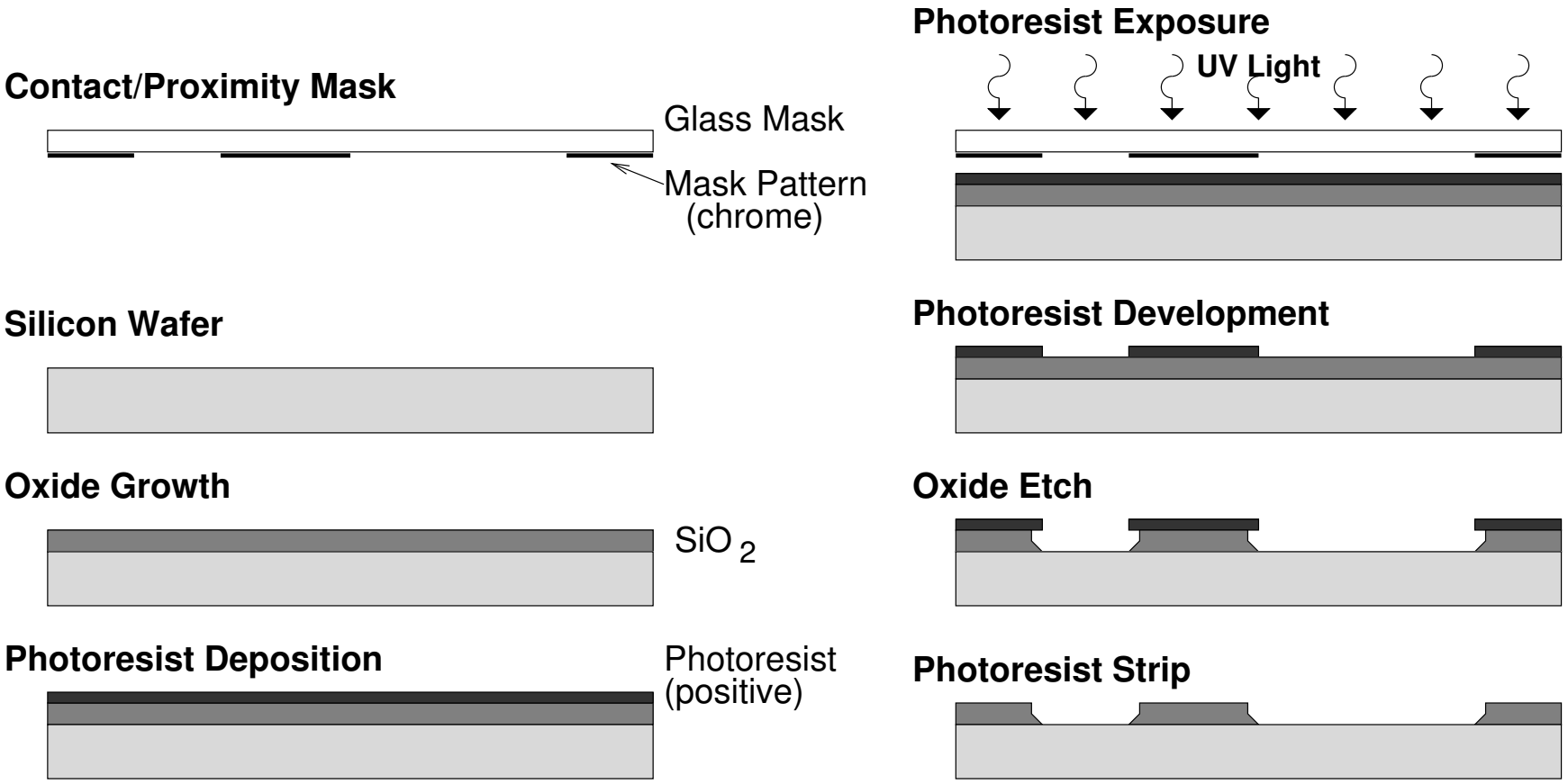
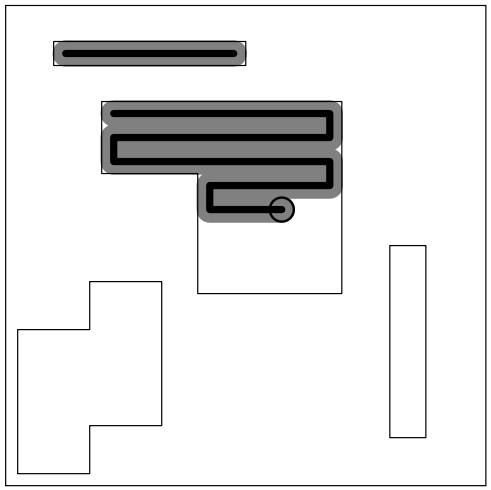
Photolithography

