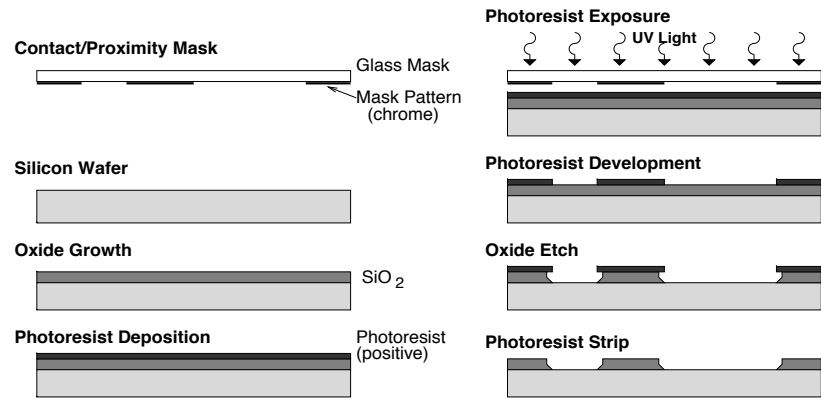


Photolithography

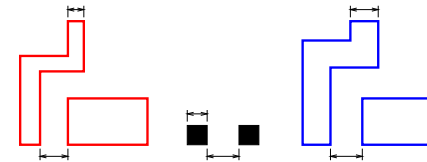


4001

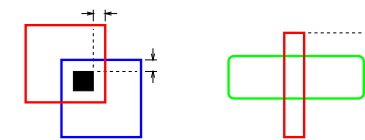
Design Rules

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

- Single layer rules



- Multi-layer rules

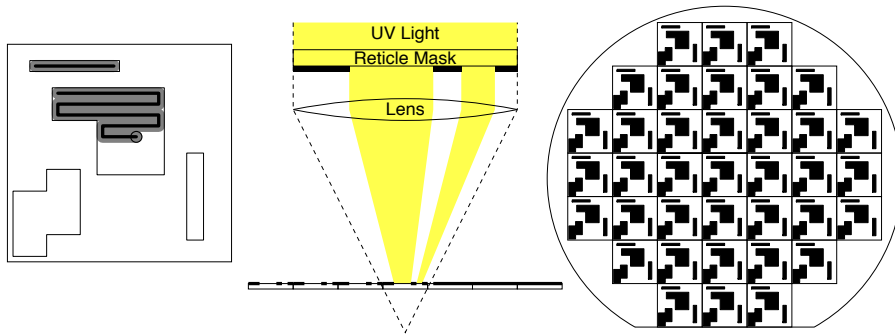


4003

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.

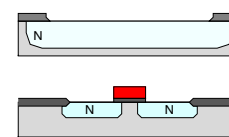
4002

Derivation of Design Rules

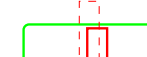
Isotropic Etching



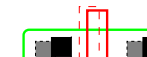
Lateral Diffusion



Mask Misalignment

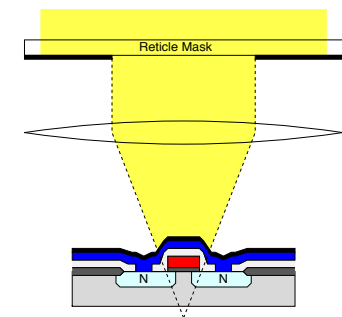


Misalignment can be Cumulative



□ is aligned to ○
■ is aligned to □

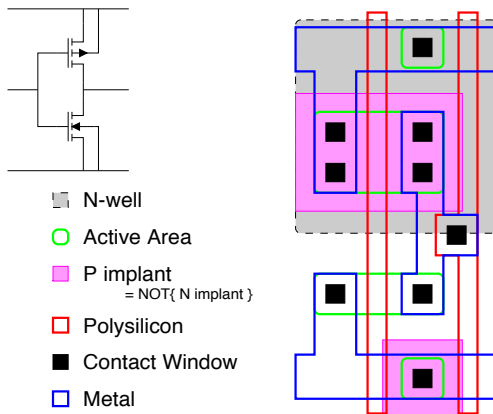
Optical Focus over 3D terrain



4004

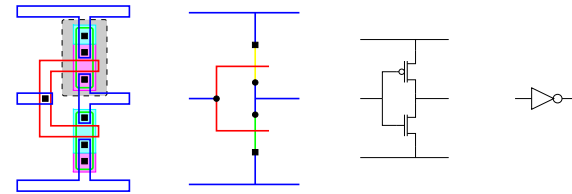
Design Rules

0.5 μm CMOS inverter



4005

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:

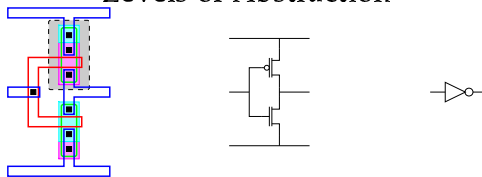
- Optimized layout may be generated much more easily from a stick diagram than from transistor or gate level designs.¹

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

4007

Abstraction

Levels of Abstraction

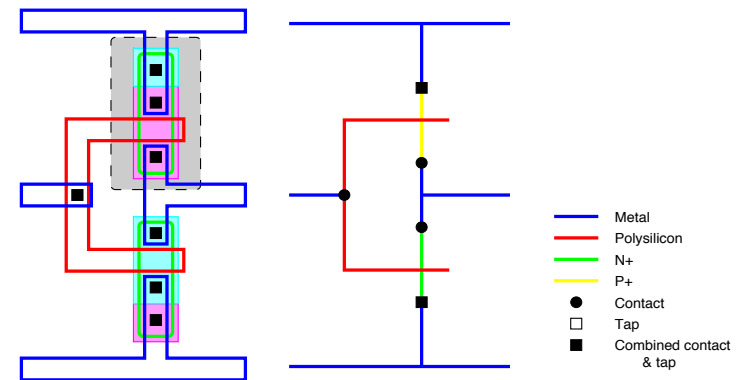


- Mask Level Design
 - Laborious Technology/Process dependent.
 - Design rules may change during a design!
- Transistor Level Design
 - Process independent, Technology dependent.
- Gate Level Design
 - Process/Technology independent.

4006

Digital CMOS Design

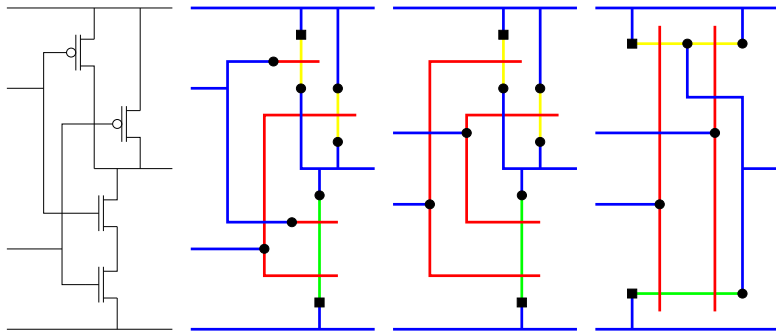
Stick Diagrams



4008

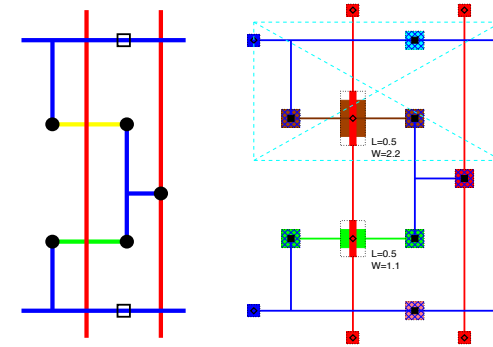
Digital CMOS Design

Stick Diagrams



4009

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.

4011

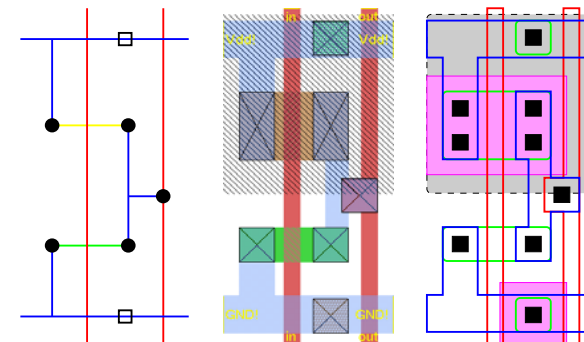
Digital CMOS Design

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.

4010

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.

4012