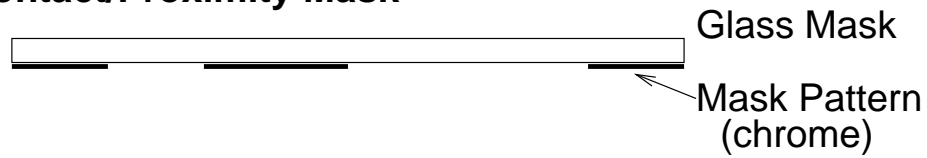


Photolithography

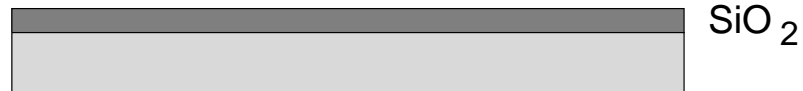
Contact/Proximity Mask



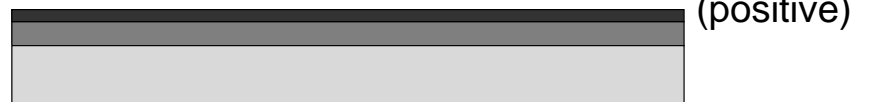
Silicon Wafer



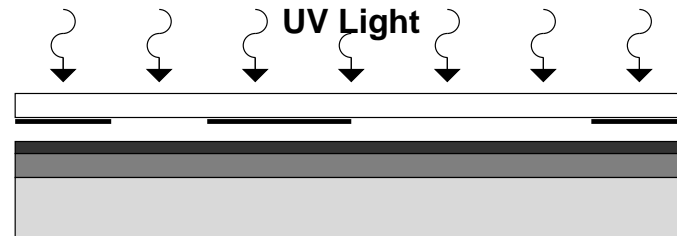
Oxide Growth



Photoresist Deposition



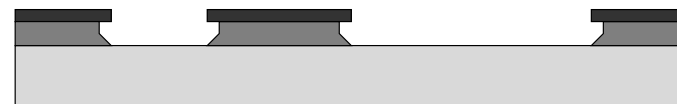
Photoresist Exposure



Photoresist Development



