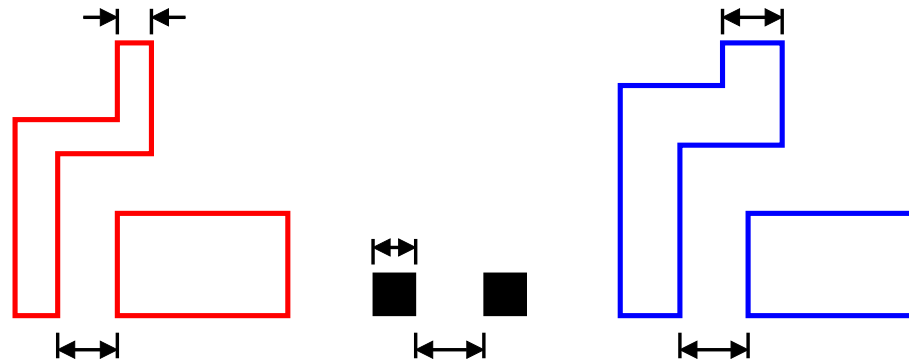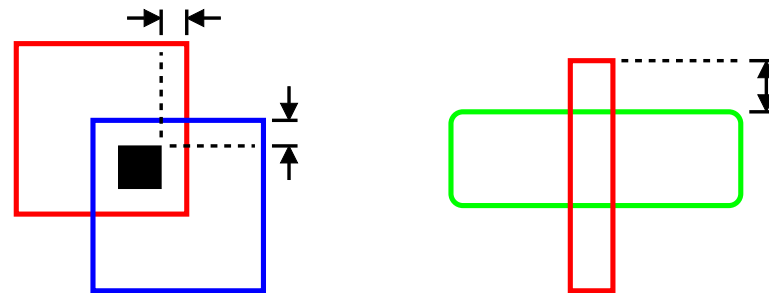# Design Rules

To prevent chip failure, designs must conform to design rules:

- Single layer rules

- Multi-layer rules
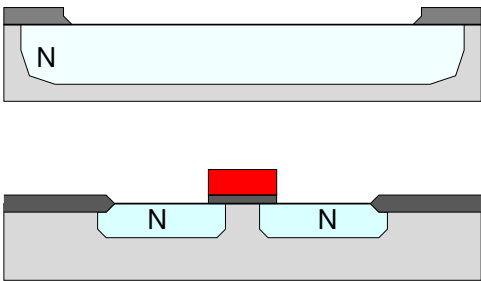
Derivation of Design Rules
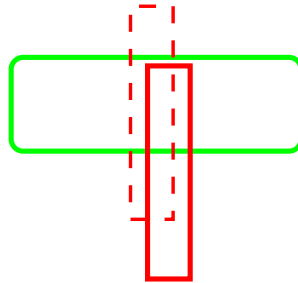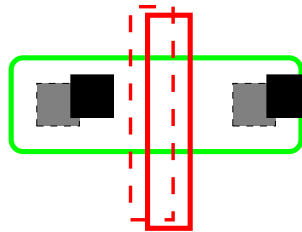
Isotropic Etching

