520.216
Introduction to VLSI Systems
Lecture 3

Integrated Circuits Fabrication
and
Very Large Scale Integration

Charges and Their Movement (I)

- Electrons
- Ions

Where?

Solids
Liquids
Gases

and

INTERFACES

How Well?

Superconductors
Conductors
Semiconductors
Insulators

How?

Drift / Diffusion (Classical)
Tunneling (Quantum Mechanical)

Charges and Their Movement (II)

FUNCTIONAL

- Electrical conduits (1D, 2D, 3D)
- Transistors
- Switches

STRUCTURAL

- Etching
- Film deposition (electroplating)

REDOX

We now consider transport in the solid-state and more specifically in the semiconductor Silicon

the microelectronics world does not use SI units! distance will be measured in **cm** and not meters.

for example: conductivity has units of ohm-cm

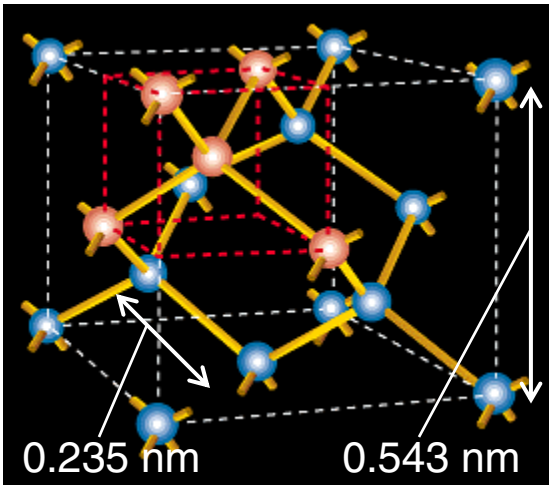
Silicon!