Oxide Etch

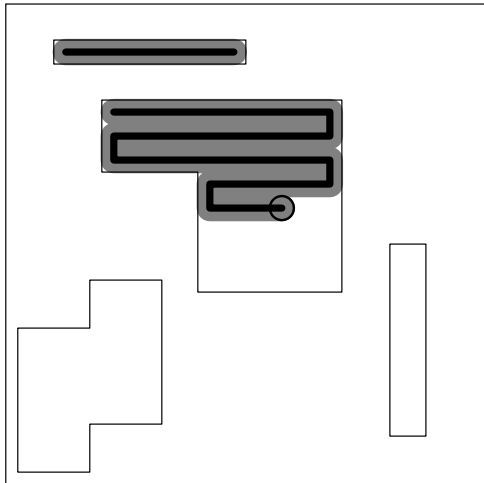


Photoresist Strip

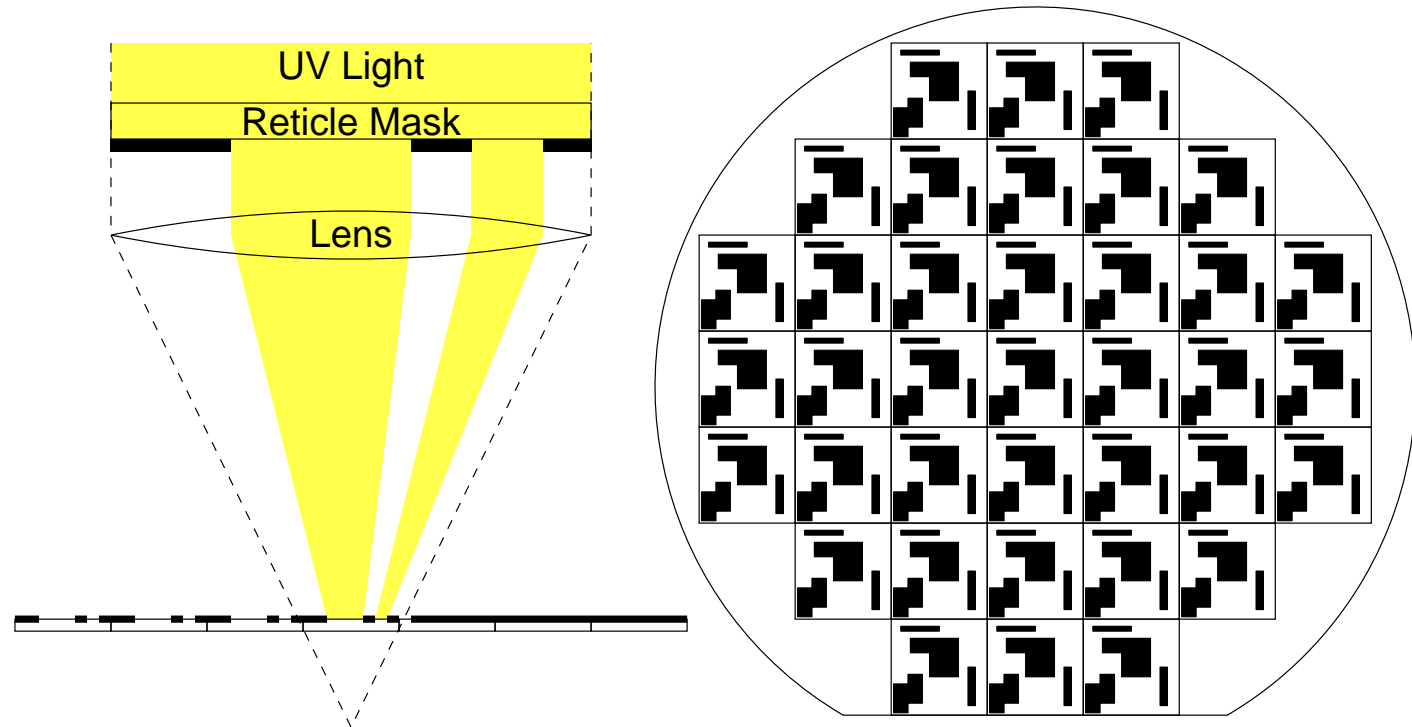


Mask Making

Reticle written by scanning electron beam



Pattern reproduced on wafer (or contact/proximity mask) by step and repeat with optical reduction

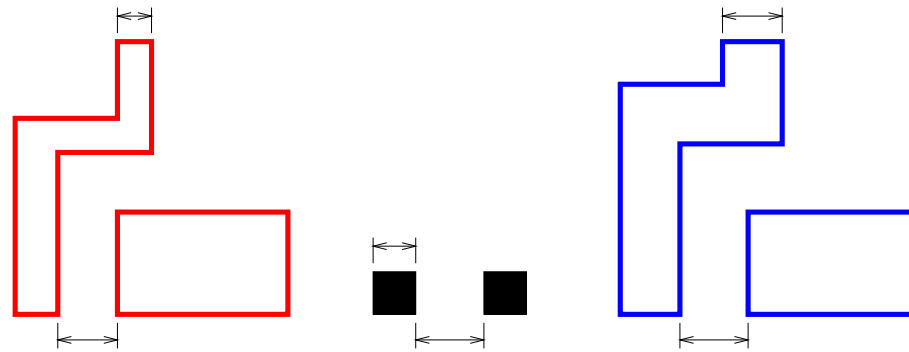


- Optical reduction allows narrower line widths.