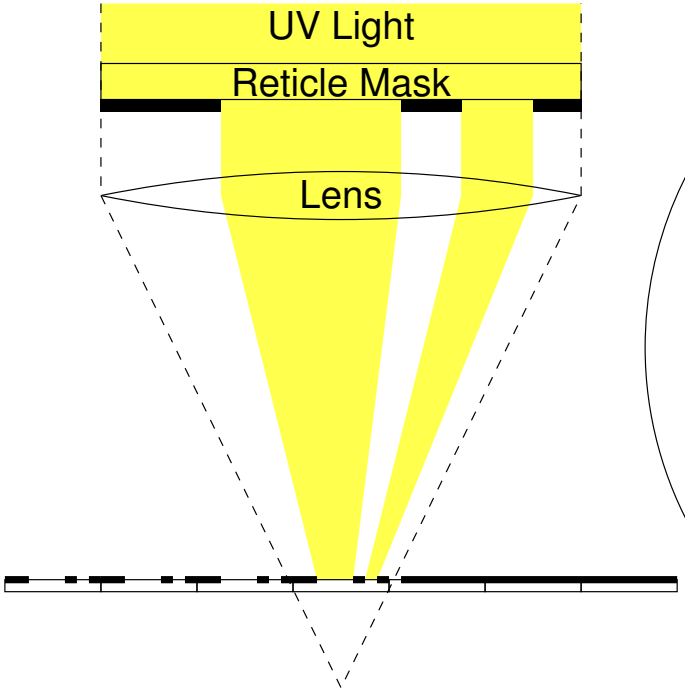


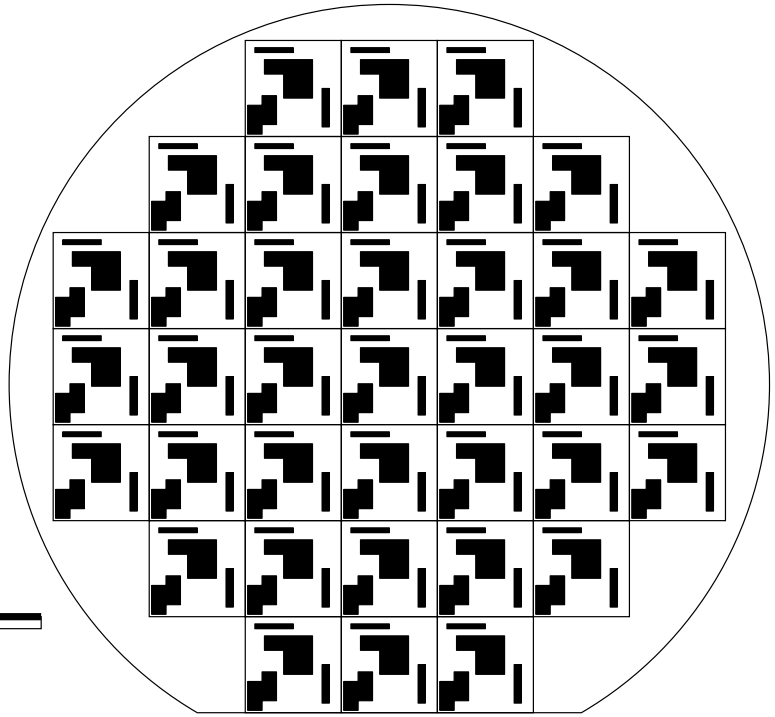
Mask Making

Reticle written by scanning electron beam



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



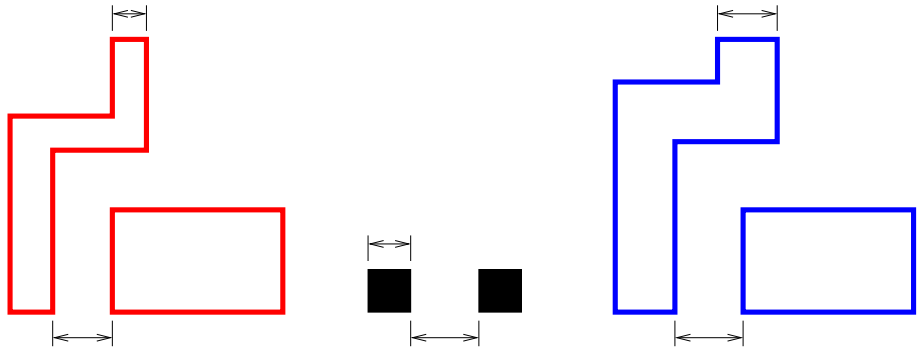


- Optical reduction allows narrower line widths.