14

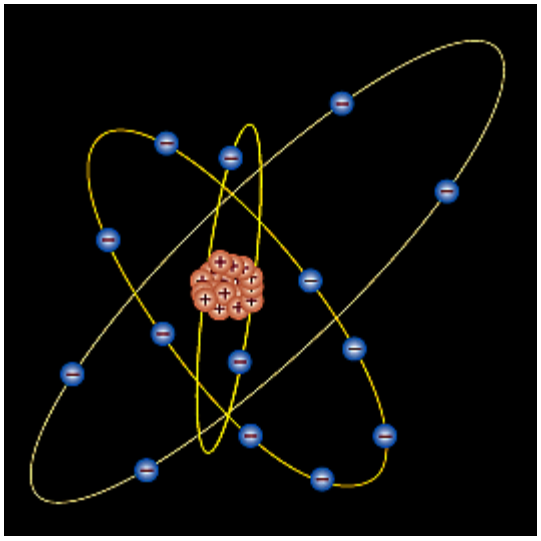
Si Silicon

6 C
14 Si
32 Ge
50 Sn
82 Pb
114 Uuq

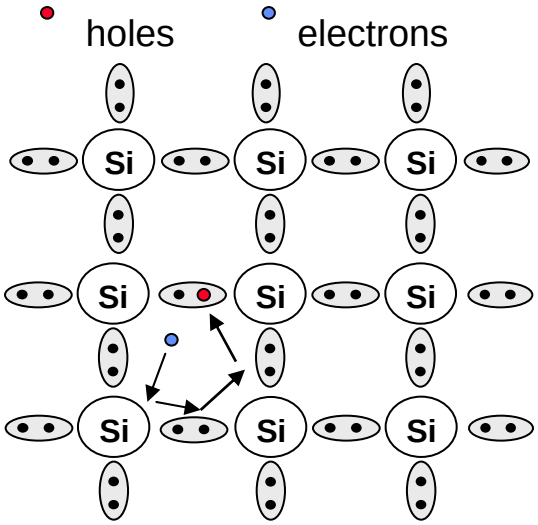
semiconductor

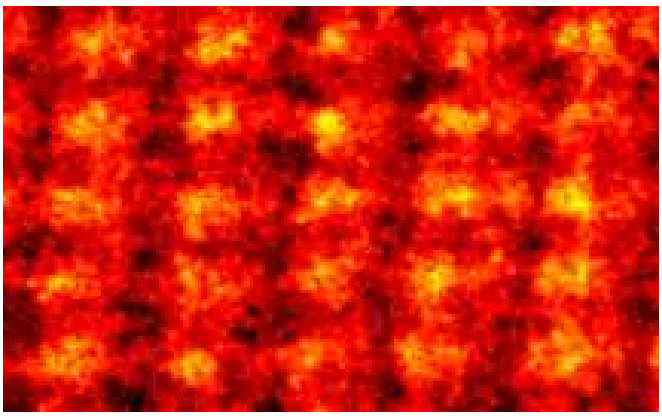


Silicon molecule
5 silicon atoms in a unit cell
Diamond lattice
Covalent bonds



14 electrons
4 valence electrons

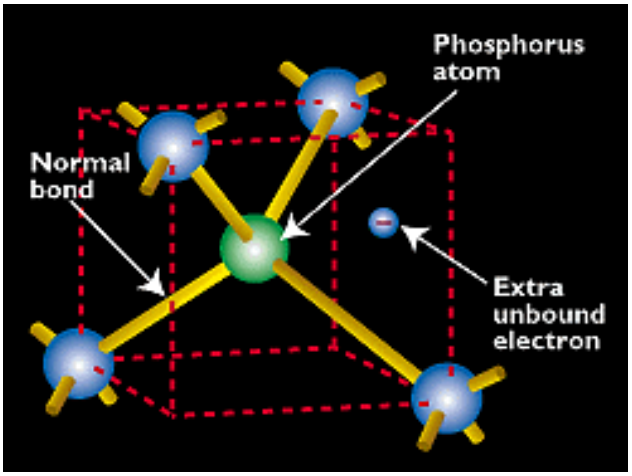




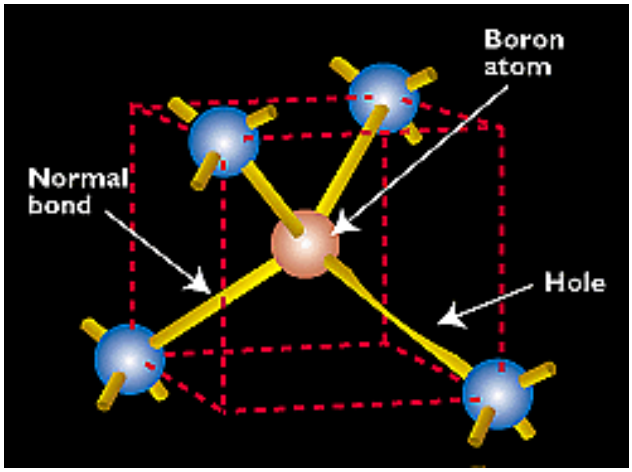
P.D. Neillist, "Incoherent Transmission Electron Microscopy"
Phys. Rev. Lett. 81, 4156 (9 Nov. 1998)

