Simplified Example of a LOCOS Fabrication Process

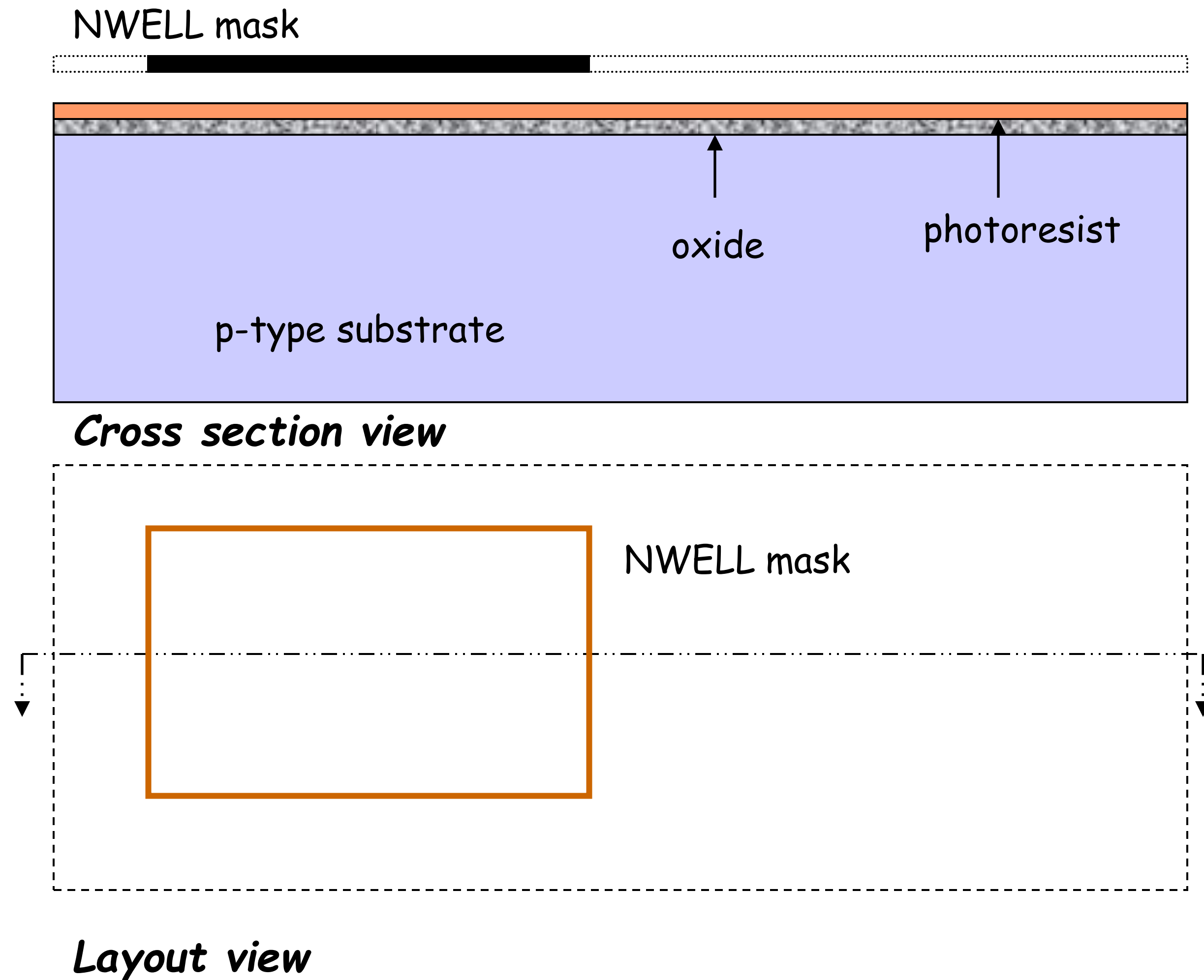
LOCOS Defined

- LOCOS = LOCal Oxidation of Silicon
- Defines a set of fabrication technologies where
  - the wafer is masked to cover all active regions
  - thick field oxide (FOX) is grown in all non-active regions
- Used for electrical isolation of CMOS devices
- Relatively simple to understand so often used to introduce/describe CMOS fabrication flows
- Not commonly used in modern fabrication
  - other techniques, such as Shallow Trench Isolation (STI) are currently more common than LOCOS

LOCOS -step 1

Form N-Well regions

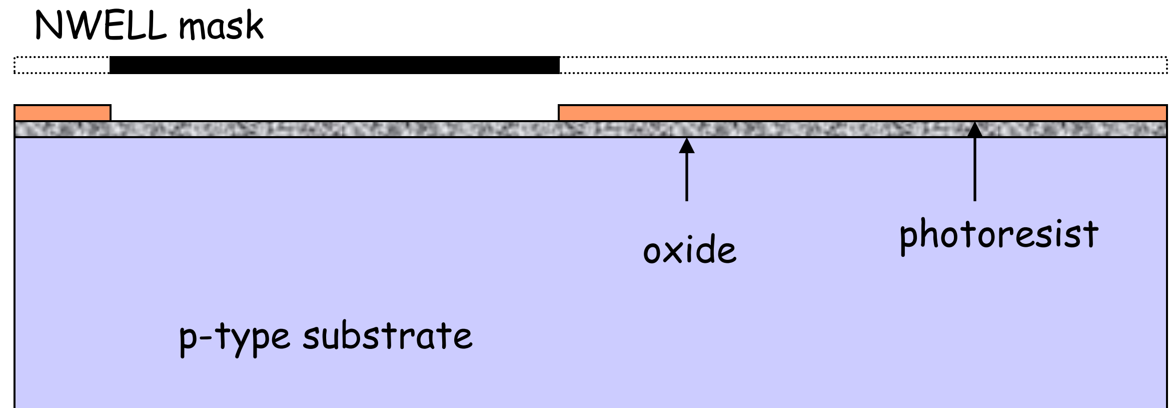
- Grow oxide
- Deposit photoresist



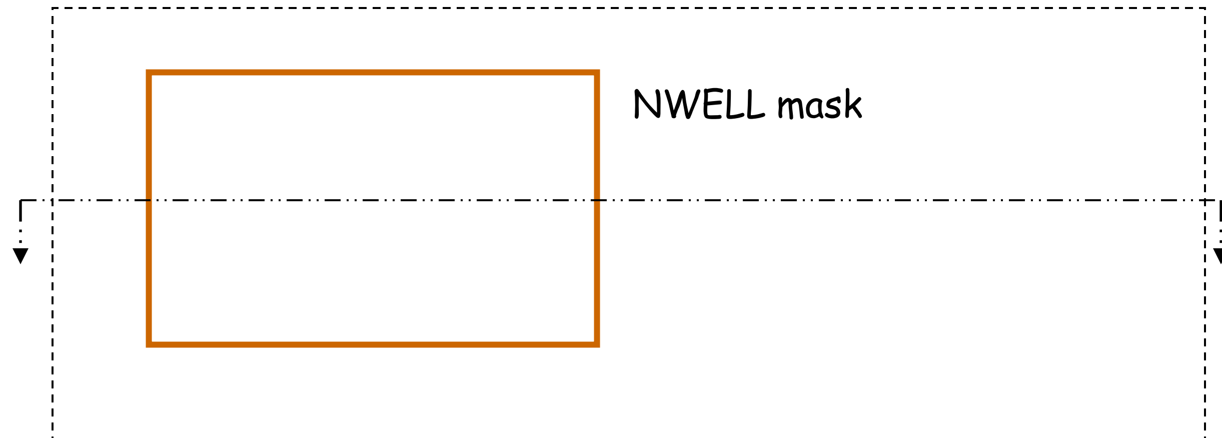
LOCOS -step 1

Form N-Well regions

- Grow oxide
- Deposit photoresist
- Pattern photoresist
  - NWELL Mask
  - expose only n-well areas