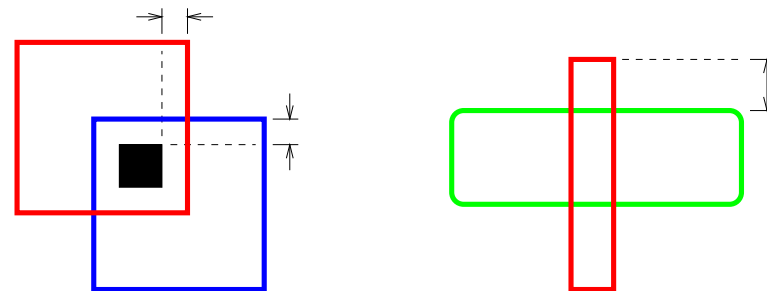
Design Rules

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

- Single layer rules



- Multi-layer rules

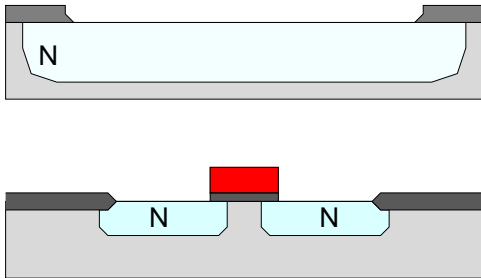


Derivation of Design Rules

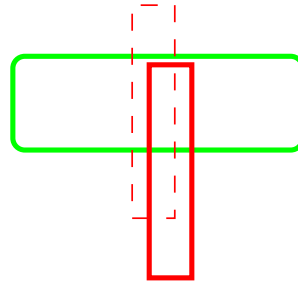
Isotropic Etching



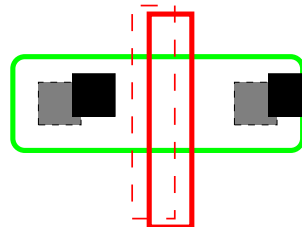
Lateral Diffusion



Mask Misalignment

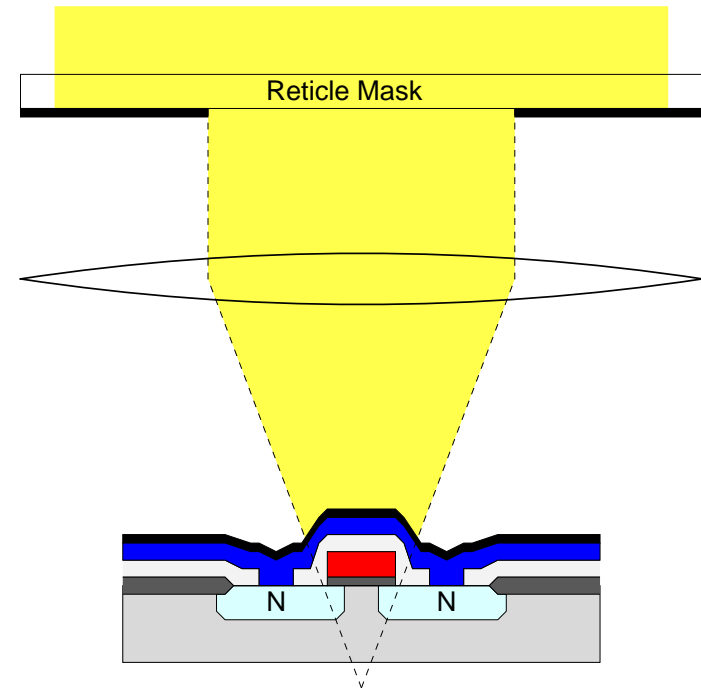


Misalignment can be Cumulative



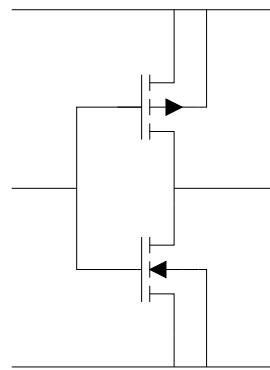