Silicon molecules: http://www.eere.energy.gov/pv/simolecule.html

Doped Silicon

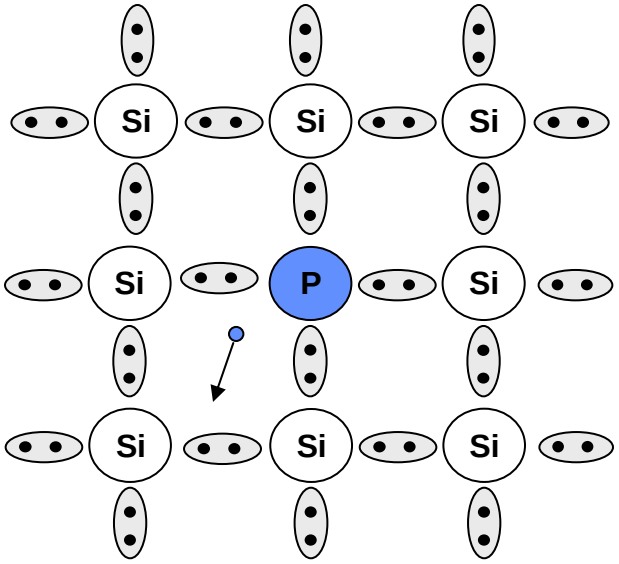


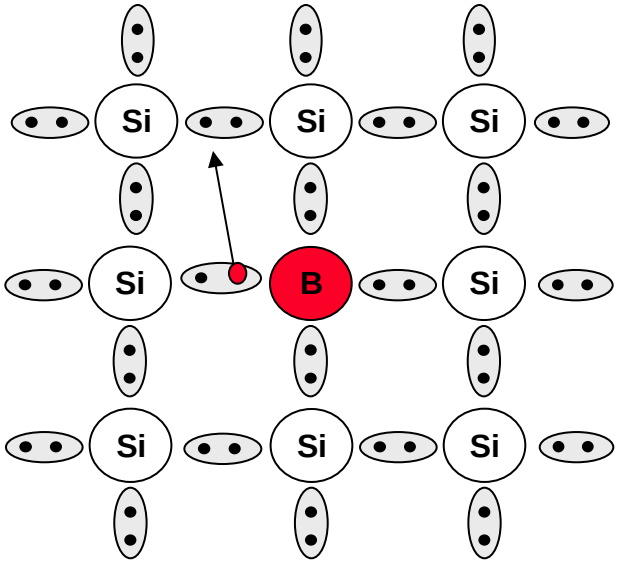
N- doped



P- doped

- bound electrons
- free electrons and holes





Silicon molecules: http://www.eere.energy.gov/pv/simolecule.html

Equilibrium Carrier Densities

$$n_n p_o = n_i^2 = 10^{20}\ \mathrm{cm}^{-3}$$

where n_o *is electron and* p_o hole carrier concentrations

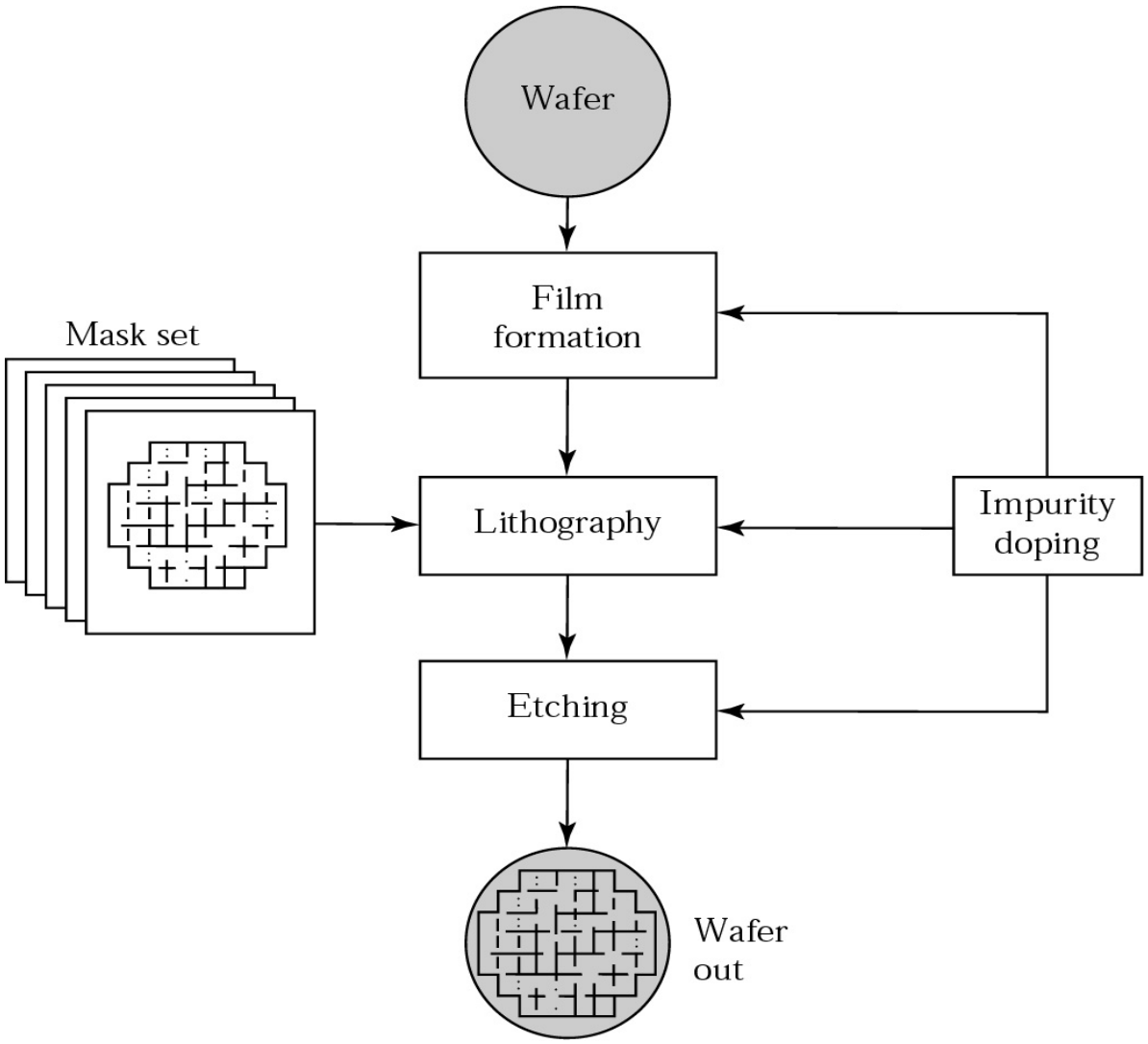
in most cases of interest the donor doping N_D *or acceptor* N_A doping concentration is much larger than the intrinsic concentration n_i so that

$$p_o = N_A \quad and \quad n_o = \frac{n_i^2}{N_A} \qquad p-type$$

$$n_o = N_D \quad and \quad p_o = \frac{n_i^2}{N_D} \qquad n-type$$

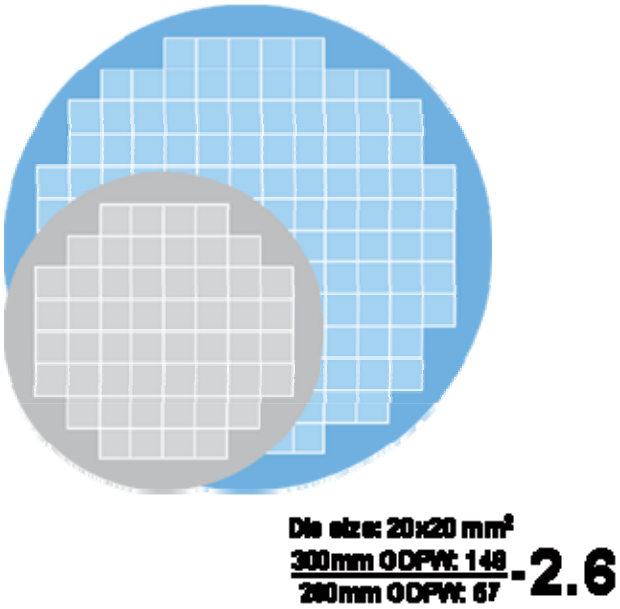
by convention, donor or acceptor concentrations as well as electron and hole concentrations are given as a number per cm^3

Integrated Circuit Fabrication



Where is it done?