Cross section view

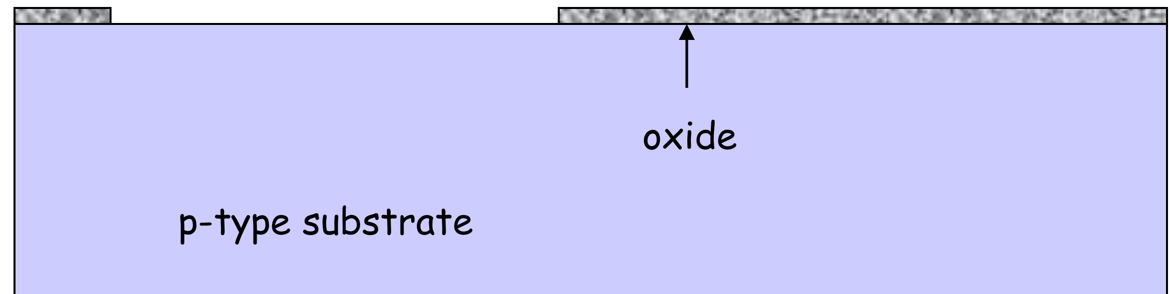


Layout view

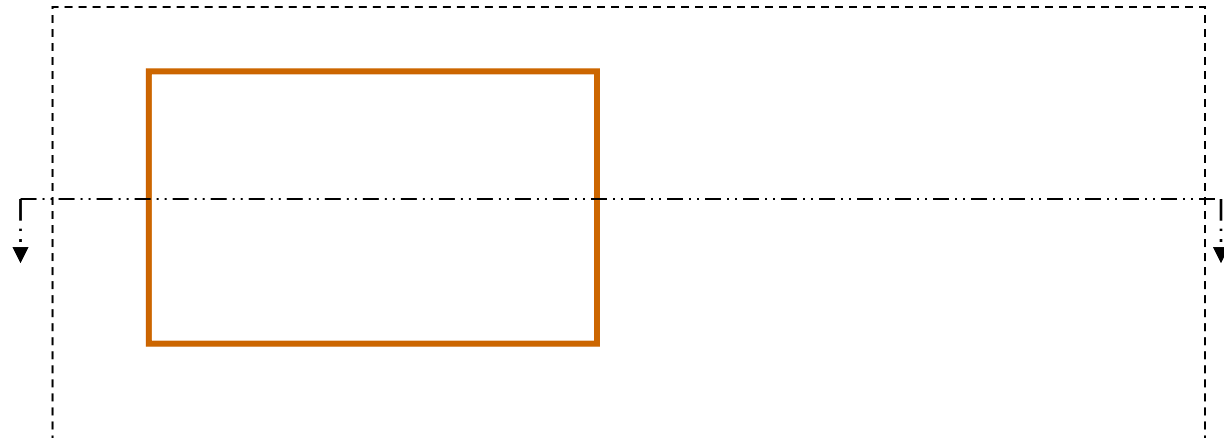
LOCOS -step 1

Form N-Well regions

- Grow oxide
- Deposit photoresist
- Pattern photoresist
  - NWELL Mask
  - expose only n-well areas
- Etch oxide
- Remove photresist



Cross section view

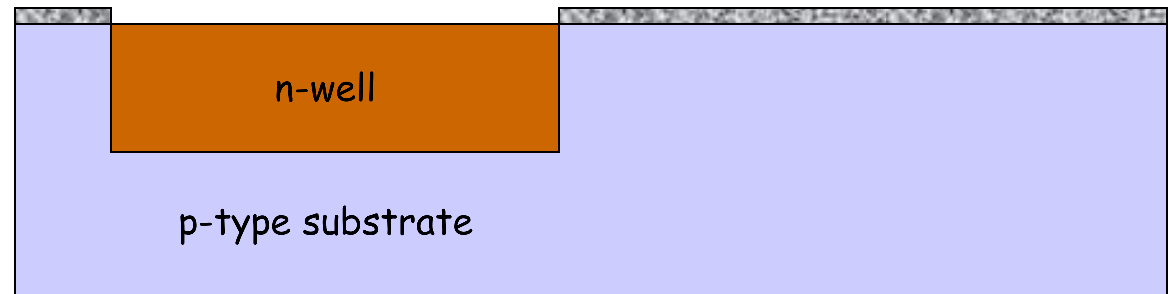


Layout view

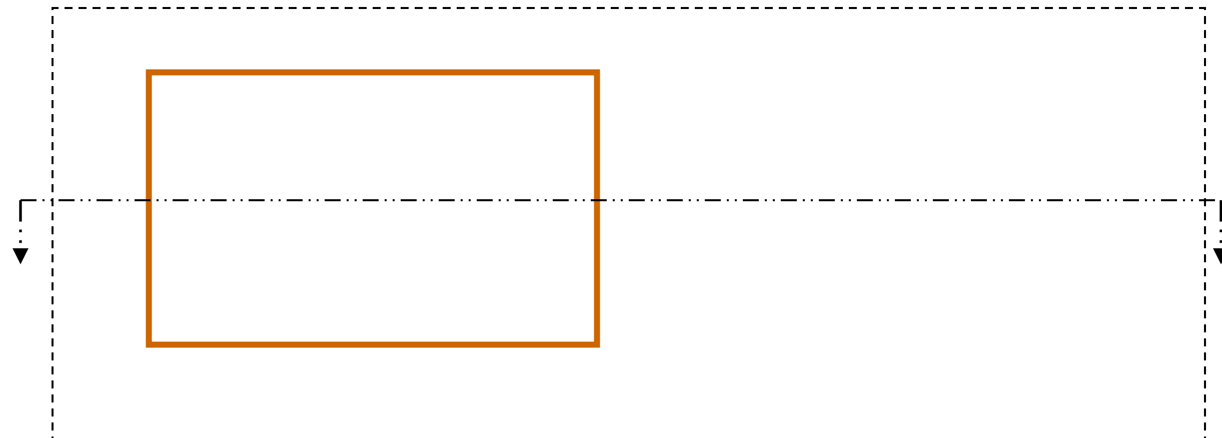
LOCOS -step 1

Form N-Well regions

- Grow oxide
- Deposit photoresist
- Pattern photoresist
  - NWELL Mask
  - expose only n-well areas
- Etch oxide
- Remove photoresist
- Diffuse n-type dopants through oxide mask layer