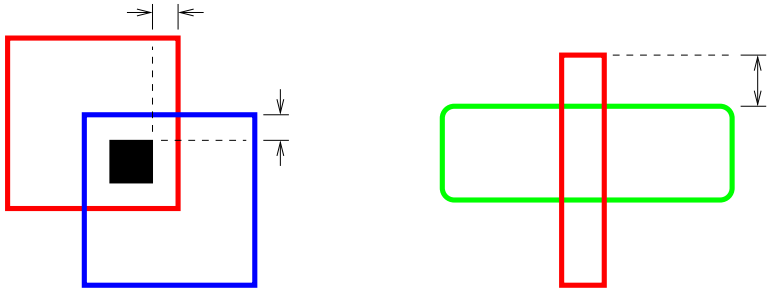
Design Rules

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

- Single layer rules



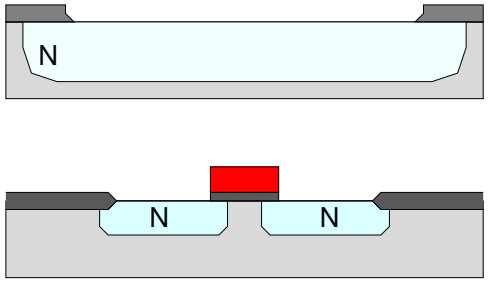
- Multi-layer rules



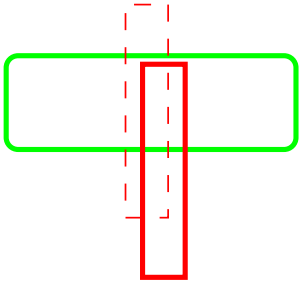
Derivation of Design Rules

Isotropic Etching

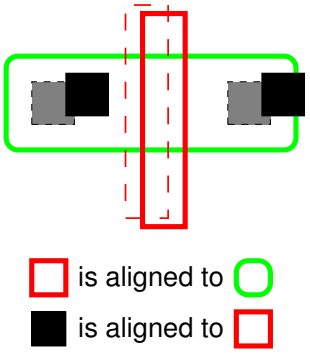
Lateral Diffusion



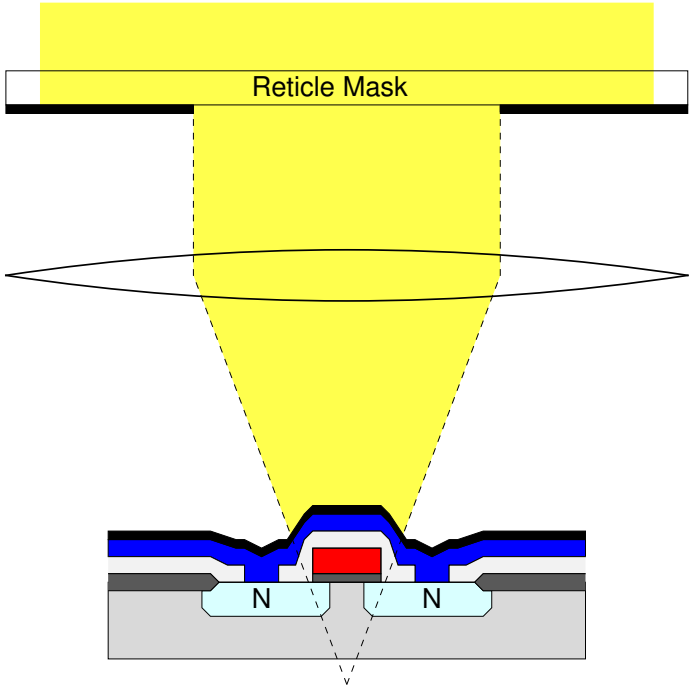