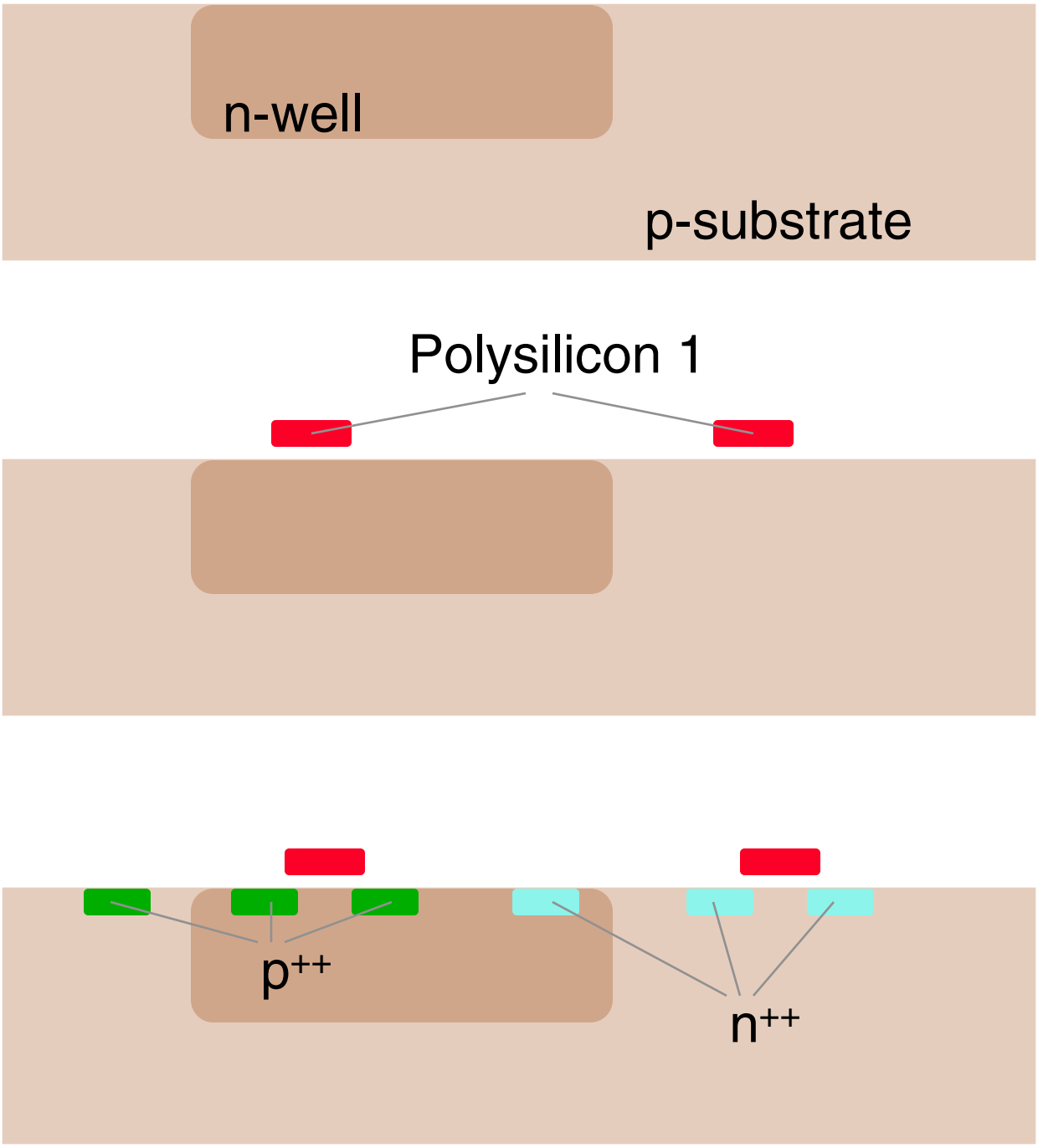
UMC 300mm wafers



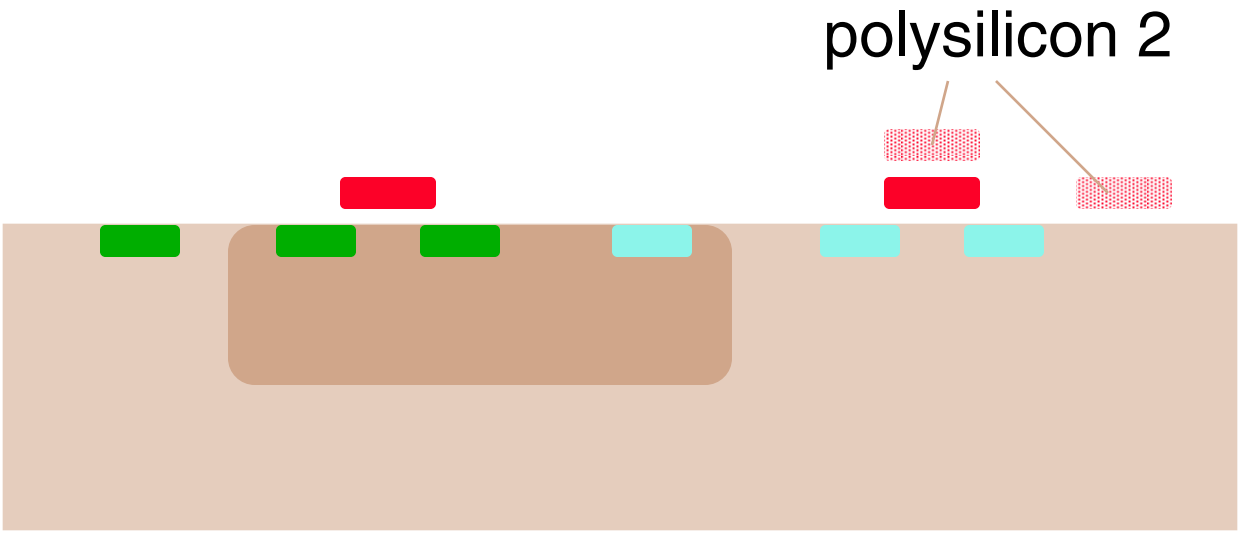
Basic CMOS components