Cross section view

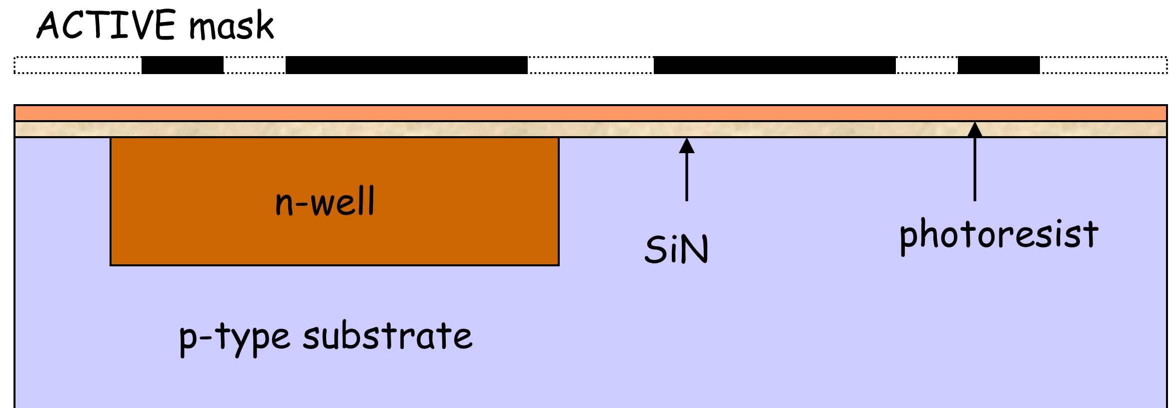


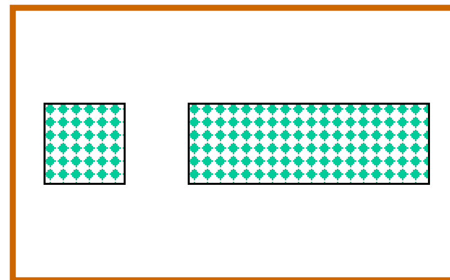
Layout view

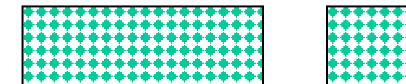
LOCOS -step 2

Form Active Regions

- Deposit SiN over wafer
- Deposit photoresist over SiN layer





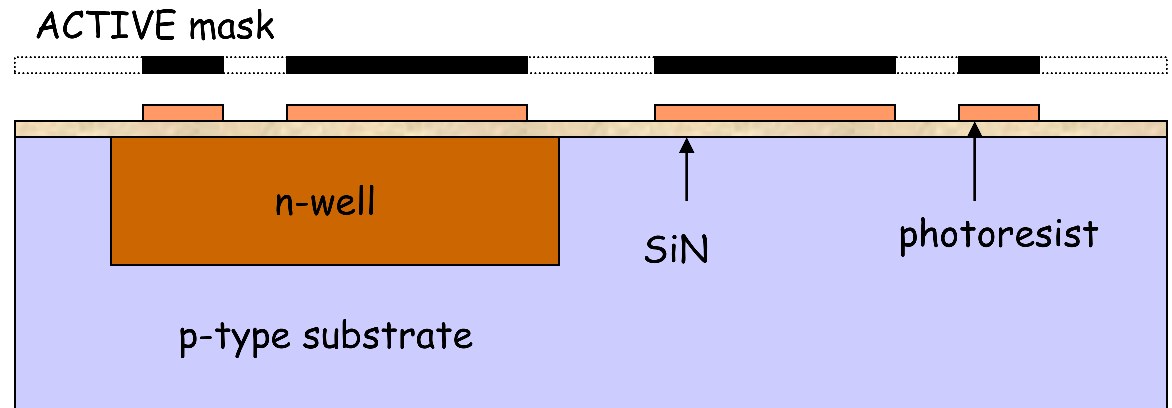


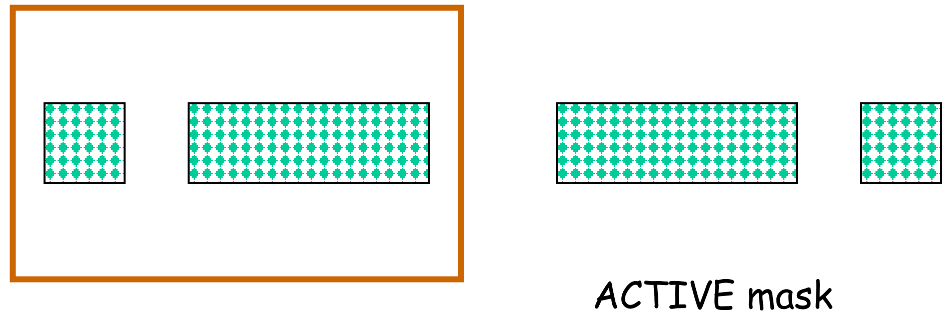
ACTIVE mask

LOCOS -step 2

Form Active Regions

- Deposit SiN over wafer
- Deposit photoresist over SiN layer
- Pattern photoresist
  - *ACTIVE MASK

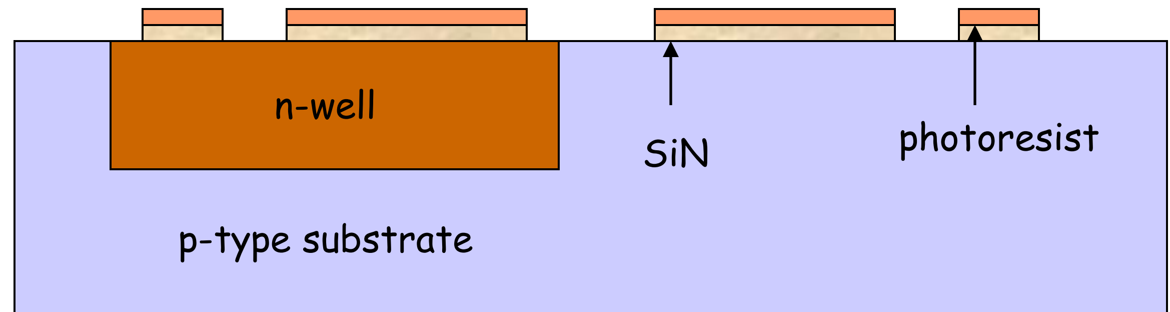


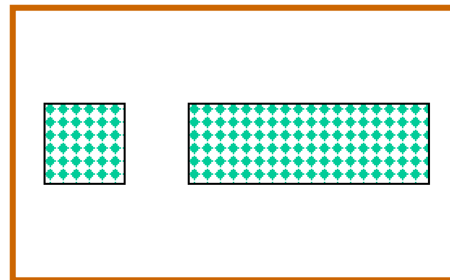


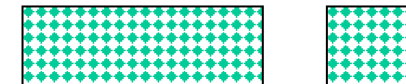
LOCOS -step 2

Form Active Regions

- Deposit SiN over wafer
- Deposit photoresist over SiN layer
- Pattern photoresist
  - *ACTIVE MASK
- Etch SiN in exposed areas
  - leaves SiN mask which blocks oxide growth





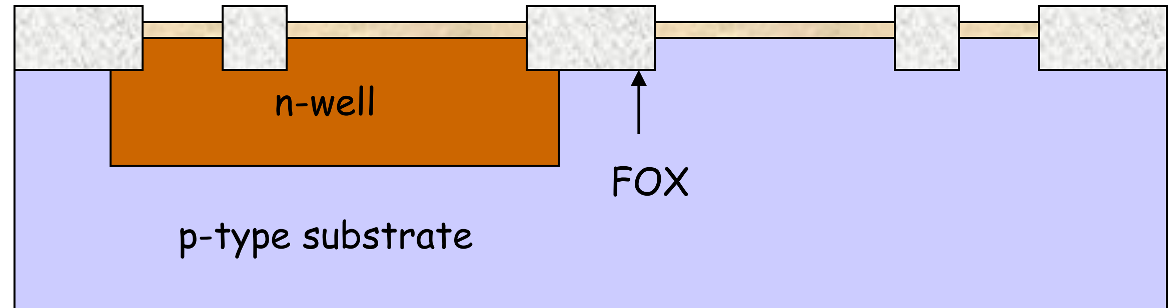


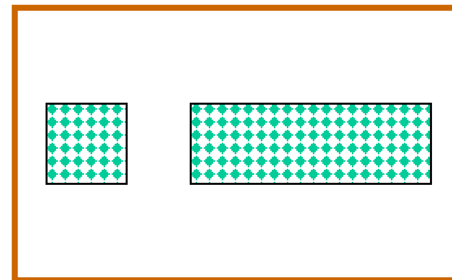
ACTIVE mask

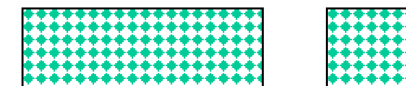
LOCOS -step 2

Form Active Regions

- Deposit SiN over wafer
- Deposit photoresist over SiN layer
- Pattern photoresist
  - *ACTIVE MASK
- Etch SiN in exposed areas
  - leaves SiN mask which blocks oxide growth
- Remove photoresist
- Grow Field Oxide (FOX)
  - thermal oxidation





