteroepitaxy





Molecular **B**eam **E**pitaxy

- ➢ hi vacuum 10^{-10} Torr
- ➢ layer thickness ~20 Å
- ➢ sandwich-type multilayers

- ➢ GaAs transistors
- ➢ organic semiconductors

Chemical Vapour Deposition
(= vapour phase epitaxy)

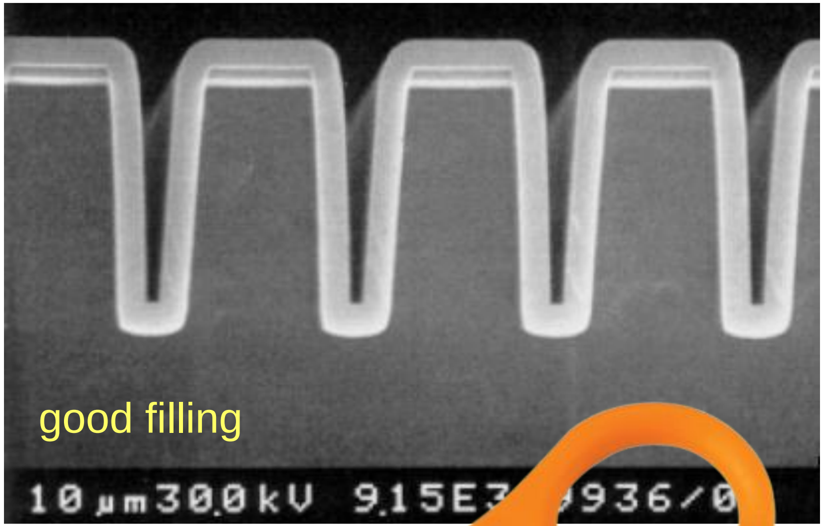
SiCl4 + H2 → **Si** + HCl	~1250 °C
SiHCl3 + H2 → **Si** + HCl	~1100 °C
Si2H2 → **Si** + HCl	
SiH4 → **Si** + H2	~1000 °C; He,Ar
Si2H6 → **Si** + H2	

SiH4 + O2 → **SiO2**	< 500 °C
SiCl2H2 + N2O → **SiO2**	~900 °C
Si(OC2H5)4 → **SiO2**	~700 °C
Si(OC2H5)4 + O3 → **SiO2**	~400 °C

SiH4 + NH3 → **Si3N4**	~800 °C
SiCl2H2 + 4NH3 → **Si3H4**	~700 °C

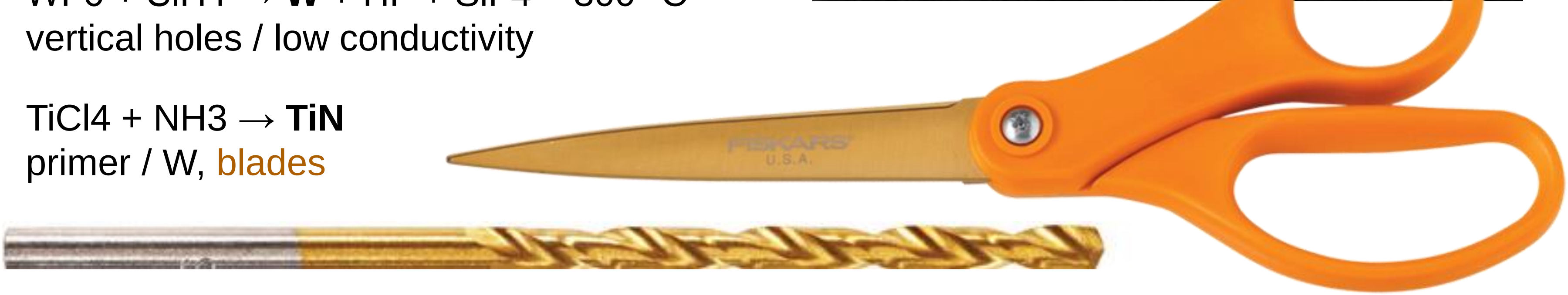
SiO_xN_y = good dielectric (**flash memory**)