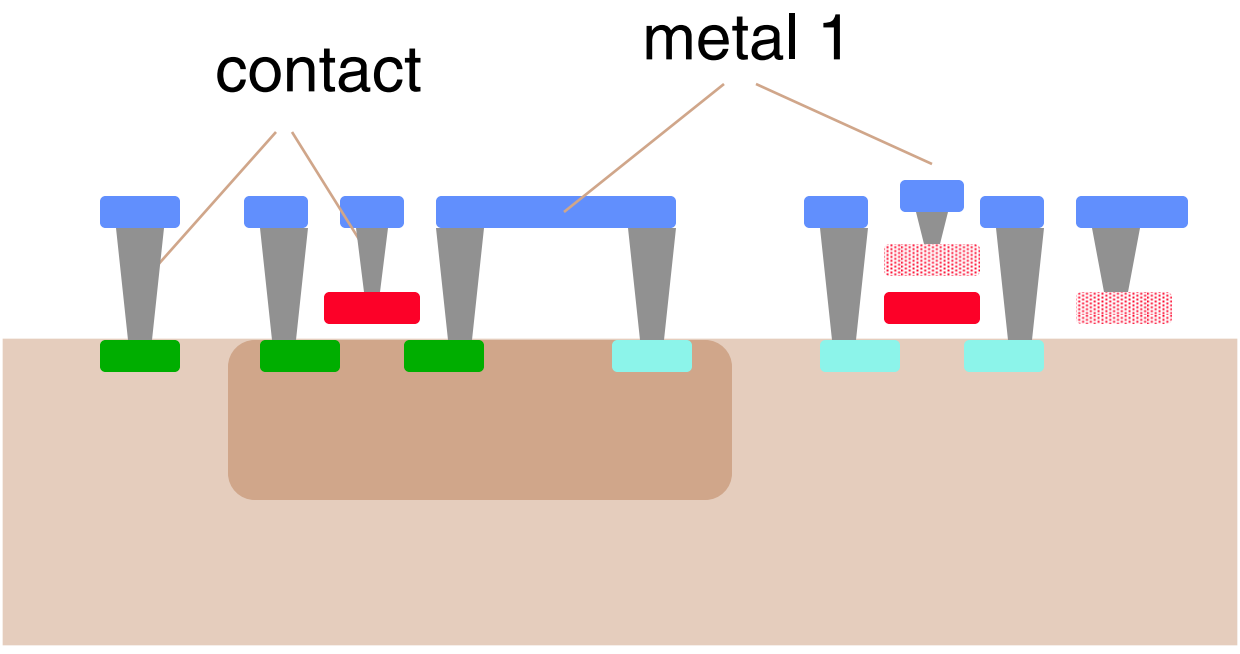
- Conductors
- Switches (MOS transistors)
- Capacitors (MOS capacitors)
- Inductors
- Resistors

Bulk CMOS Technology (I)