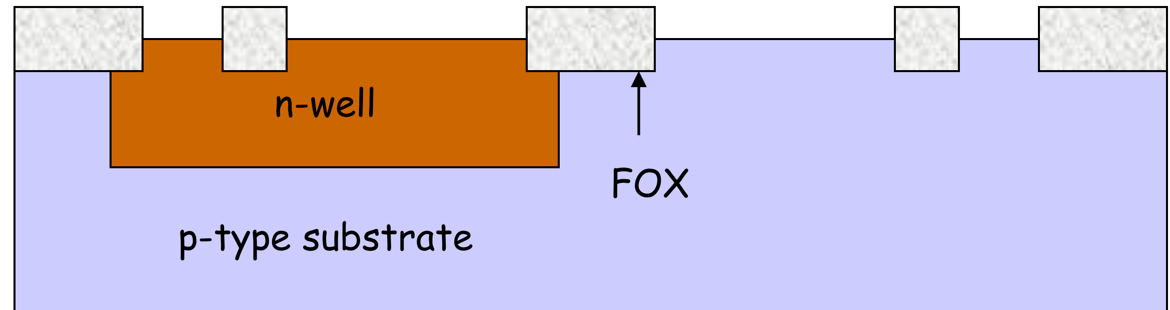


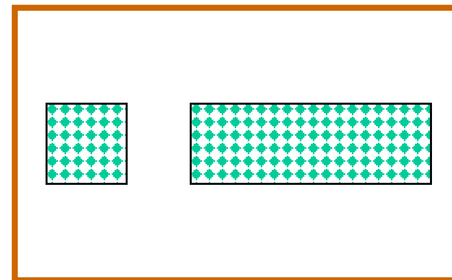
ACTIVE mask

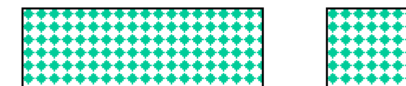
LOCOS -step 2

Form Active Regions

- Deposit SiN over wafer
- Deposit photoresist over SiN layer
- Pattern photoresist
  - *ACTIVE MASK
- Etch SiN in exposed areas
  - leaves SiN mask which blocks oxide growth
- Remove photoresist
- Grow Field Oxide (FOX)
  - thermal oxidation
- Remove SiN





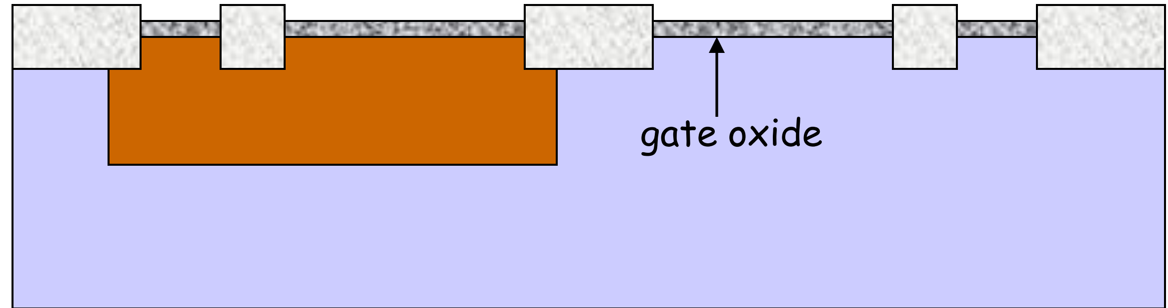


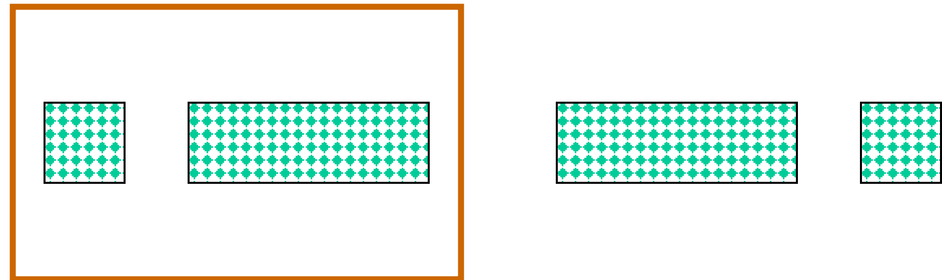
ACTIVE mask

LOCOS -step 3

Form Gate (Poly layer)

- Grow thin Gate Oxide
  - over entire wafer
  - negligible effect on FOX regions

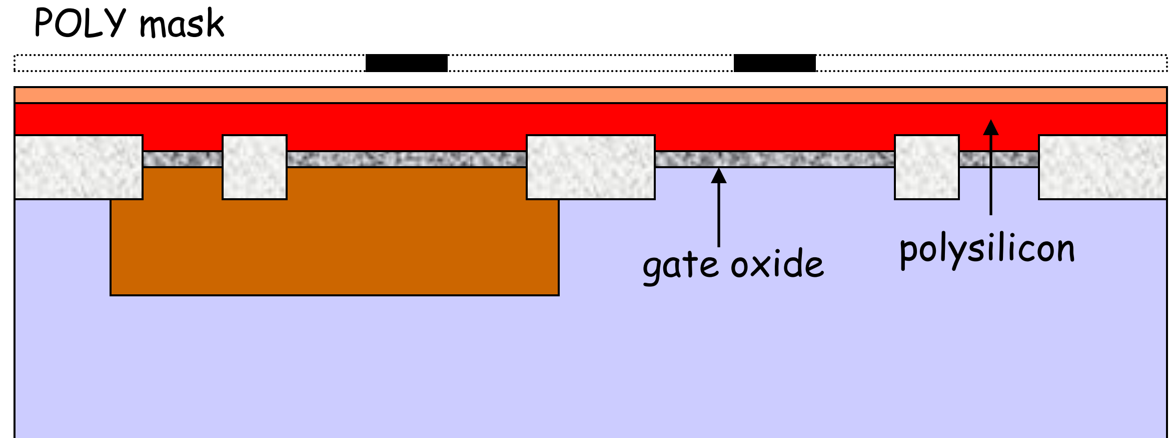


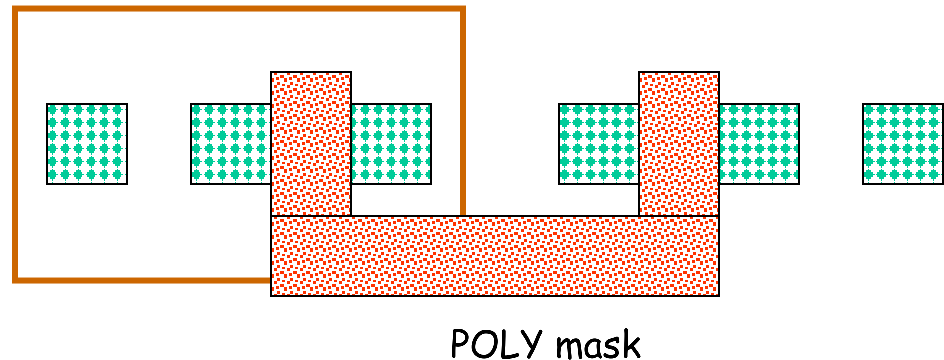


LOCOS -step 3

Form Gate (Poly layer)

- Grow thin Gate Oxide
  - over entire wafer
  - negligible effect on FOX regions
- Deposit Polysilicon
- Deposit Photoresist