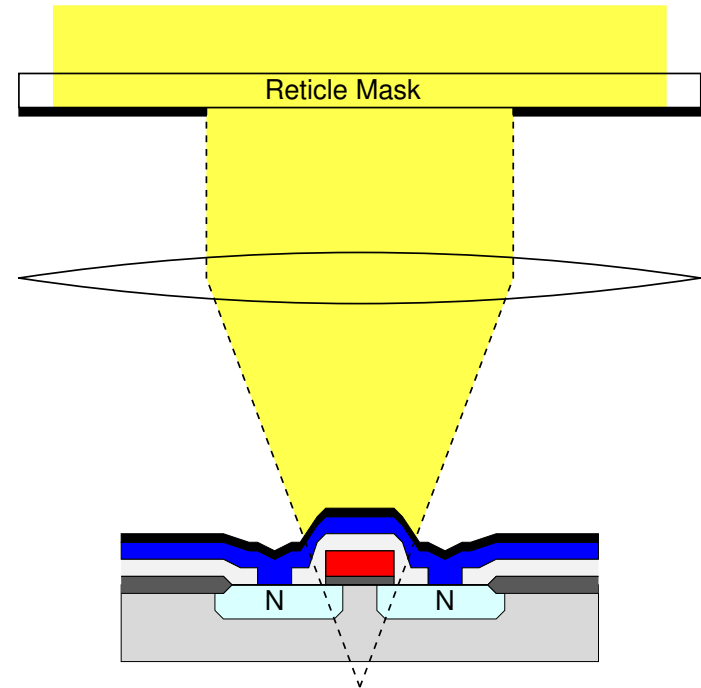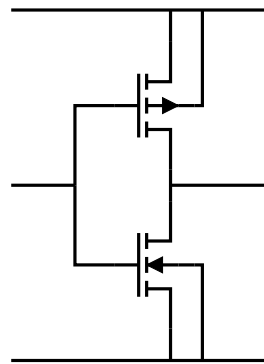**Lateral Diffusion**

N

N   N

Mask Misalignment

Misalignment can be Cumulative

☐ is aligned to ◯

■ is aligned to ☐

Optical Focus over 3D terrain

Reticle Mask

N   N

Design Rules

0.5 μm CMOS inverter

N–well

Active Area

P implant
= NOT{ N implant }

Polysilicon

Contact Window

Metal

Abstraction

Levels of Abstraction

- Mask Level Design
  - Laborious Technology/Process dependent.
  - Design rules may change during a design!

- Transistor Level Design
  - Process independent, Technology dependent.

- Gate Level Design
  - Process/Technology independent.

5004

Abstraction - Stick Diagrams
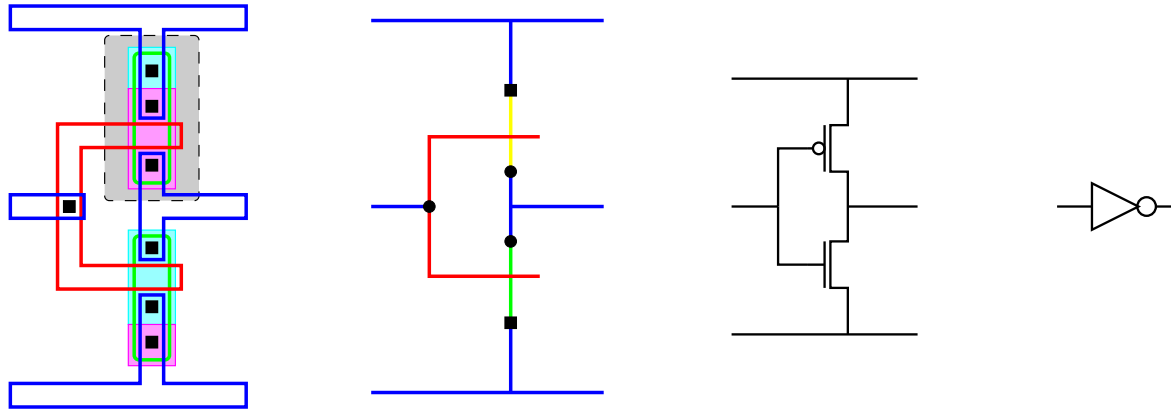
Stick diagrams give us many of the benefits of abstraction:

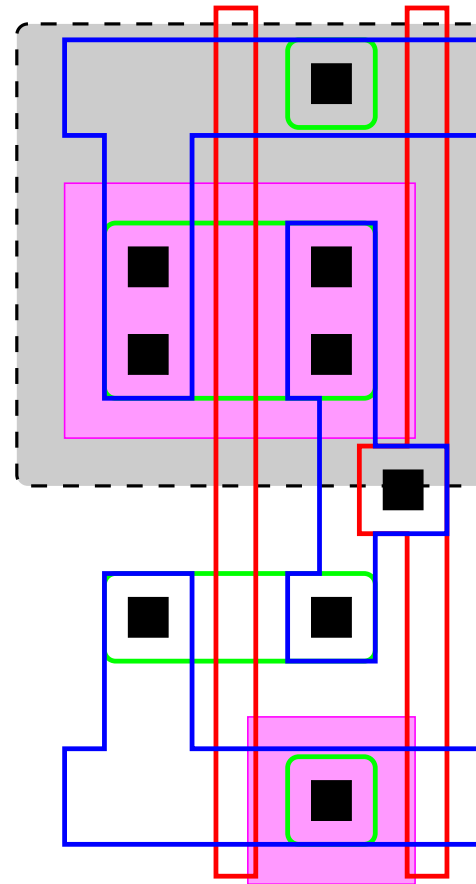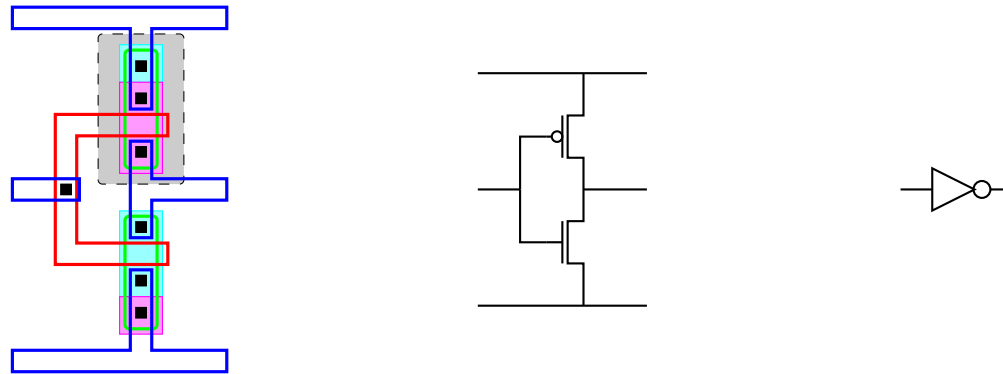- Much easier/faster than full mask specification.

- Process independent (valid for any CMOS process).

- Easy to change.

while avoiding some of the problems:

- Optimized layout may be generated much more easily from a stick diagram than from transistor or gate level designs.[1]

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[1]note that all IC designs must end at the mask level.