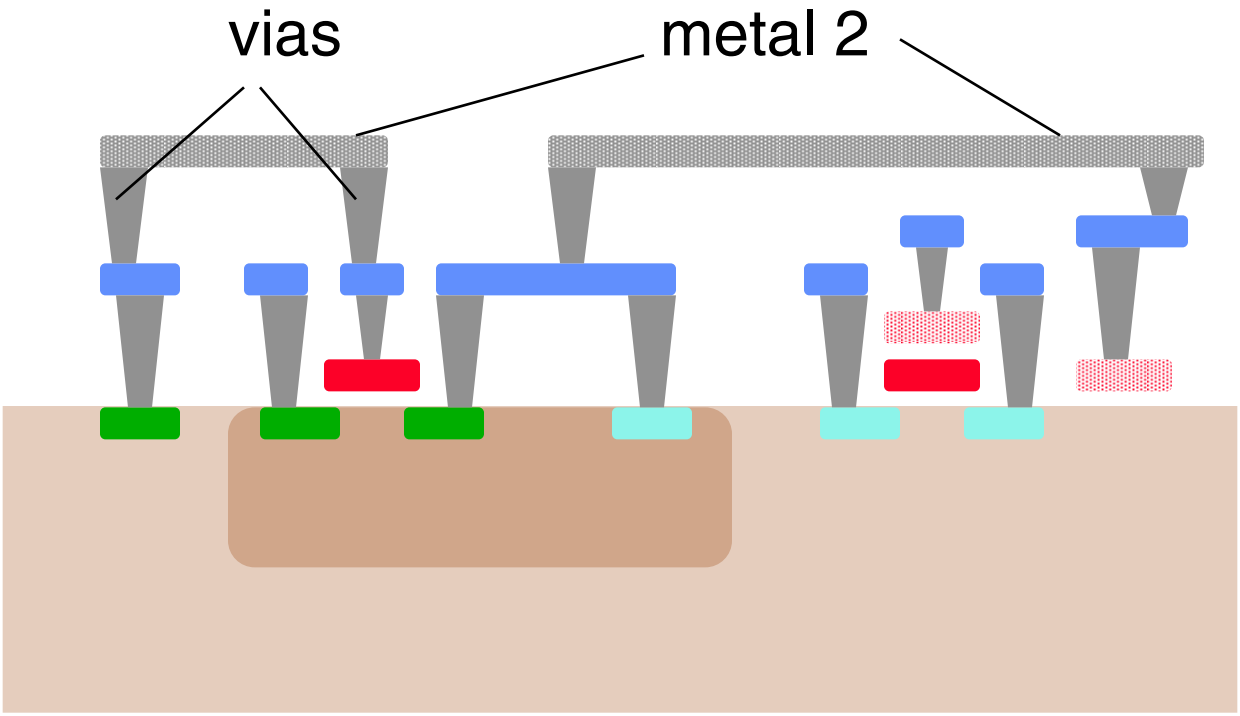


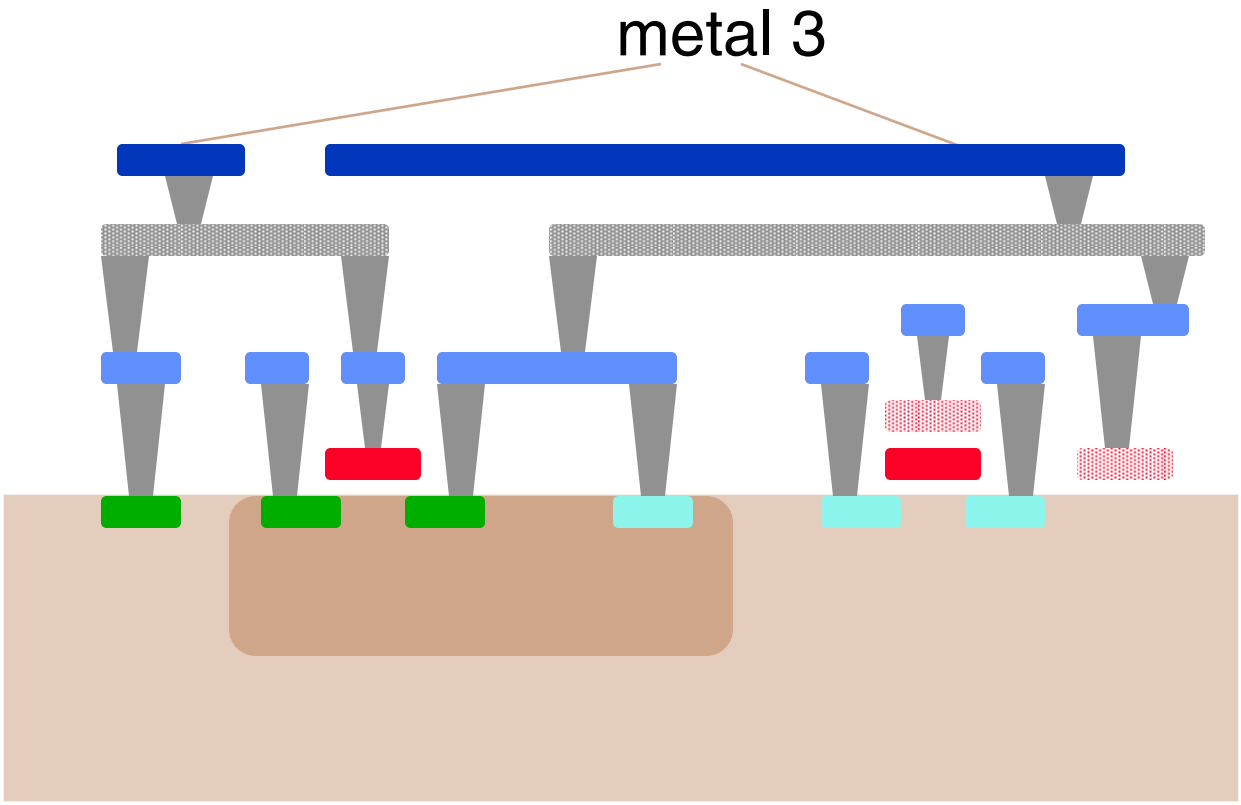
Bulk CMOS Technology (II)