□ is aligned to ○
■ is aligned to □

Optical Focus over 3D terrain

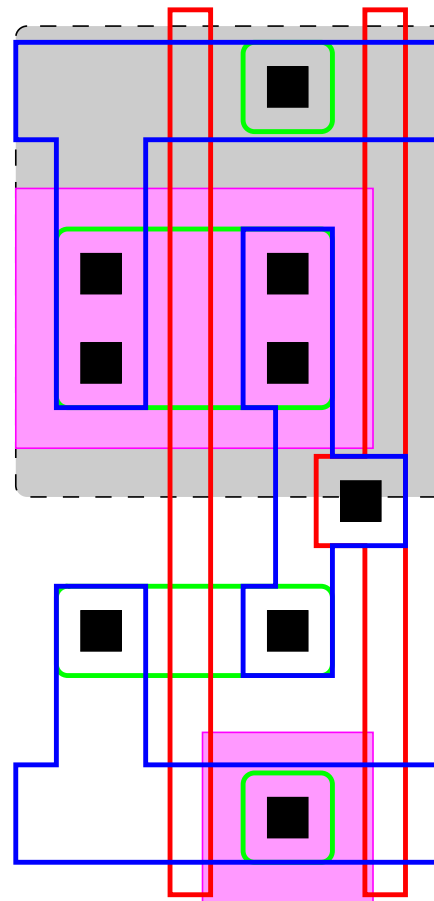


Design Rules

0.5 μm CMOS inverter

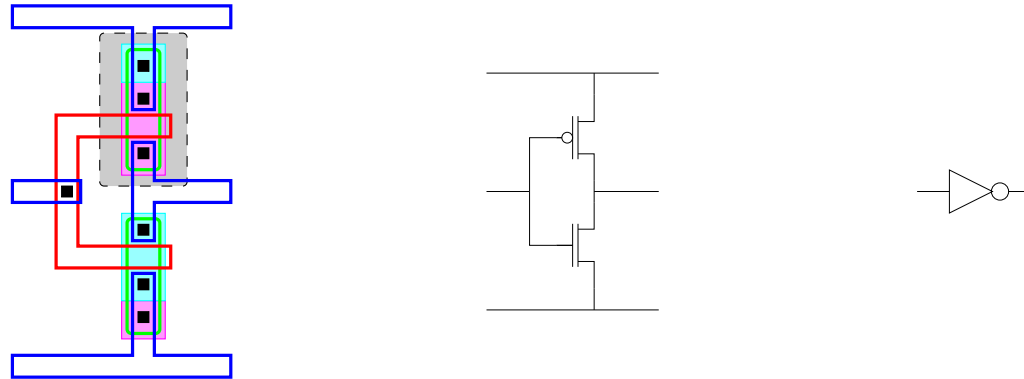


- N-well
- Active Area
- P implant
= NOT{ N implant }
- Polysilicon
- Contact Window
- Metal



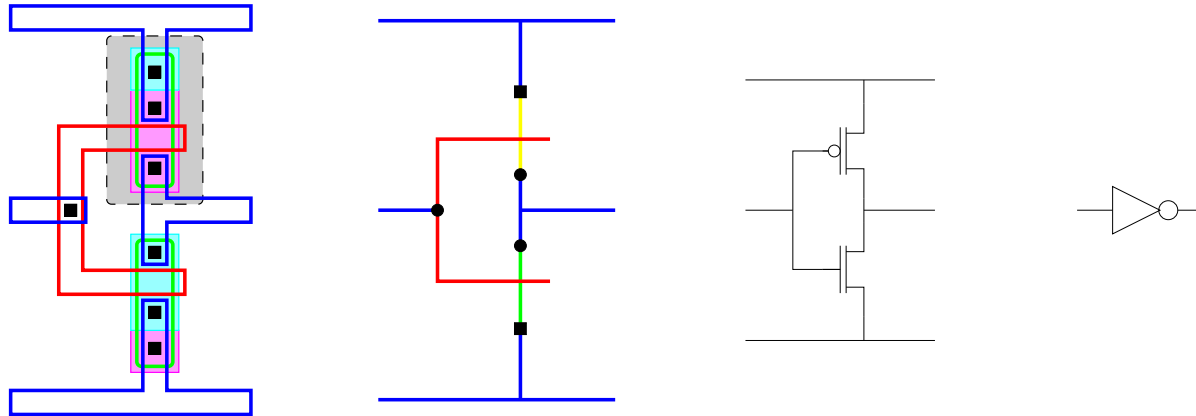
Abstraction

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.

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.

