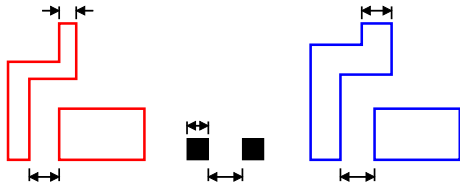


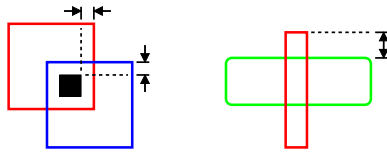
## Design Rules

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

- Single layer rules



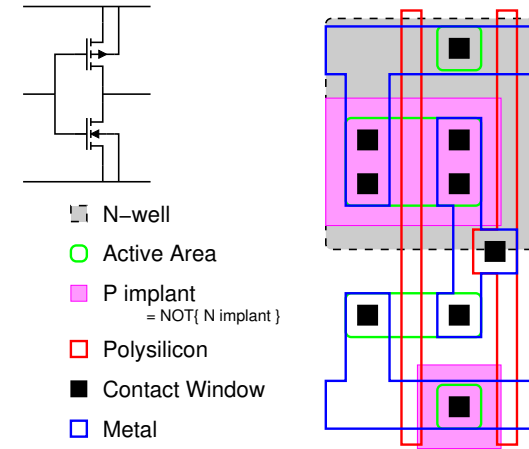
- Multi-layer rules



5001

## Design Rules

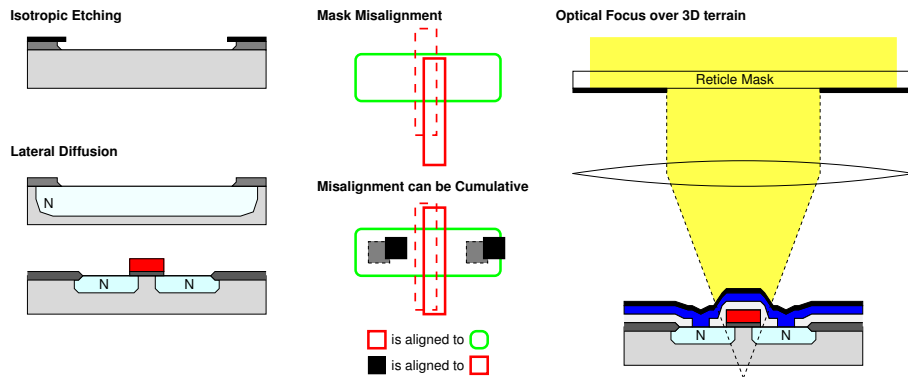
### 0.5 $\mu\text{m}$ CMOS inverter



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

5003

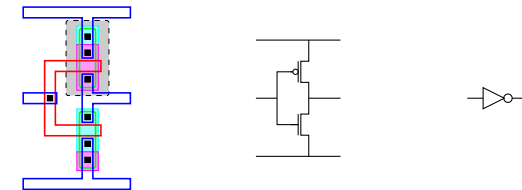
## Derivation of Design Rules



5002

## Abstraction

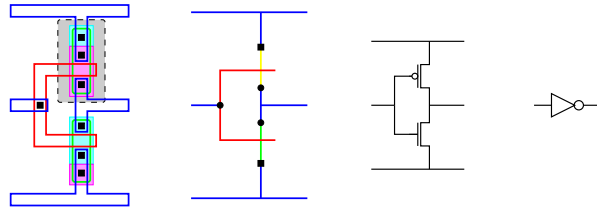
### Levels of Abstraction



- 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:

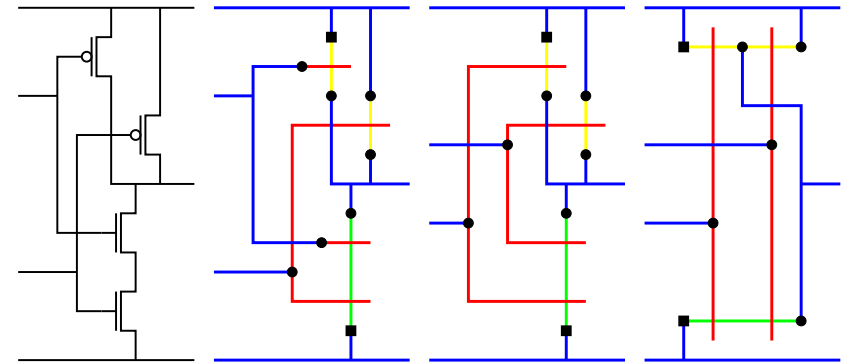
- Optimized layout may be generated much more easily from a stick diagram than from transistor or gate level designs.<sup>1</sup>

<sup>1</sup>note that all IC designs must end at the mask level.

5005

## Digital CMOS Design

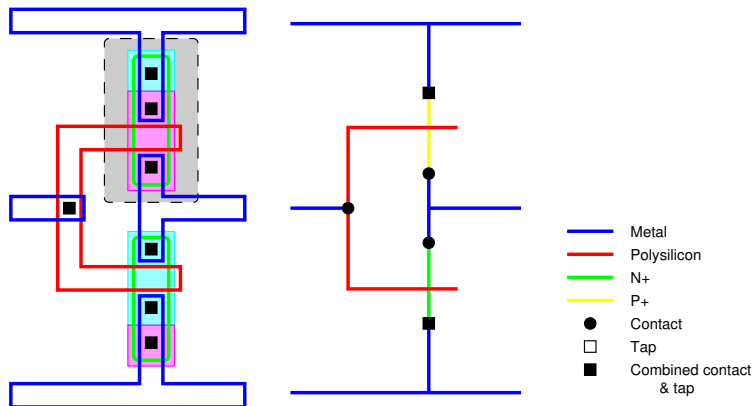
### Stick Diagrams



5007

## Digital CMOS Design

### Stick Diagrams



5006

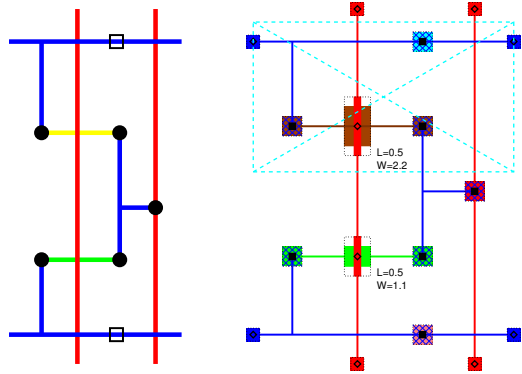
## Digital CMOS Design

### 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.

5008

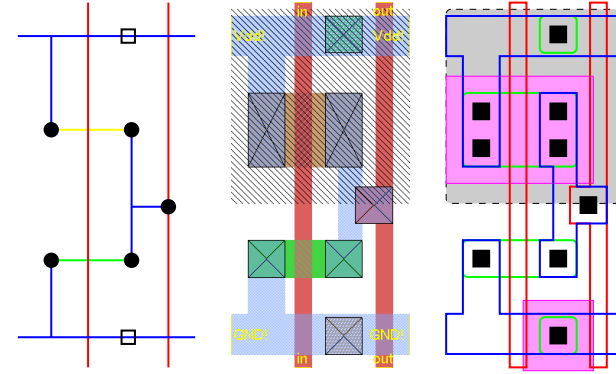
## Sticks and CAD - Symbolic Capture



- 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.

5009

## 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.

5010