Mask Misalignment



Misalignment can be Cumulative

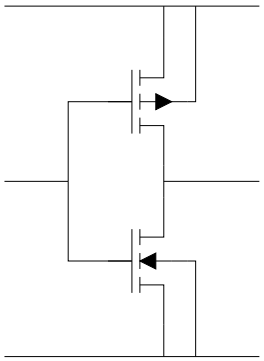


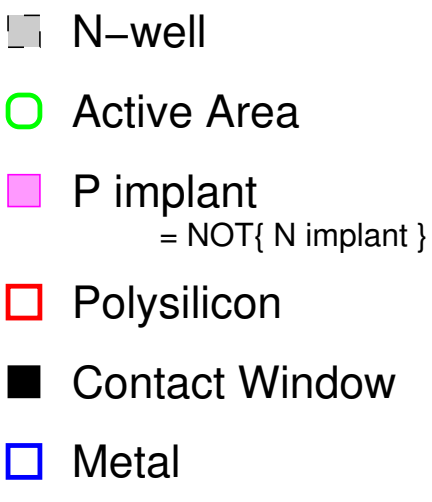
Optical Focus over 3D terrain

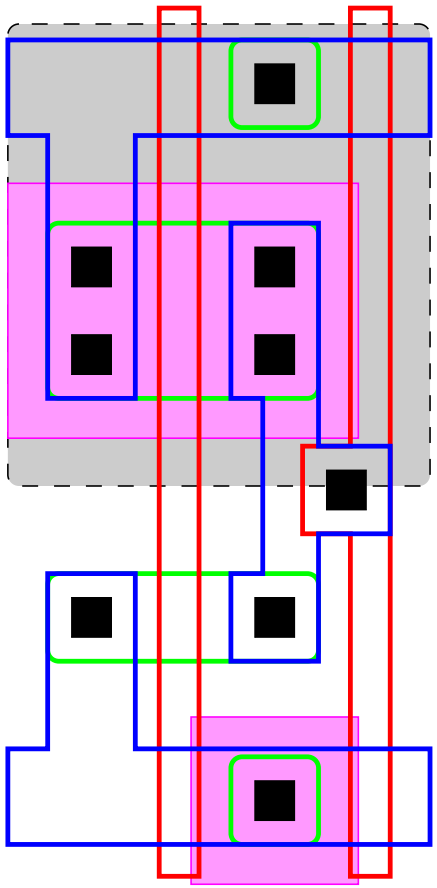


Design Rules

0.5 μm CMOS inverter

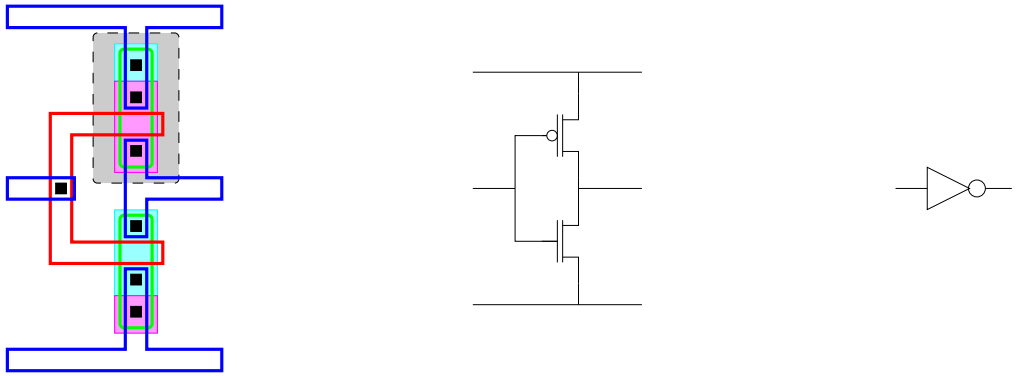






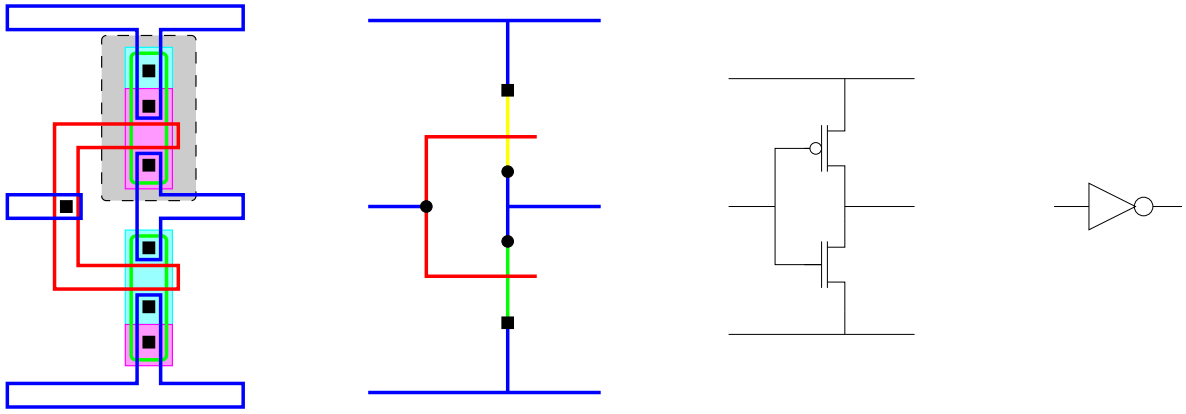
Abstraction

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:

