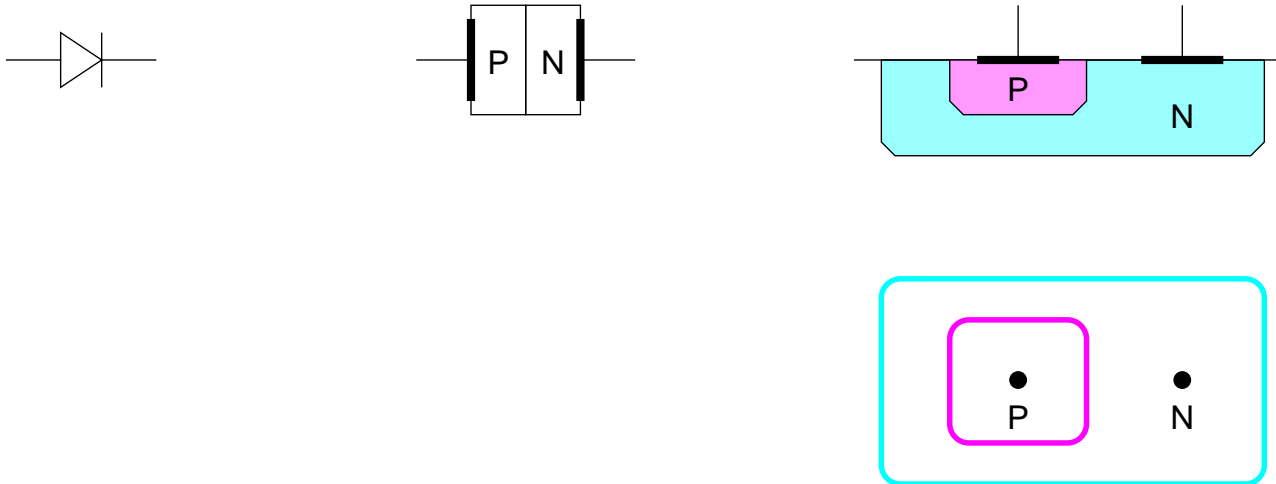


# Components for Digital IC Design

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## Diodes and Bipolar Transistors

Diode



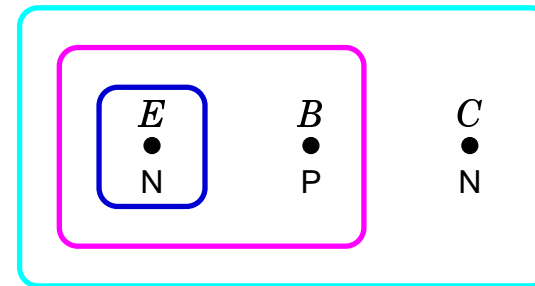
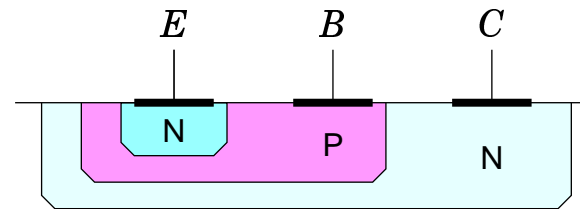
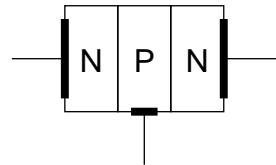
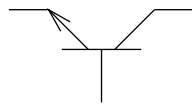
- Ideal structure - 1D
- Real structure - 3D
- Depth controlled implants.

# Components for Digital IC Design

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## Diodes and Bipolar Transistors