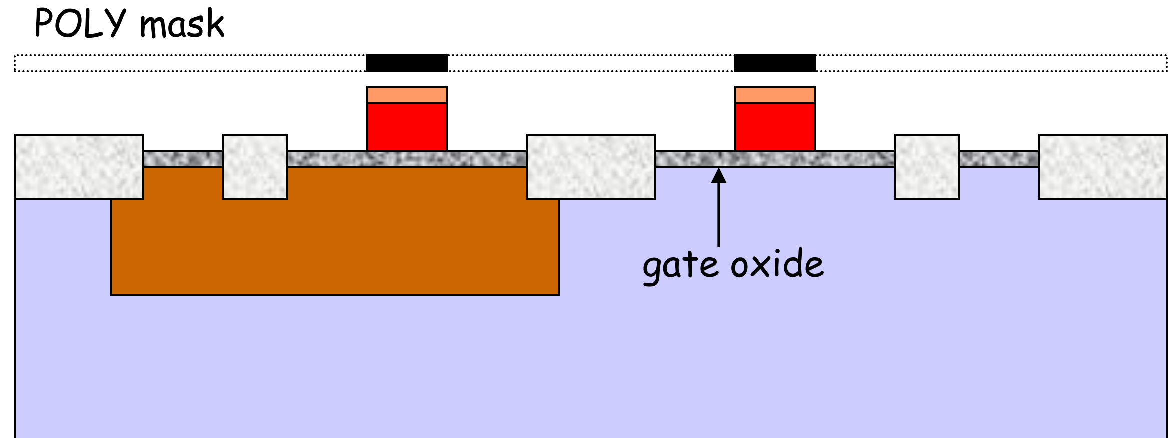


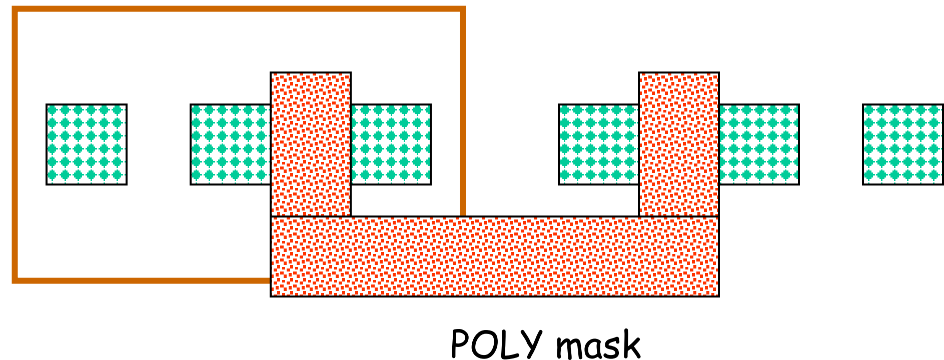


LOCOS -step 3

Form Gate (Poly layer)

- Grow thin Gate Oxide
  - over entire wafer
  - negligible effect on FOX regions
- Deposit Polysilicon
- Deposit Photoresist
- Pattern Photoresist
  - *POLY MASK
- Etch Poly in exposed areas
- Etch/remove Oxide
  - gate protected by poly





LOCOS -step 3

Form Gate (Poly layer)

- Grow thin Gate Oxide
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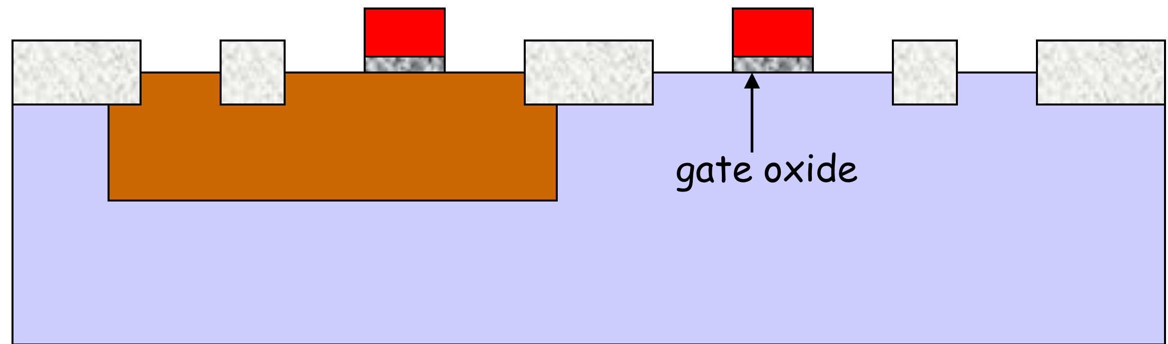
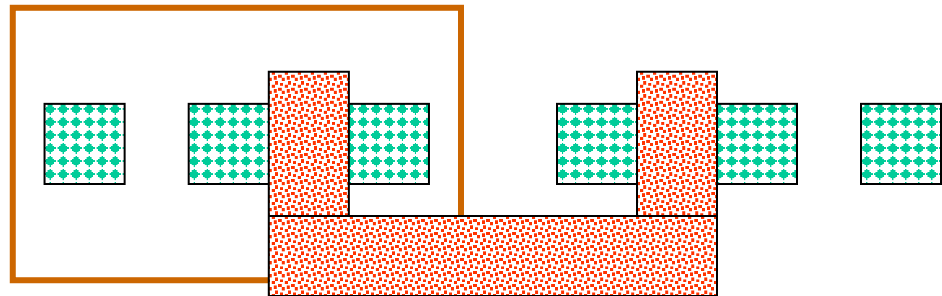
  - *POLY MASK
- Etch Poly in exposed areas
- Etch/remove Oxide
  - gate protected by poly