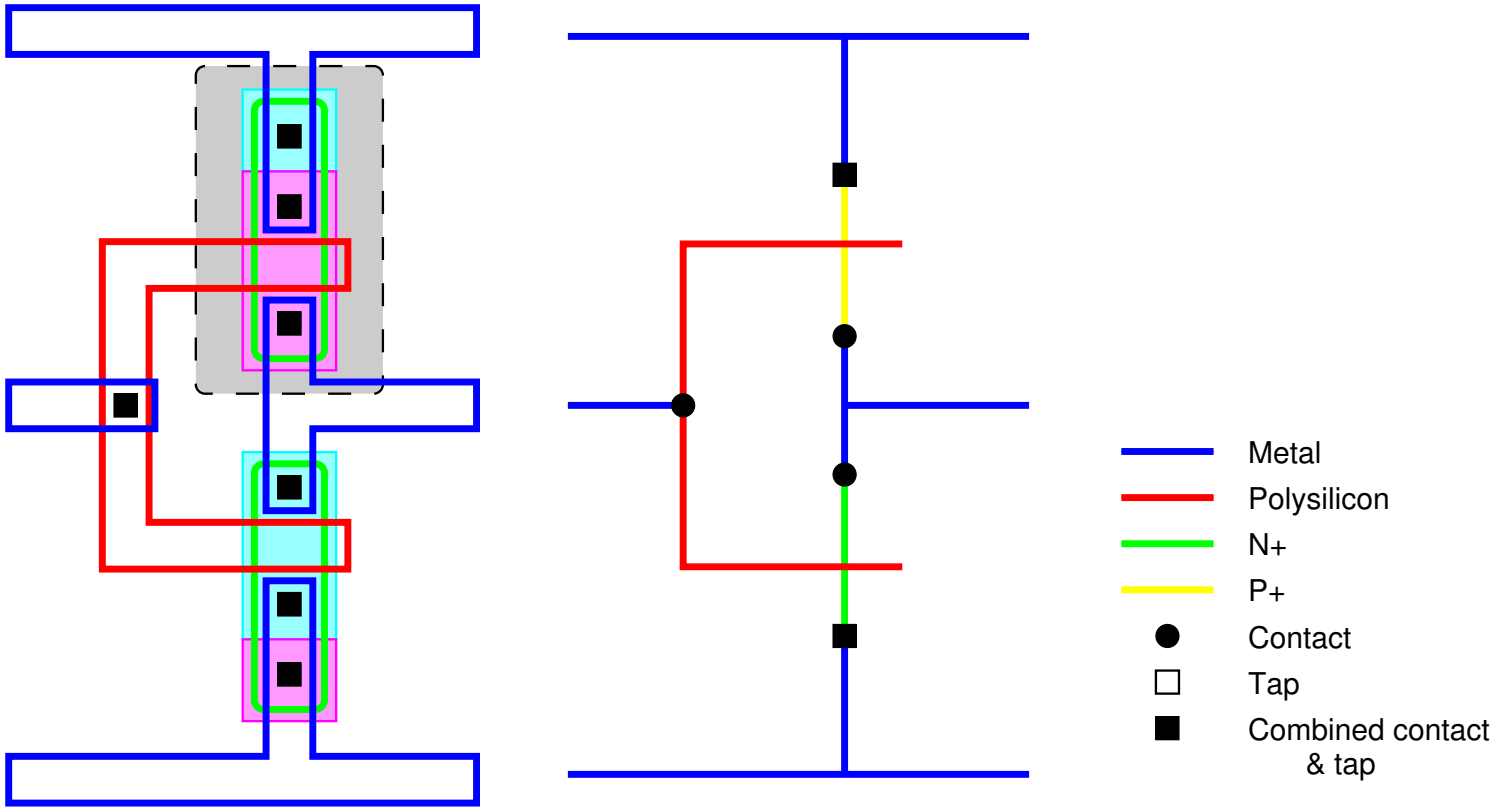
- Much easier/faster than full mask specification.
- Process independent (valid for any CMOS process).
- Easy to change.

while avoiding some of the problems:

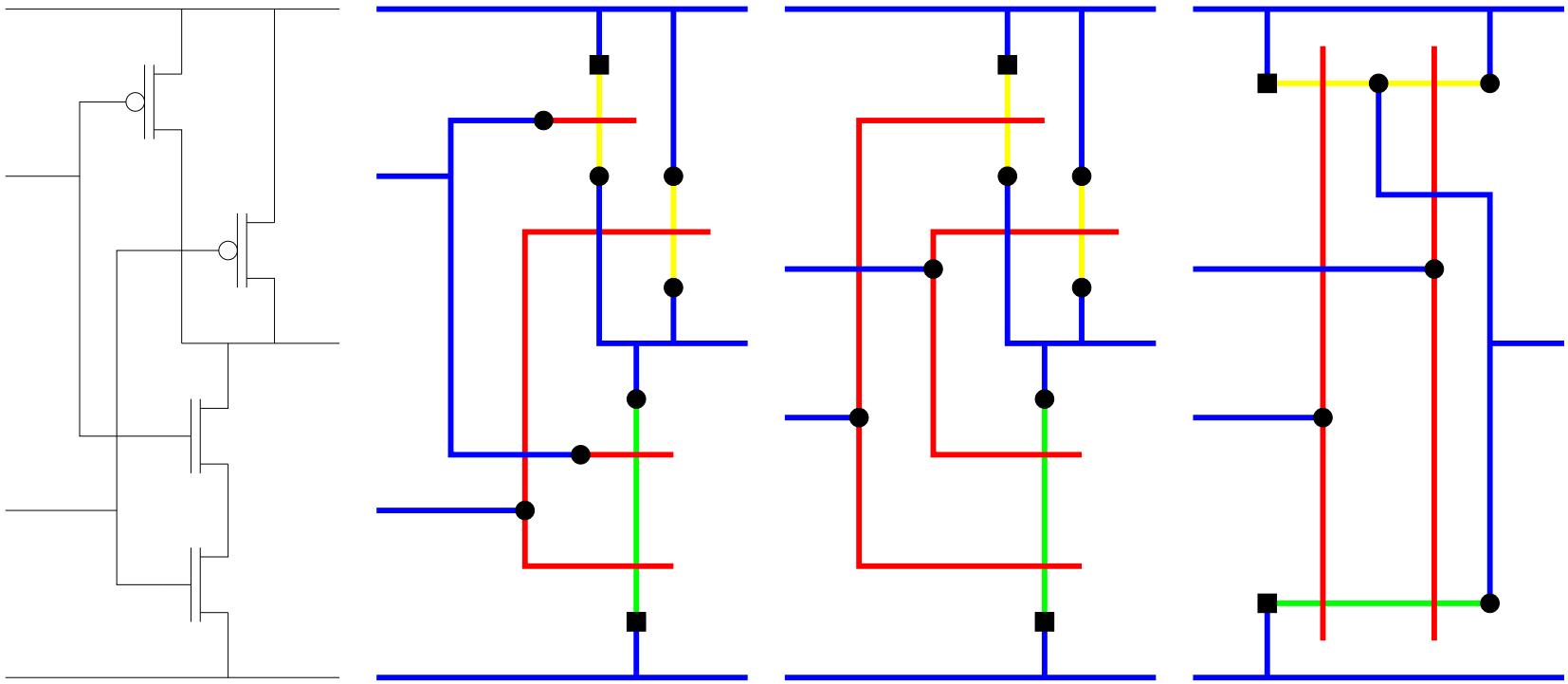
- Optimized layout may be generated much more easily from a stick diagram than from transistor or gate level designs.[1]