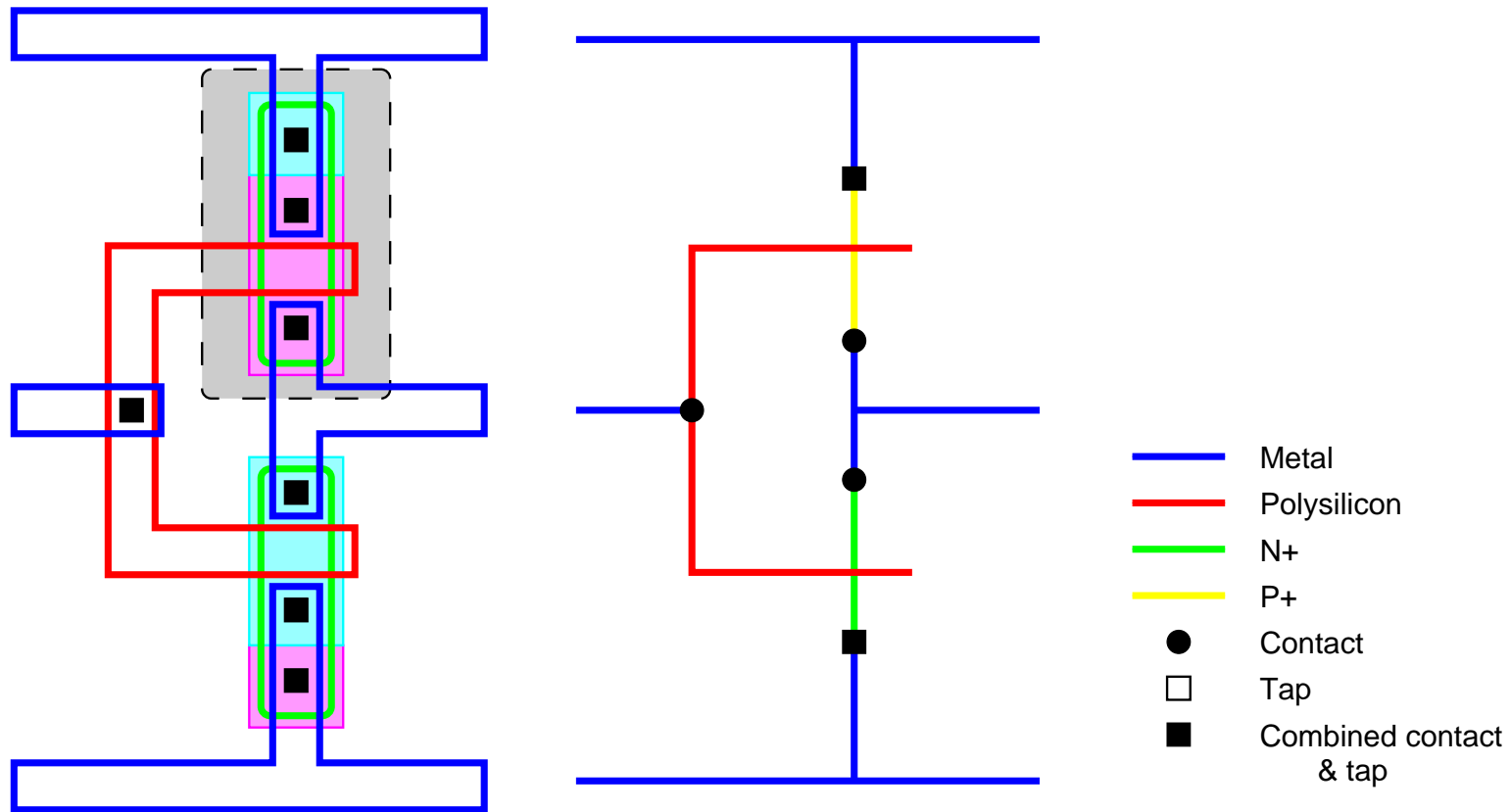
while avoiding some of the problems:

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

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

Digital CMOS Design

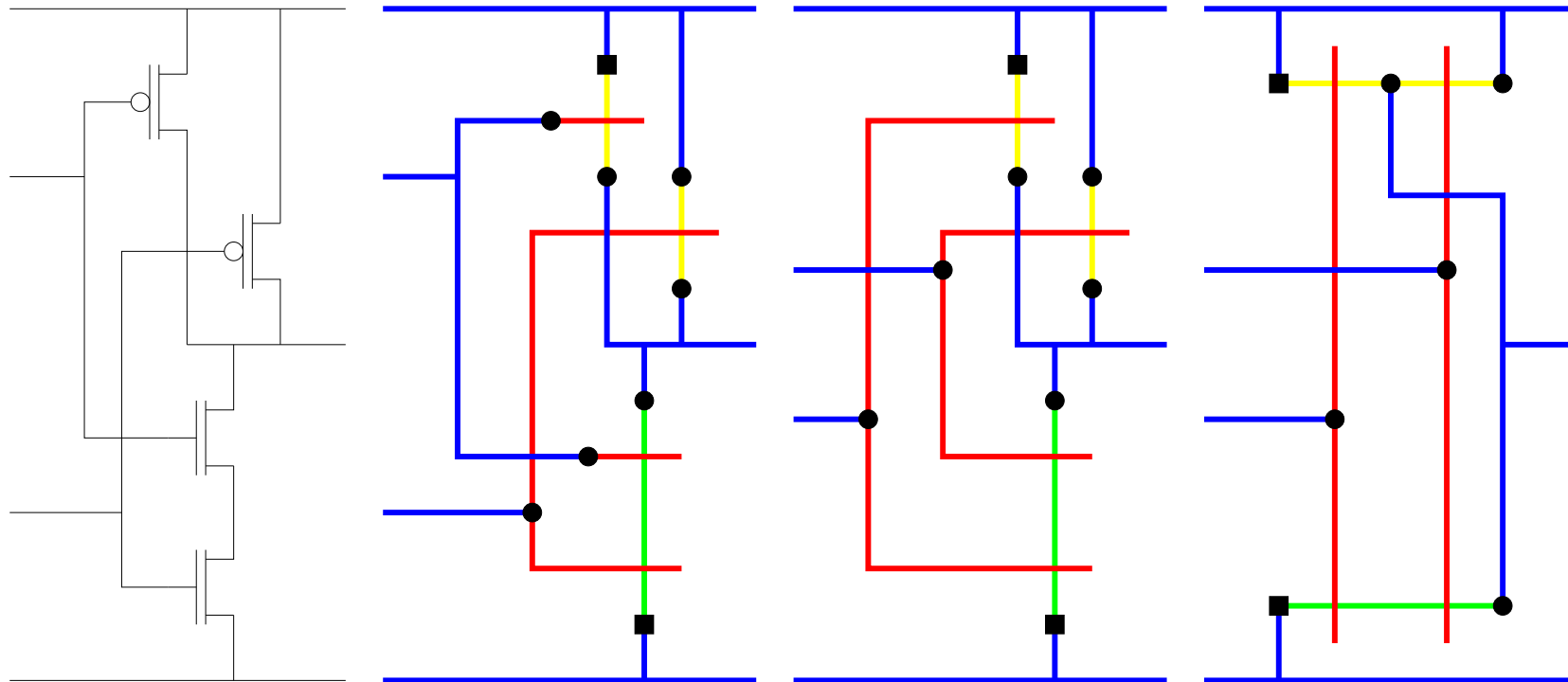
Stick Diagrams



4008

Digital CMOS Design

Stick Diagrams

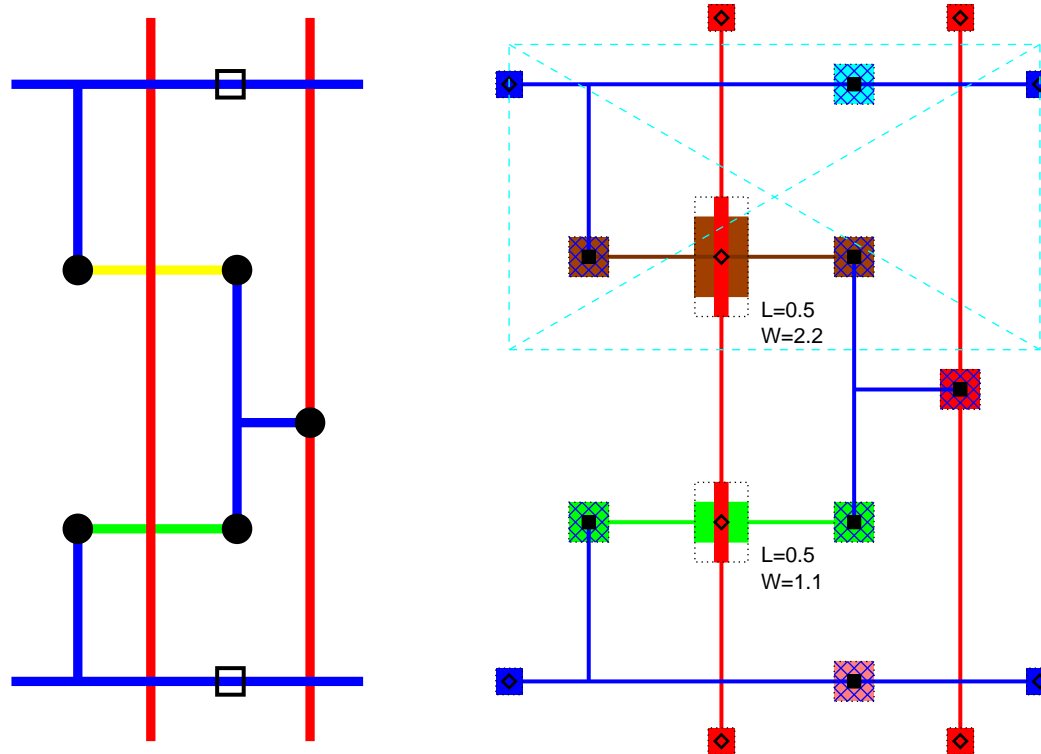


Digital CMOS Design

Stick Diagrams

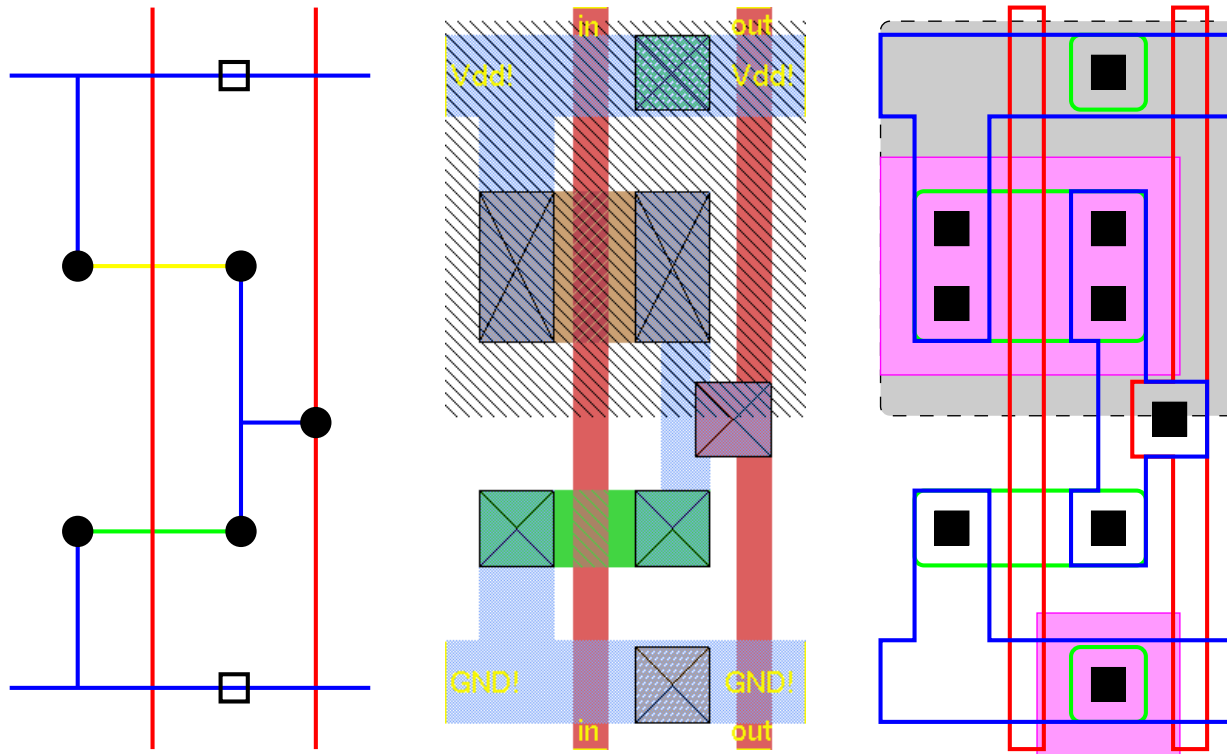
- *Explore your Design Space.*
 - Implications of crossovers.
 - Number of contacts.
 - Arrangement of devices and connections.
- Process independent layout.
- Easy to expand to a full layout for a particular process.

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.

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.