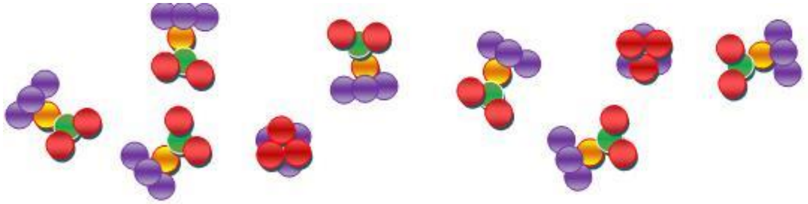
CVD **plasma** – no stoichiometry


good filling

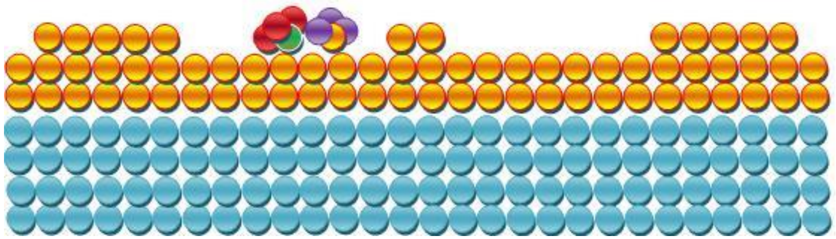
WF6 + H2 → **W** + HF
WF6 + SiH4 → **W** + HF + SiF4 ~300 °C
vertical holes / low conductivity

TiCl4 + NH3 → **TiN**
primer / W, blades

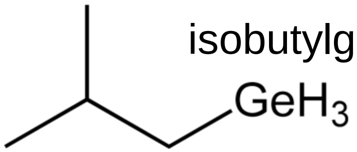




Metal Organic CVD



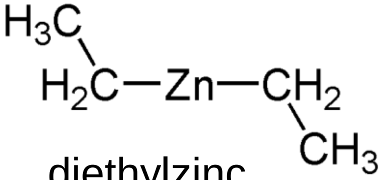
Si-Ge:



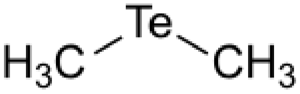
isobutylgermane

A(II)B(VI):

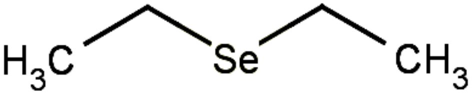
dimethyl cadmium



diethylzinc



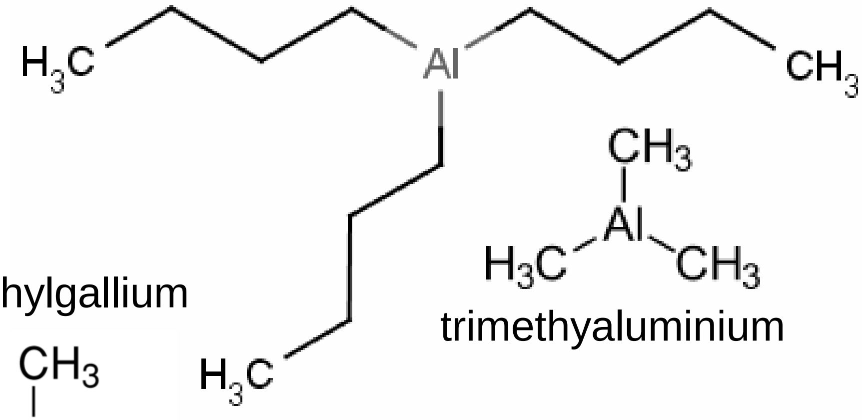
dimethyl telluride



diethyl selenide

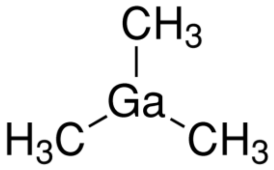
A(III)B(V):

