Manufacturing of nanodevices

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Methods and requirements

- UP - BOTTOM technique - size reduction of micrometer-sized structures down to sizes of 1-100 nm
- BOTTOM - UP technique - nm sized structures are built from atoms
- The purity requirement for Si-based nanodevices : $1:10^{9}$
- The purity requirement for Ge-based nanodevices : $1:10^{13}$

Growth of monocrystals

$SiO_2 + 2C \rightarrow Si + 2CO$ (on 1800 ^oC)

The obtained Si is not a monocrystal and not pure enough

$Si + 3HCl \rightarrow HSiCl_3 + H_2$

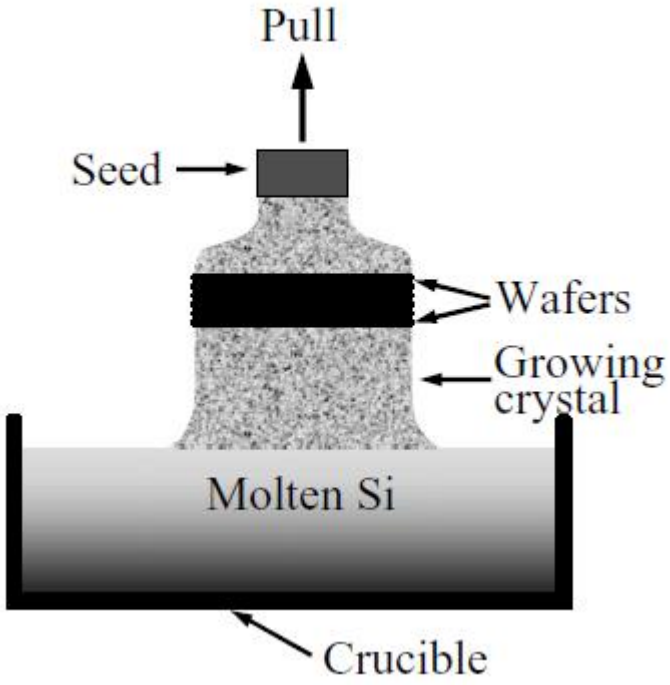
Trichlorosilane is liquid but contanimated Trichlorosilane can be separated from impurities by fractional distillation.

$HSiCl_3 + 2\ H_2 \rightarrow 2Si + 6HCl$

The resulting Si is highly pure, but polycrystalline!

Growth of monocrystals

- The Czochralski method (zone melting - at 1412 ^{o}C)

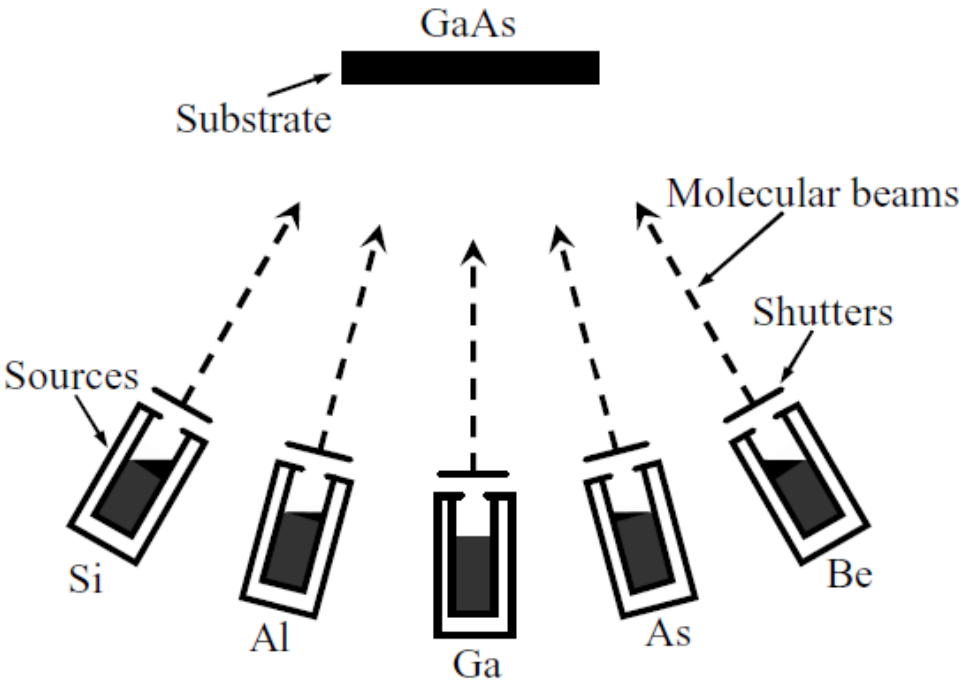


• wafers (h ~ 100 μm) are made from the resulting monocrystal cylinder

• these wafers can serve as a good basis for designing nanodevices on their surfaces (chemical, crystallographic, etc. fitting problems)