### NPN Transistor

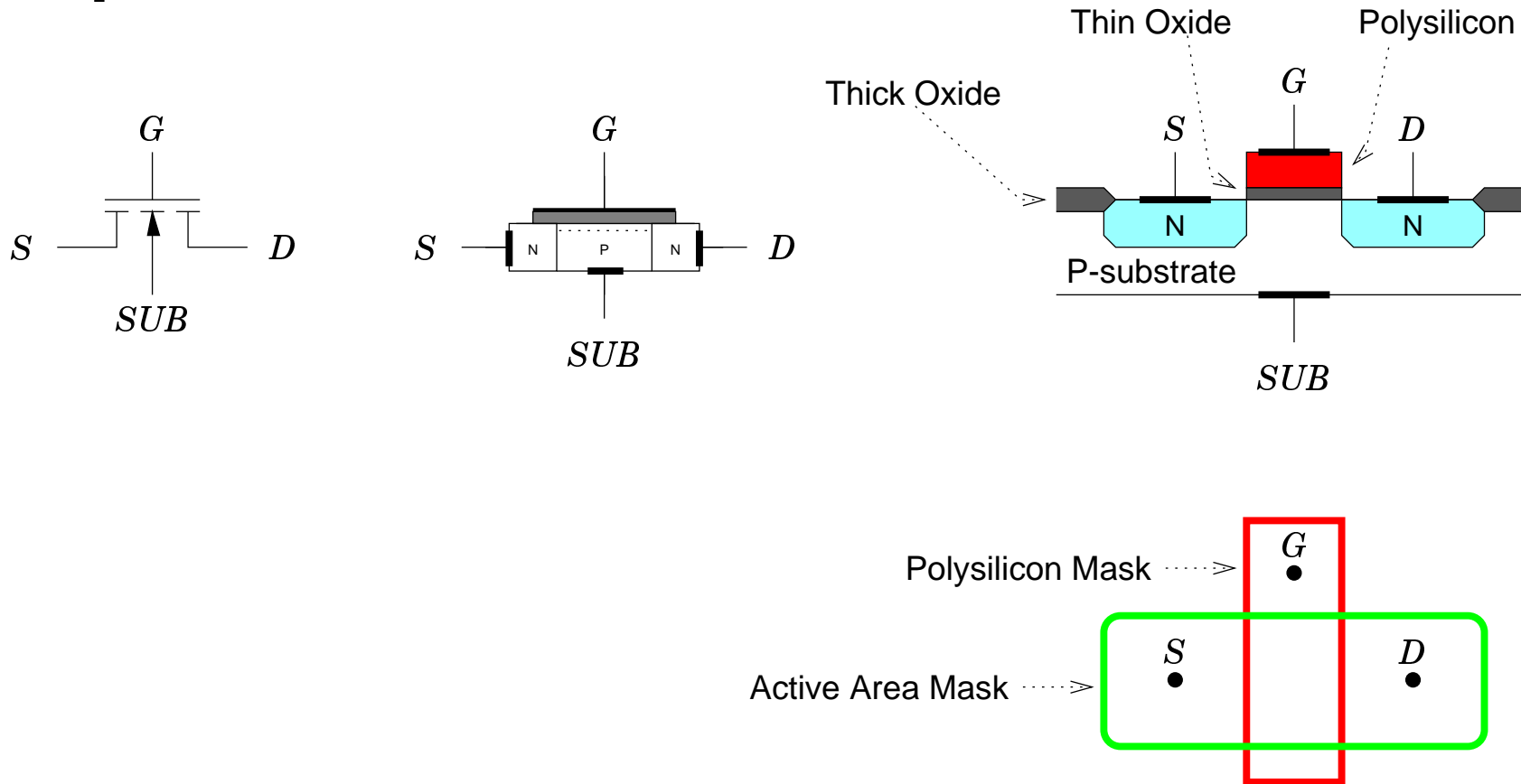


- Two n-type implants.