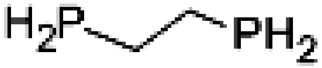
tributhylaluminium



trimethyaluminium

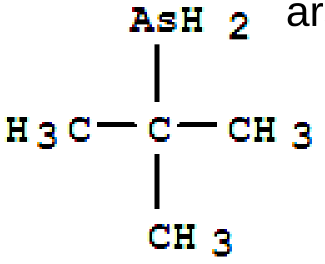
trimethylgallium

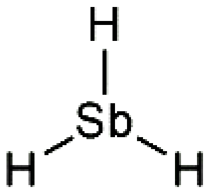




bisphosphinoethane

tertiary butyl arsine

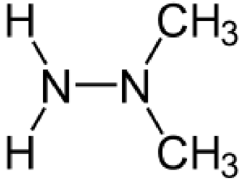


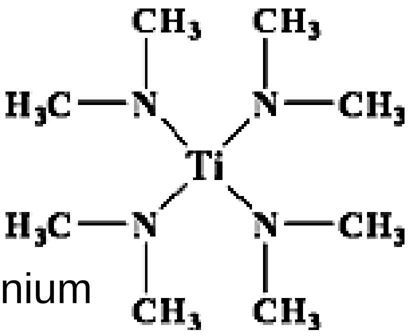


stibine

+ low temperature
+ various materials
- combustible / toxic precursors

TiN: dimethylhydrazine + TiCl4

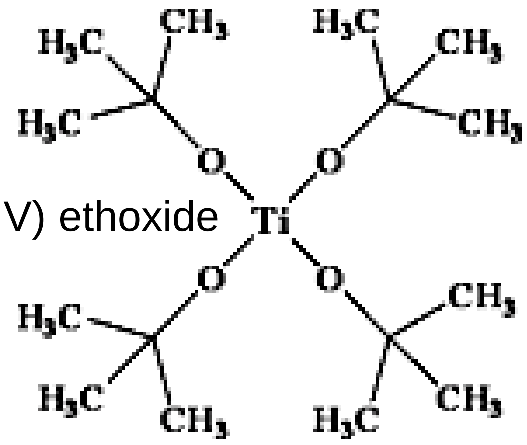




tetrakis(dimethylamino) titanium

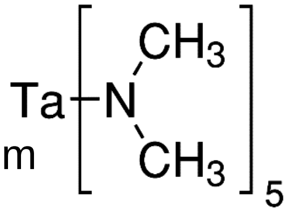
TiO2:

titanium(IV) ethoxide

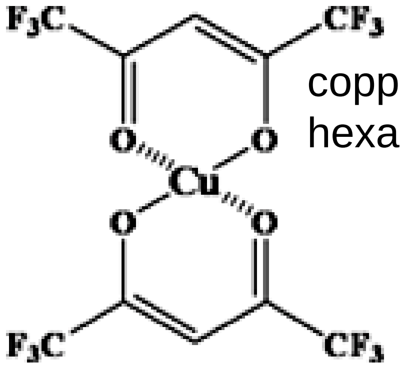


TaN:

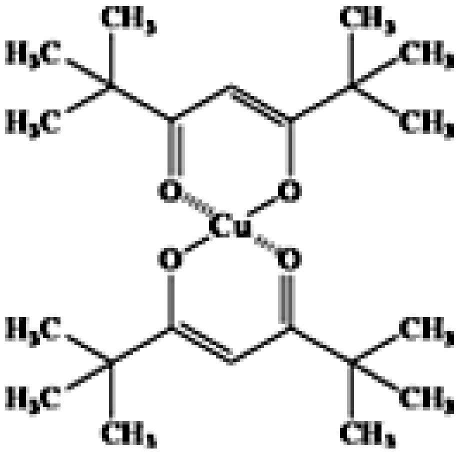
pentakis(diethylamino) tantalum



Cu:



copper(I) hexafluoroacetylacetonate



copper bis(2,2,6,6-tetramethyl-3,5-heptanedionate)