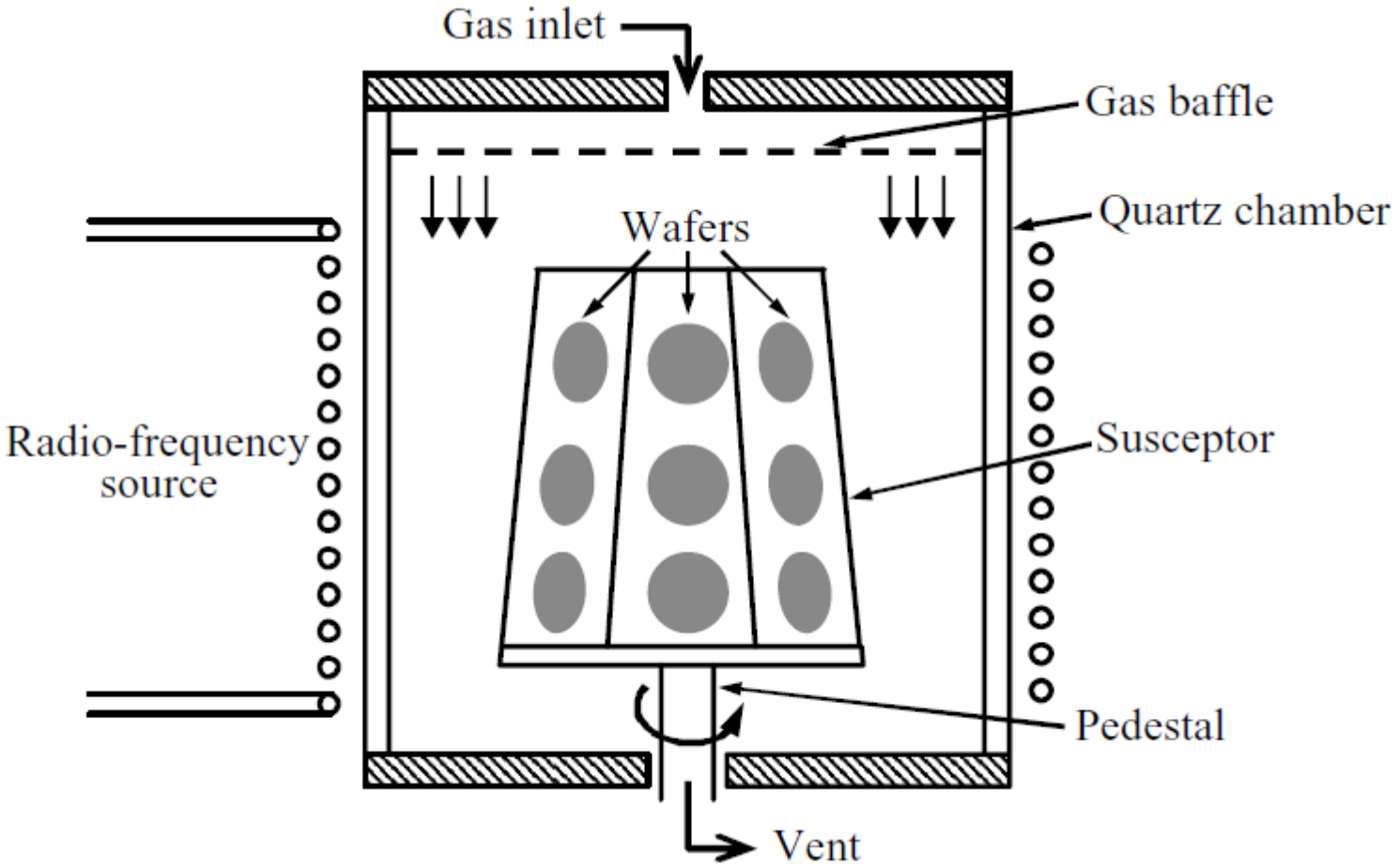
Molecular beam epitaxial growth

- Formation of single-crystal thin layers in vacuum under controlled conditions on a base plate - e.g. fabrication of heterostructures