Digital CMOS Design
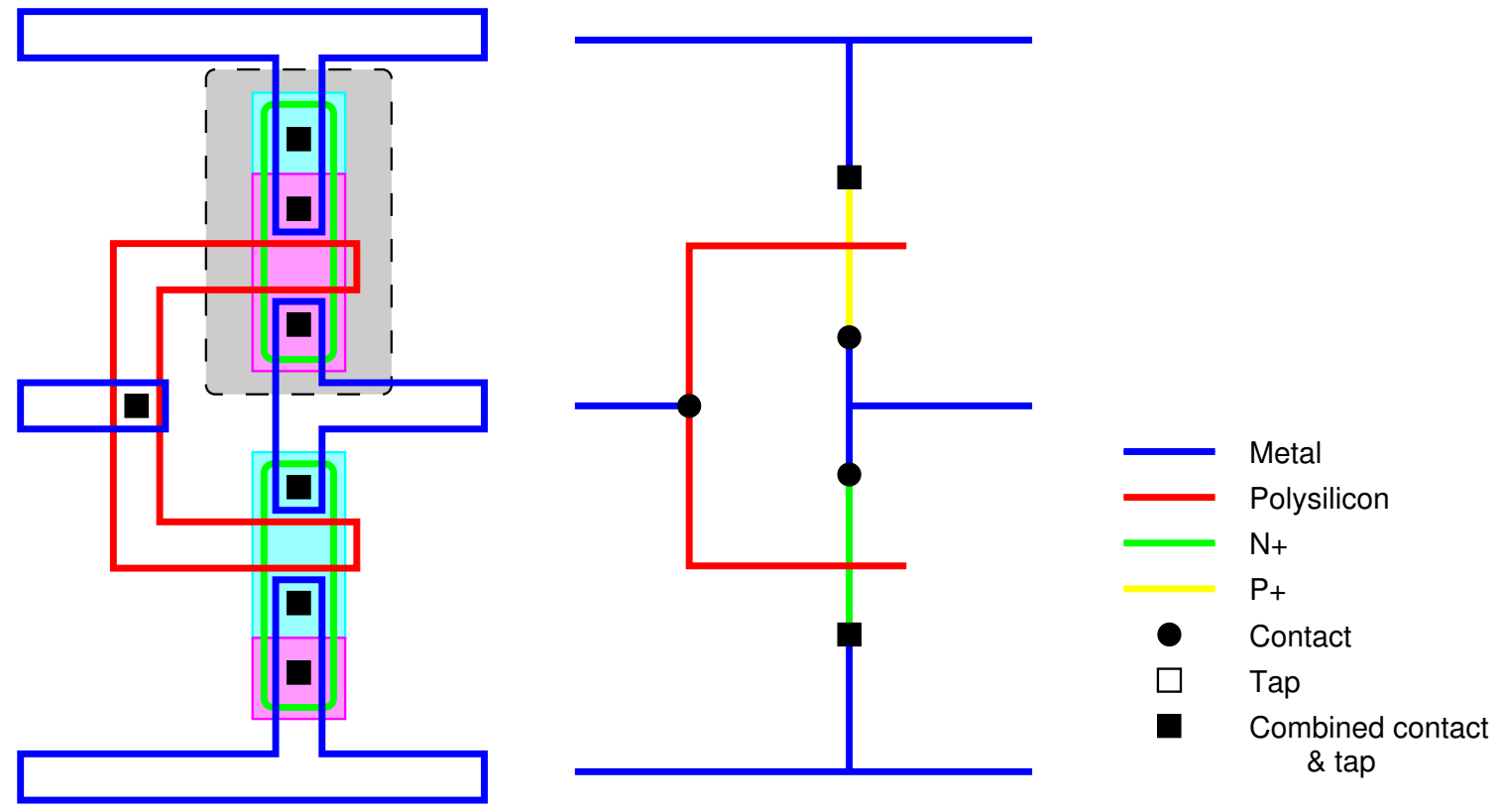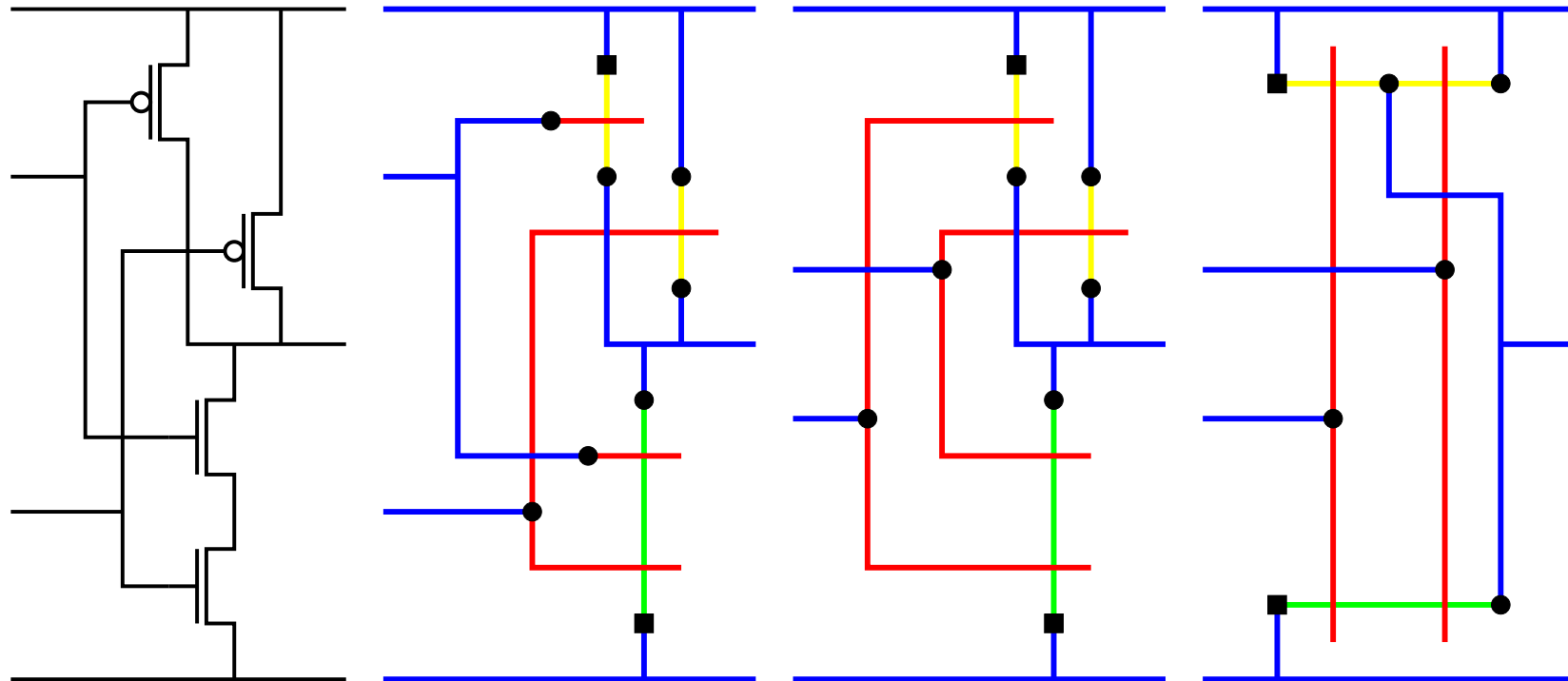
Stick Diagrams