# Components for Digital IC Design

## MOS Transistors

### Simple NMOS Transistor



# Components for Digital IC Design

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## Simple NMOS Transistor

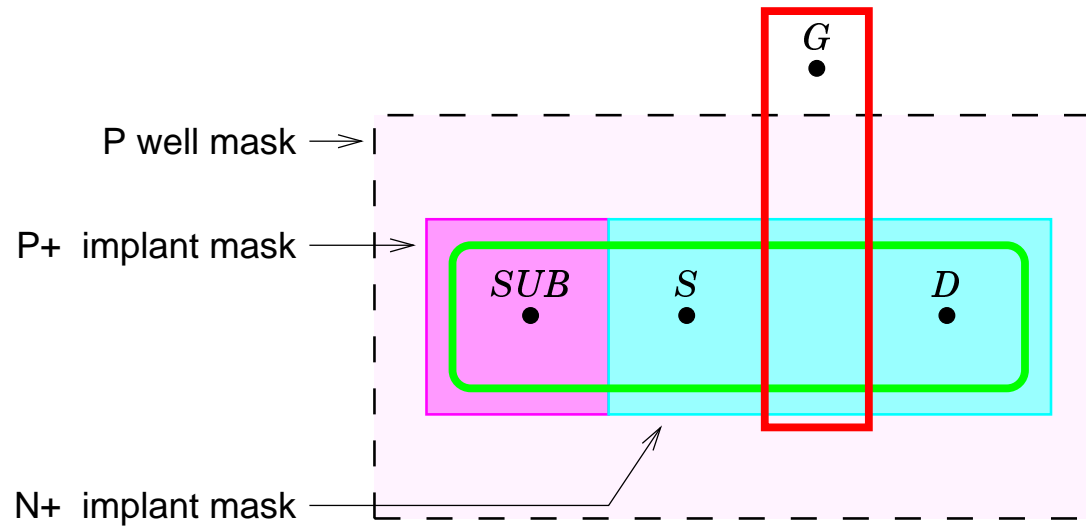
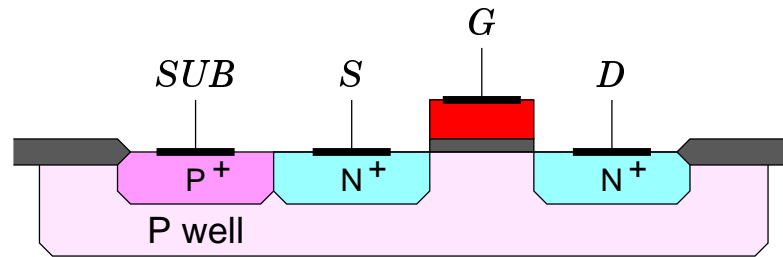
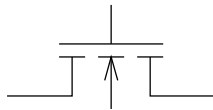
- Active Area mask defines extent of *Thick Oxide*.
- Polysilicon mask also controls extent of *Thin Oxide* (alias *Gate Oxide*).
- N-type implant has no extra mask.
  - It is blocked by thick oxide and by polysilicon.
  - The implant is *Self Aligned*.
- Substrate connection is to bottom of wafer.
  - All substrates to ground.
- Gate connection not above transistor area.
  - Design Rule.

# Components for Digital IC Design

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## MOS Transistors

### NMOS Transistor



# Components for Digital IC Design

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## NMOS Transistor

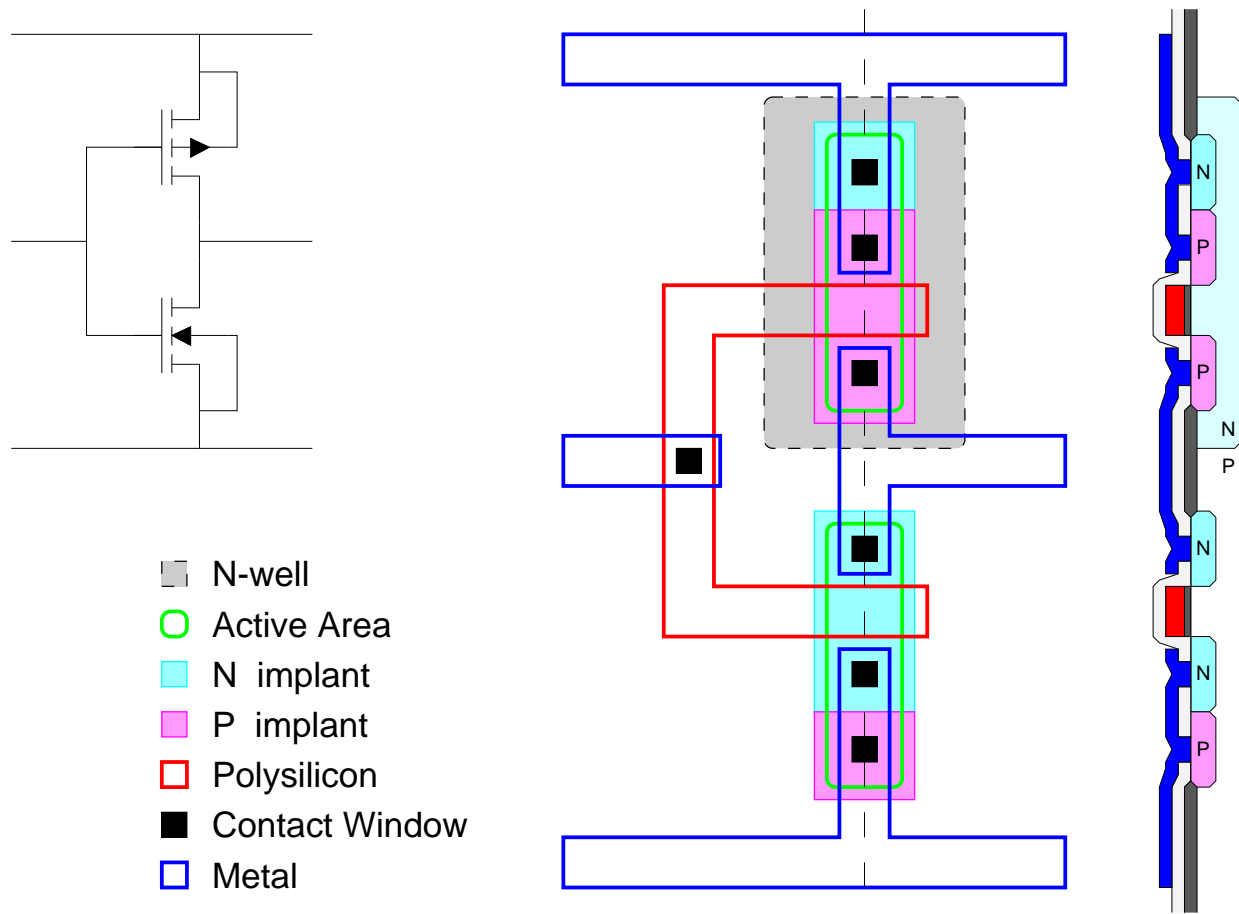
Where it is not suitable for substrate connections to be shared, a more complex process is used.

