We want:

![NMOS Diagram]

Gate G — Bulk Body

Source

4-terminal device

![PMOS Diagram]

But both NMOS + PMOS must exist in the same substrate

"N-well process"
"Dual-well process"

- Layout in mask for PBC 110

"Triple-well process"

p-substrate

n-substrate
7 Primary Chip Ingredients

1) Silicon - crystalline
   - Near-perfect crystal
   - Semiconductor - conduction can be altered

2) SiO₂ - Silicon dioxide
   - silicon + oxygen
   - insulator

3) Silicon - polycrystalline, poly, polysilicon
   - small crystalline regions

4) n-type dopants
   - 5 outer electrons
   - "donors"
   - Ex: phosphorus, arsenic

5) p-type dopants
   - 3 outer electrons
   - "acceptors"
   - Ex: boron, gallium

6) Metal wires
   - In past, aluminum. New copper.
   - Conductors

7) "Vertical" connections - Contacts/Vias
   - Tungsten and aluminum
5 Primary Fab. - Materials and Fab. Processes

1) Photore sist
   - Positive photore sist - becomes soluble when exposed to UV light
   - Negative " " insutable " " " "
   - Applied ~ 1 mm thick to entire wafer

2) Etching processes
   - Selectivity - what is etch and what is not
   - Acid (wet etch)
     Ex: HF acid
   - Plasma (dry etch)

3) Masks - one per patterned shape

4) Laying down material
   A) Deposition
      Ex: CVD - chemical vapor deposition
      Ex: SiO₂, silicon
   B) Growth
      Ex: SiO₂ on silicon substrate (gate oxide)
   C) Implantation
      - Produce high-dopant concentration regions
- Diffusion implantation
  - Silicon exposed to dopant gas at high temp.
- Im implantation
  - Implanted at high speed with an accelerator
  - Cause lattice damage
  - Normally follow with annealing
    - Ex: source/drain
      - Channels
      - Well + substrate contacts
      - Poly silicon
- D) Sputtering - for metal

5) Planarization - extreme flattening of wafers' surface

CMP: Chemical Mechanical Planarization

- for reliability
- for uniform layer thickness
Basic Repeated Process

1) Deposit a material

2) Coat with photoresist (P.R.)

3) Expose P.R. to a pattern of UV light with a mask

4) Remove soluble P.R.

5) Remove material below P.R. w/ etch

6) Remove remaining P.R.