Metal

Polysilicon

N+

P+

● Contact

□ Tap

■ Combined contact & tap

5006

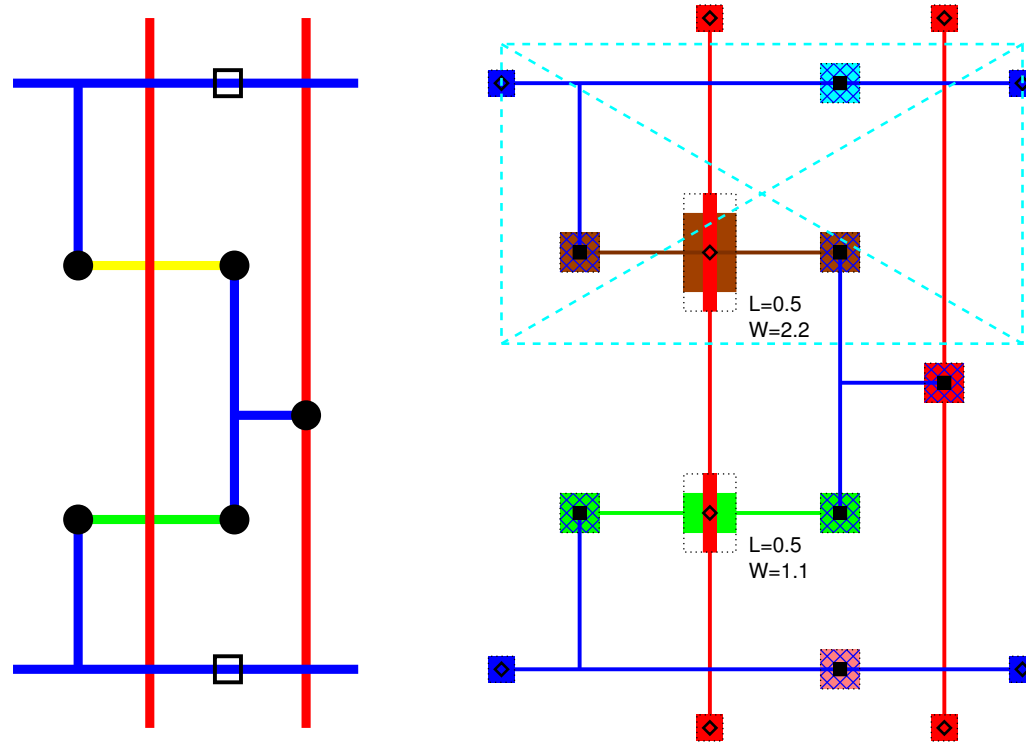# Digital CMOS Design

Stick Diagrams

5007

Digital CMOS Design

Stick Diagrams

- *Explore your Design Space.*

  - Implications of crossovers.