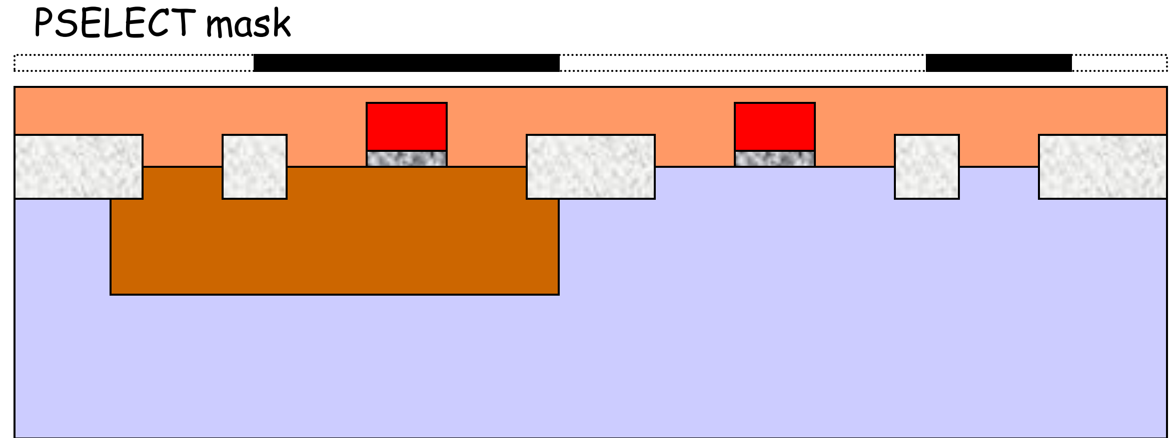


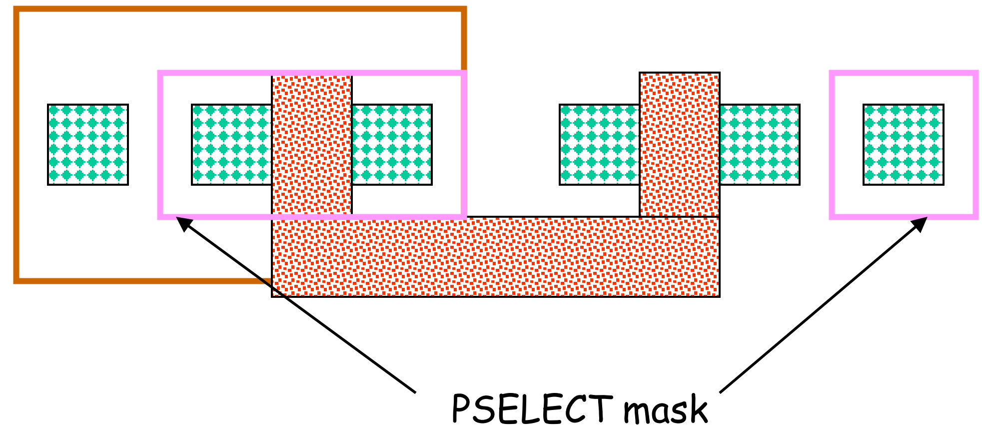


LOCOS -step 4

Form pmos S/D

- Cover with photoresist

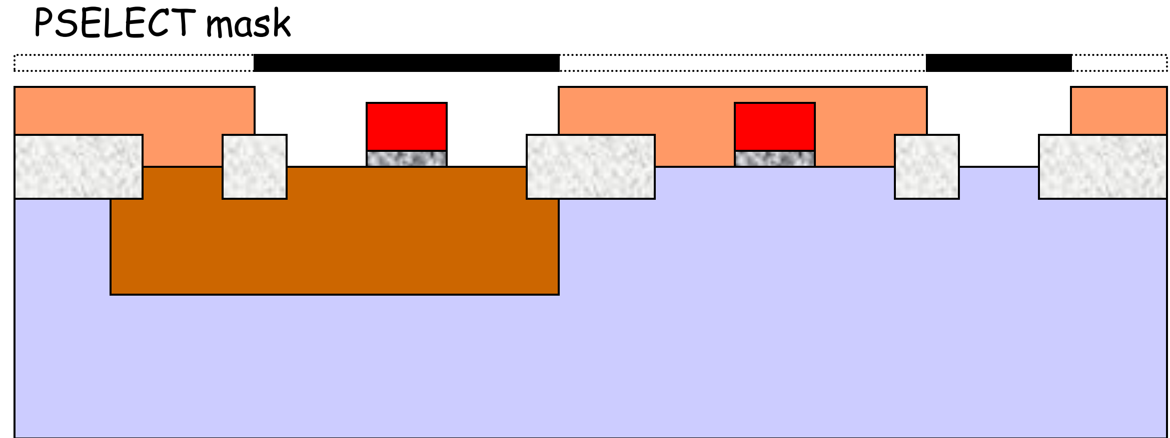


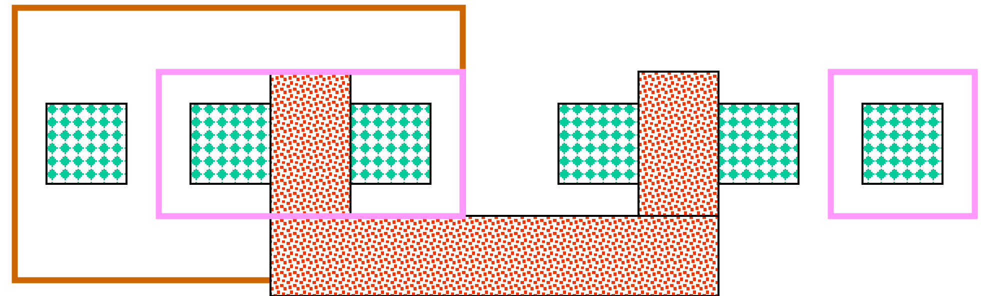


LOCOS -step 4

Form pmos S/D

- Cover with photoresist
- Pattern photoresist
  - *PSELECT MASK

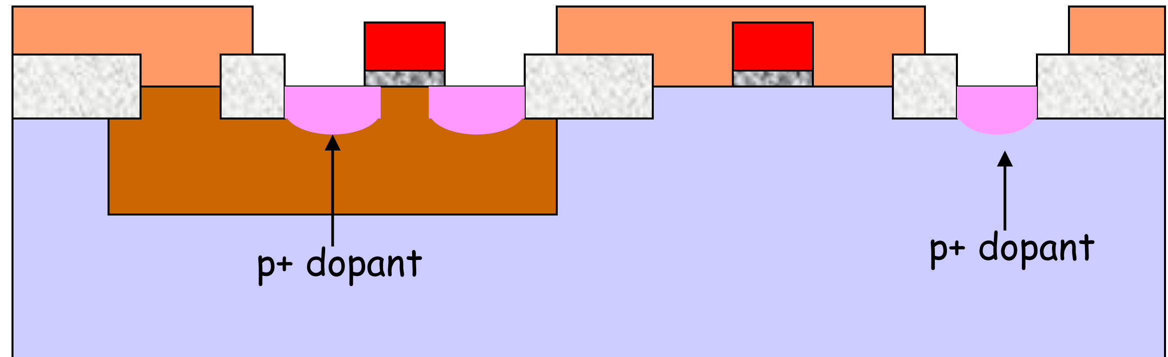


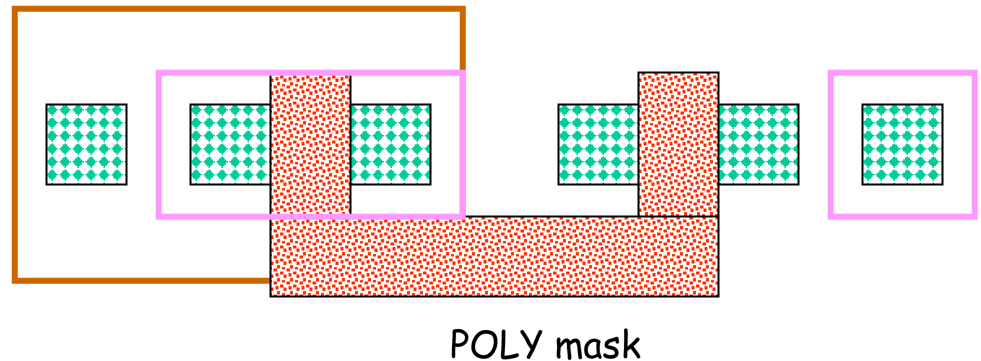


LOCOS -step 4

Form pmos S/D

- Cover with photoresist
- Pattern photoresist
  - *PSELECT MASK
- Implant p-type dopants
- Remove photoresist