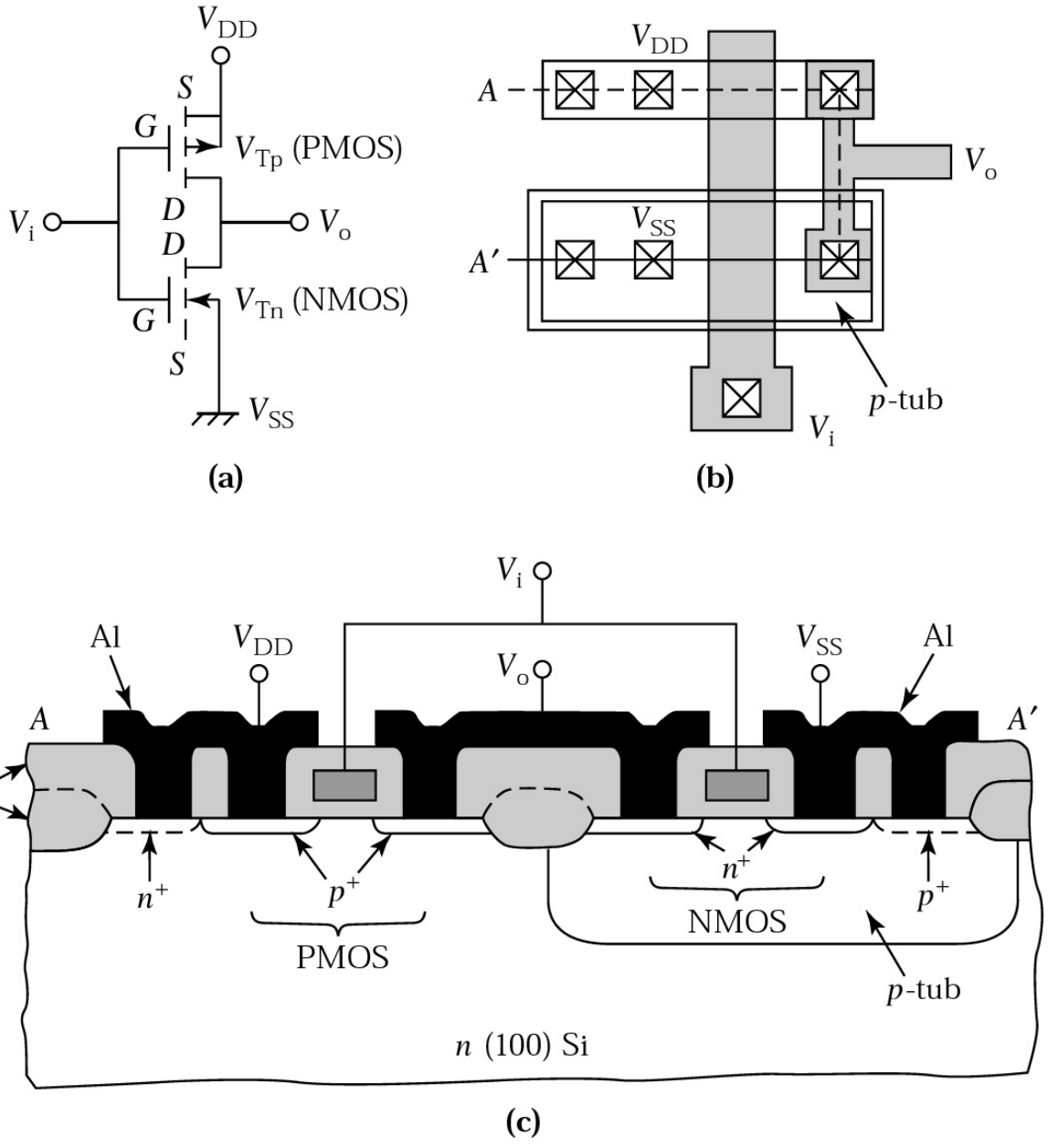


Bulk CMOS Technology (III)