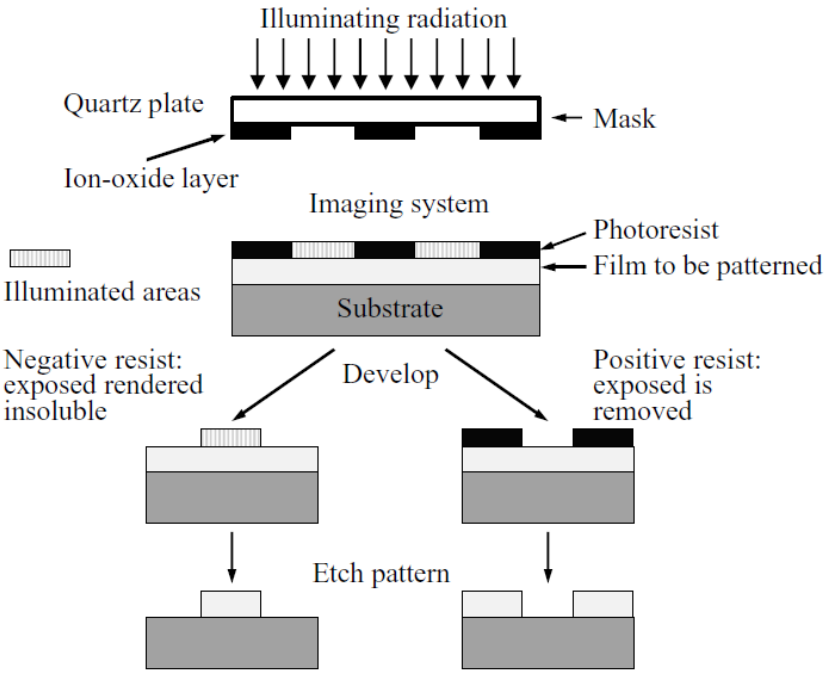
- slow – 1 atomic layer per second

Deposition of chemical vapors



Nanolitography

- It is not possible to do lithography with visible light at nanoscale, because the wavelength of the light is too long → UV, X-ray, electron beam lithography is needed



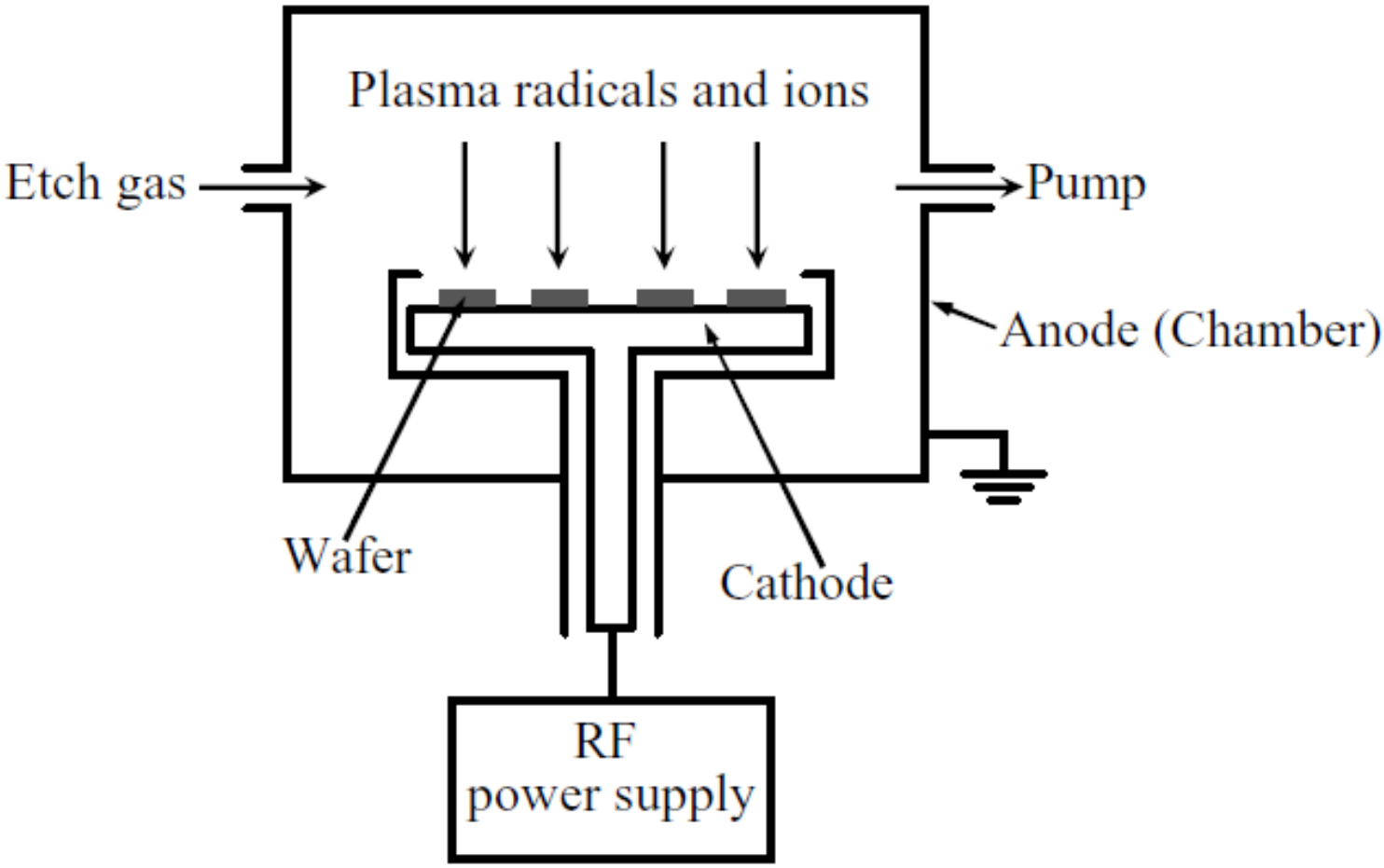
- making nanochannels and quantum wires on compatible surfaces
- making quantum dots on compatible surfaces
- etching is the last step