  - Number of contacts.

  - Arrangement of devices and connections.

- Process independent layout.

- Easy to expand to a full layout for a particular process.

Sticks and CAD - Symbolic Capture

- Transistors are placed and explicitly sized.

  - components are joined with zero width wires.

  - contacts are automatically selected as required.

- A semi-automatic compaction process will create DRC correct layout.

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Sticks and CAD - Magic
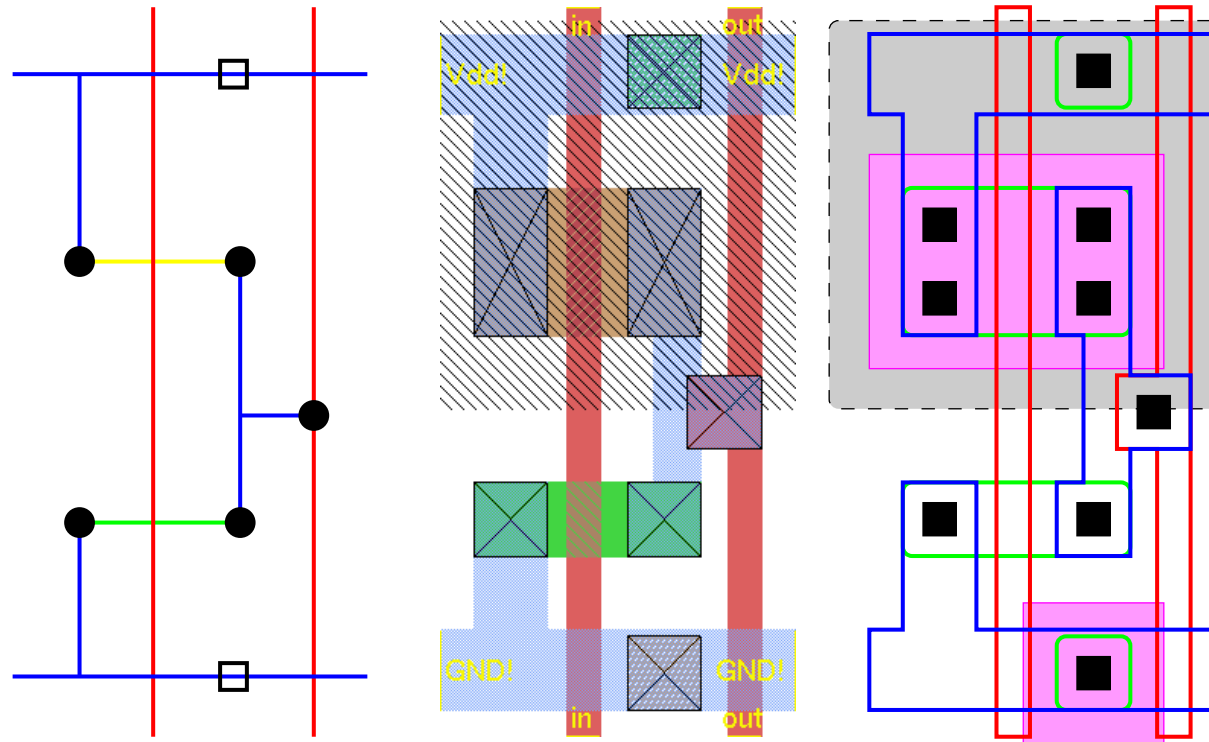
- Log style design (sticks with width) - DRC errors are flagged immediately.
  - again contacts are automatically selected as required.

- On-line DRC leads to rapid generation of correct designs.
  - symbolic capture style compaction is available if desired.