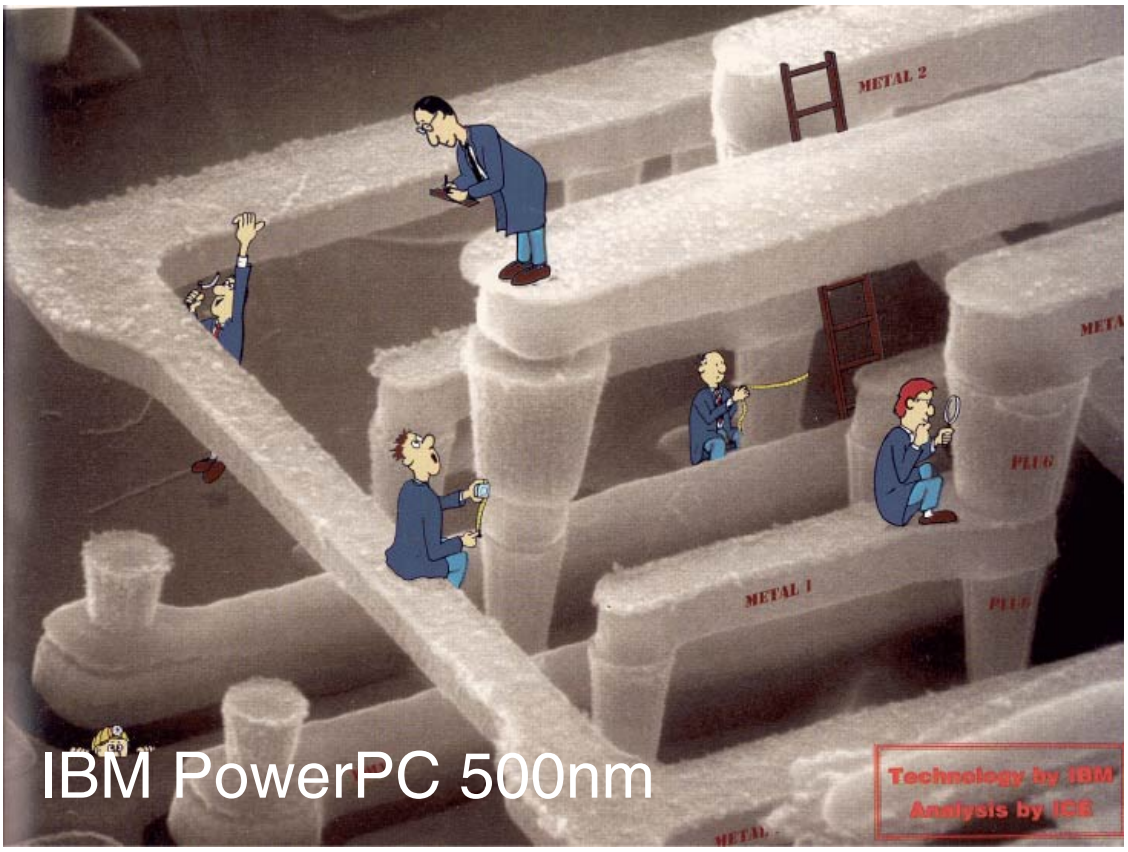


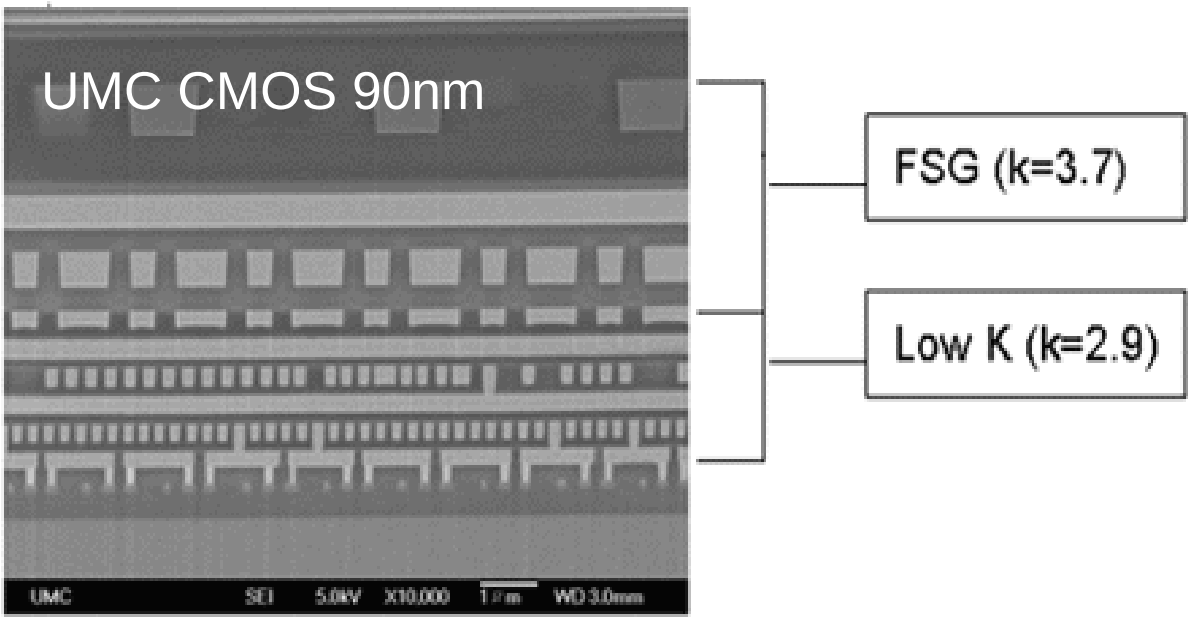


CMOS Inverter



Metallization Details





L90 1P9M Cu/Low-k (k<2.9)