Etching processes

- Dry etching technologies (electron beam, ion beam or UV laser etching)

- Wet etching technologies (chemical etching processes)

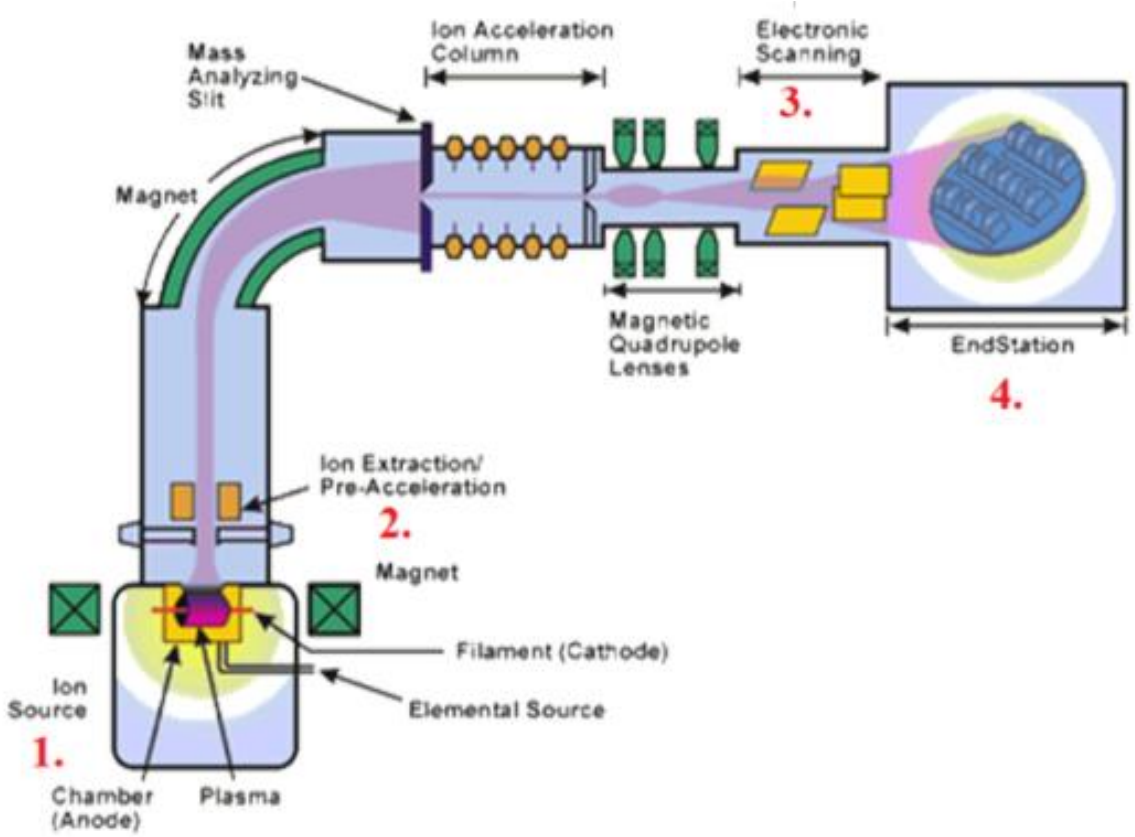
Etching by plasma ions



Ionimplantation

Berendezés:

1. ionforrás
2. gyorsítás
3. pásztázás
4. mintakamra (target)



Single atom deposition (STM)

- Placement of individual atoms on a compatible surface - the principle of a scanning tunneling microscope