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

Stick Diagrams



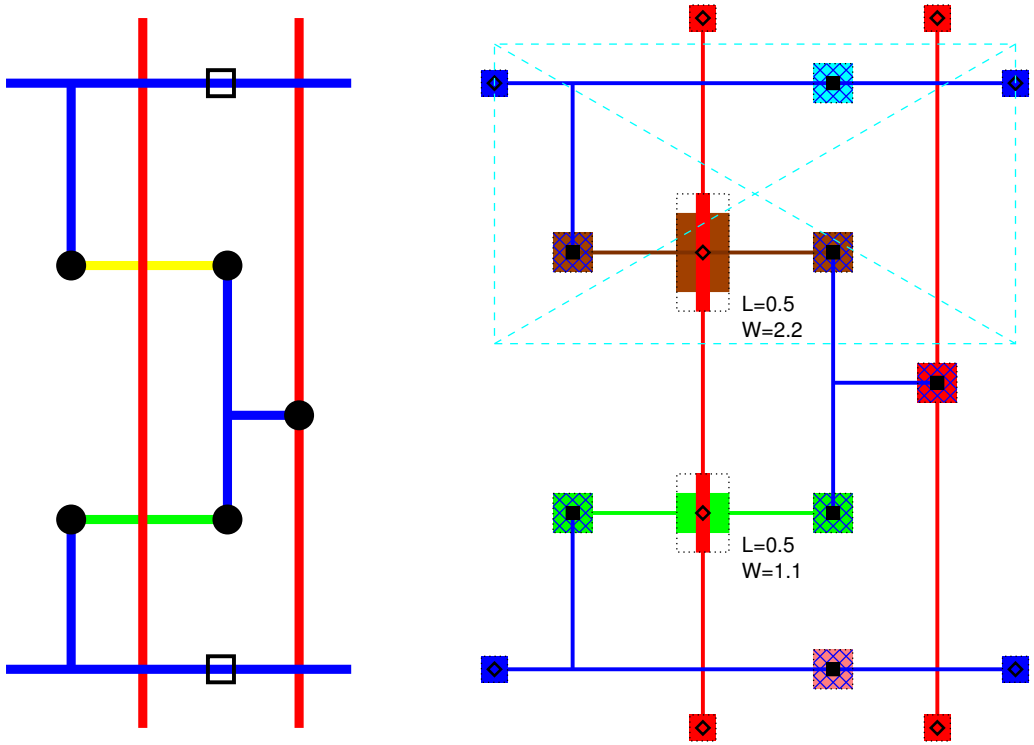
Stick Diagrams



Stick Diagrams

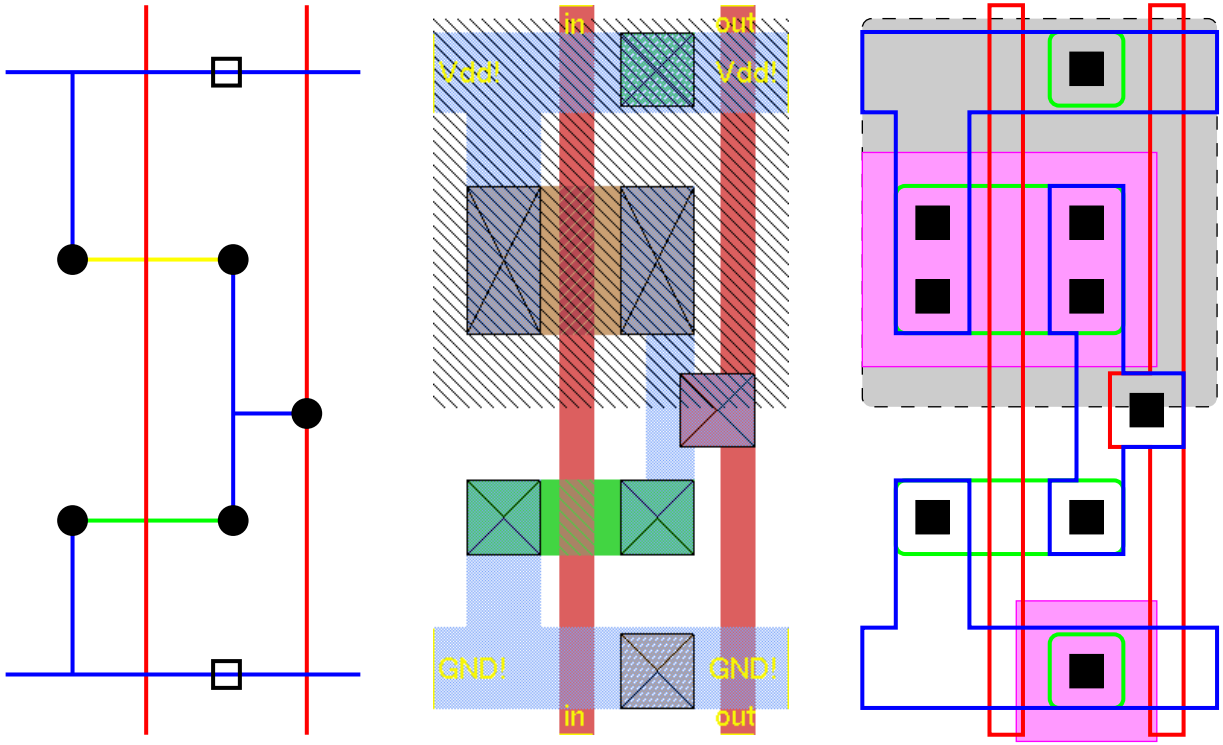
- *Explore your Design Space*.
  - Implications of crossovers.
  - Number of contacts.
  - Arrangement of devices and connections.
- Process independent layout.
- Easy to expand to a full layout for a particular process.

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.