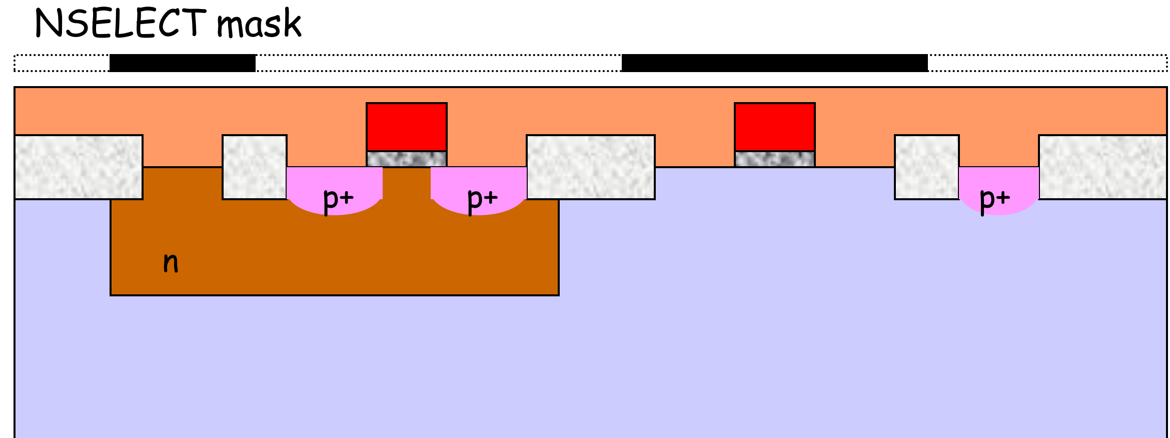


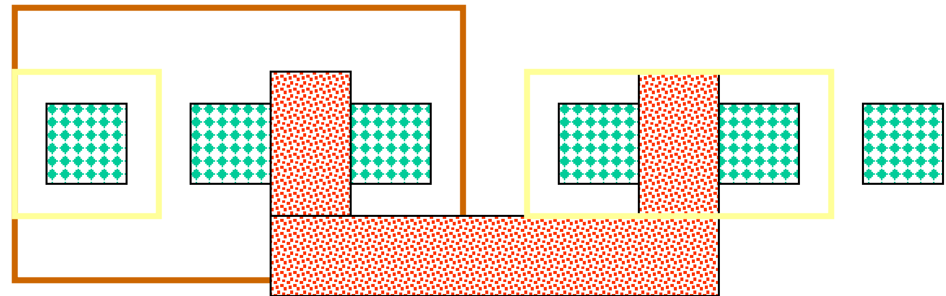


LOCOS -step 5

Form nmos S/D

- Cover with photoresist

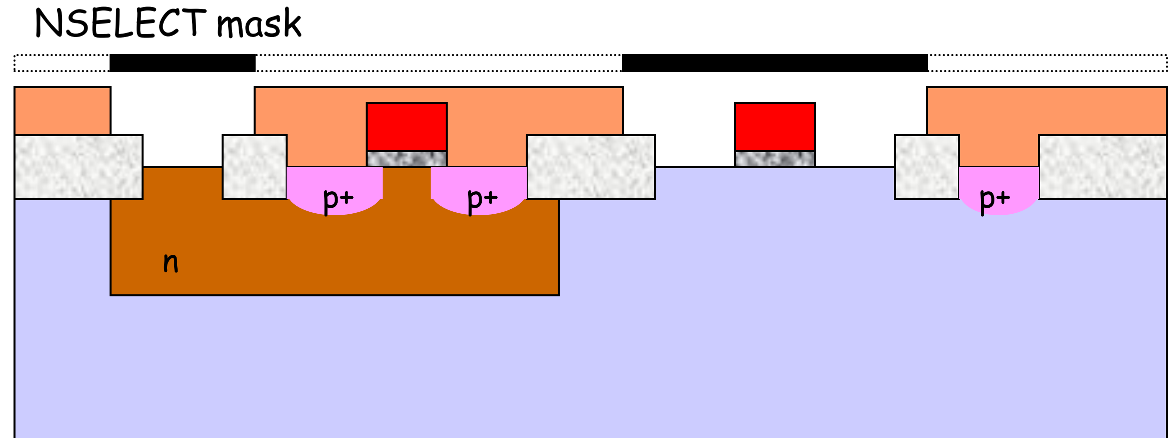


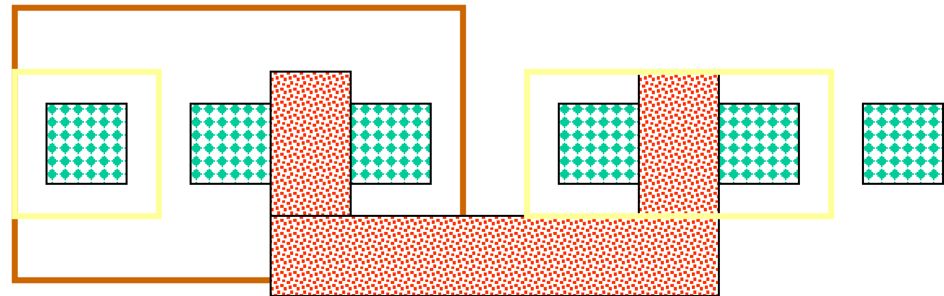


LOCOS -step 5

Form nmos S/D

- Cover with photoresist
- Pattern photoresist
  - *NSELECT MASK

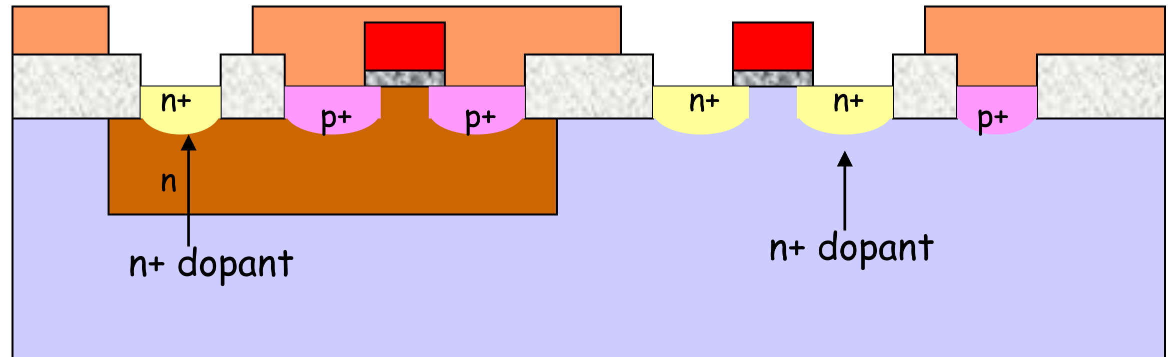


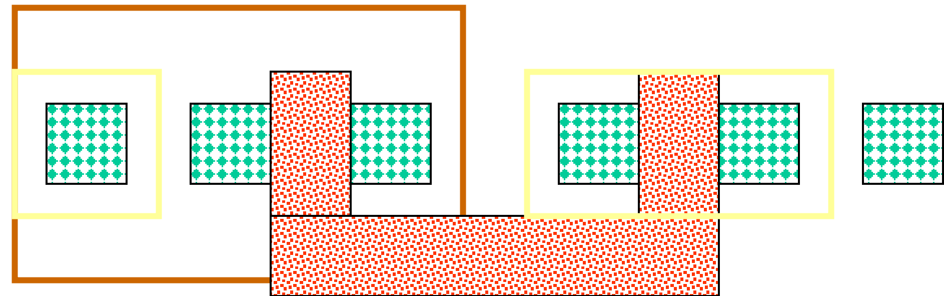


LOCOS -step 5

Form nmos S/D

- Cover with photoresist
- Pattern photoresist
  - *NSELECT MASK
- Implant n-type dopants
- Remove photoresist