- Five masks must be used to define the transistor:
  - P Well
  - Active Area
  - Polysilicon
  - N+ implant
  - P+ implant
- P Well, for isolation.
- Top *substrate* connection.
- P+/N+ implants produce good *ohmic* contacts.

# CMOS Process

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## CMOS Inverter



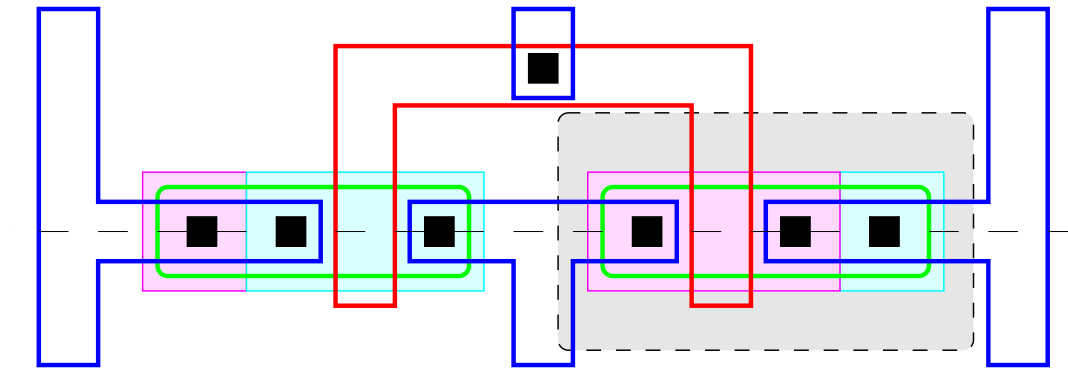
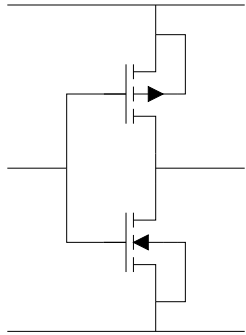
# CMOS Process








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## CMOS Inverter

- The process described here is an *N Well process* since it has only an N Well. P Well and Twin Tub processes also exist.
- Note that the P-N junction between chip substrate and N Well will remain reverse biased.  
Thus the transistors remain isolated.
- N implant defines NMOS source/drain and PMOS substrate contact.
- P implant defines PMOS source/drain and NMOS substrate contact.





-  N-well
-  Active Area  
defines Thick Oxide
-  Polysilicon  
defines Thin Oxide
-  N implant  
aligned to AA and Poly
-  P implant  
aligned to AA and Poly
-  Contact Window
-  Metal