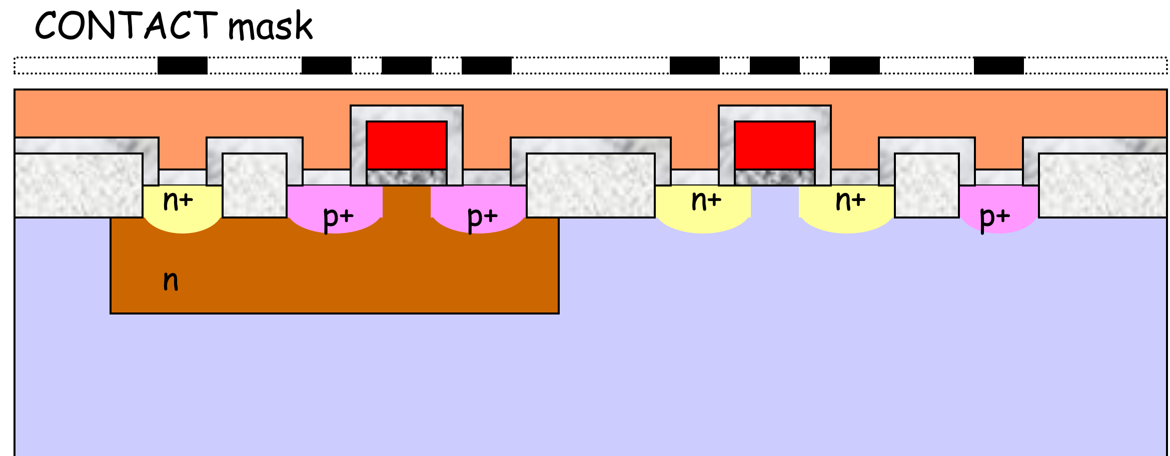


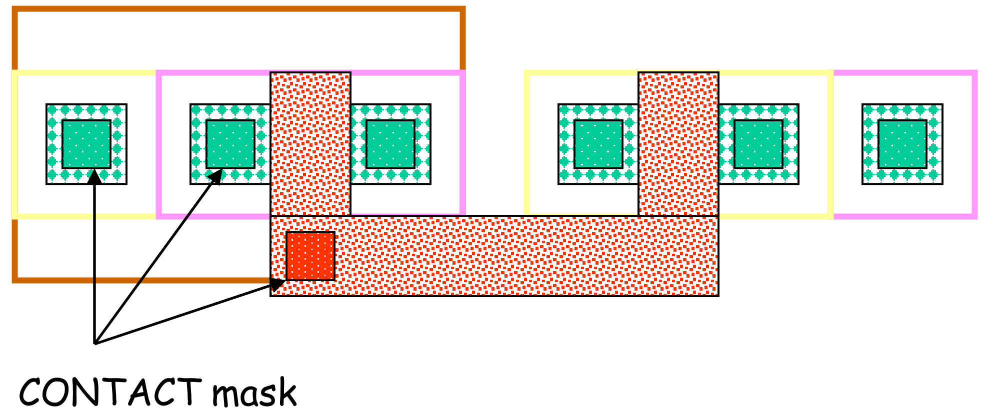
POLY mask

LOCOS -step 6

Form Contacts

- Deposit oxide
- Deposit photoresist

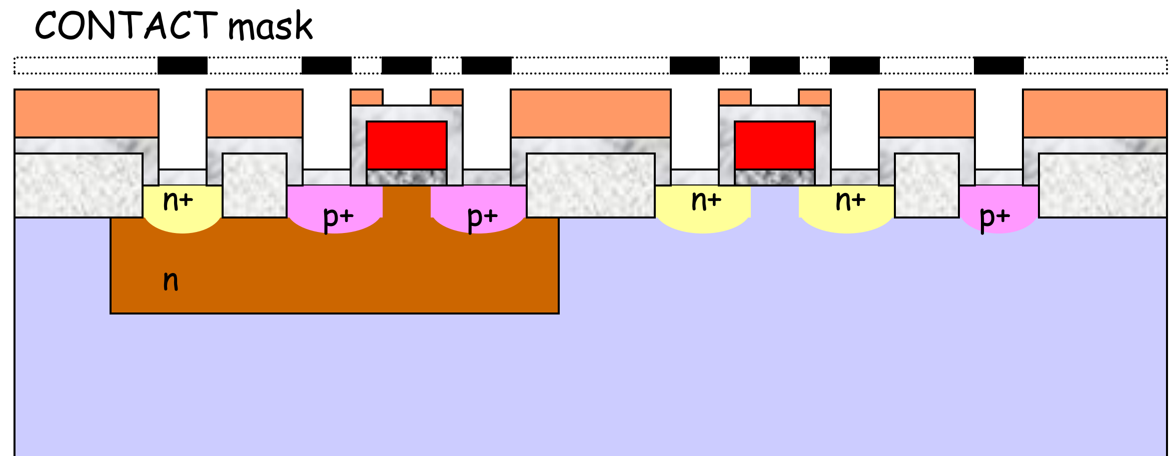


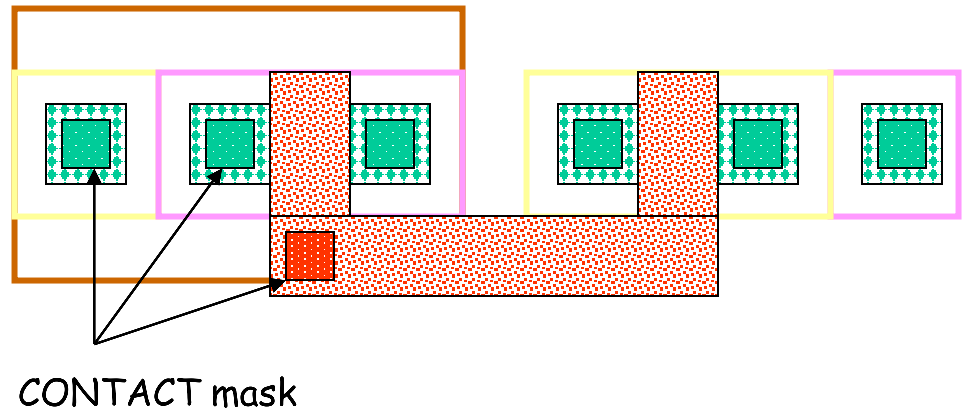


LOCOS -step 6

Form Contacts

- Deposit oxide
- Deposit photoresist
- Pattern photoresist
  - *CONTACT Mask
  - One mask for both active and poly contact shown

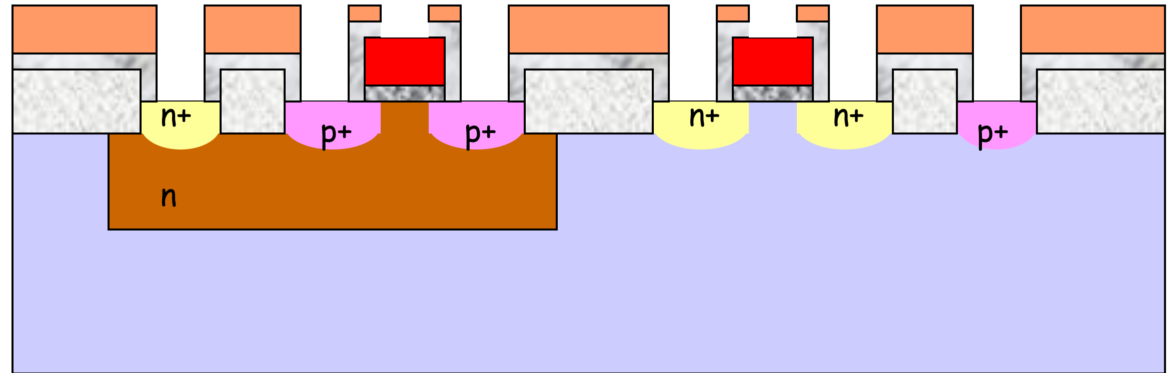


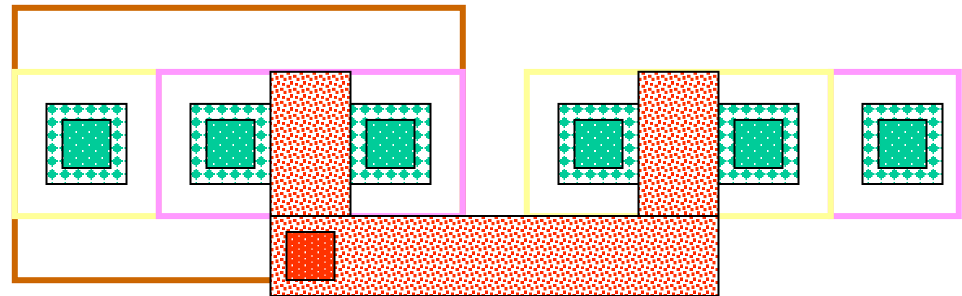


LOCOS -step 6

Form Contacts

- Deposit oxide
- Deposit photoresist
- Pattern photoresist
  - *CONTACT Mask
  - One mask for both active and poly contact shown
- Etch oxide

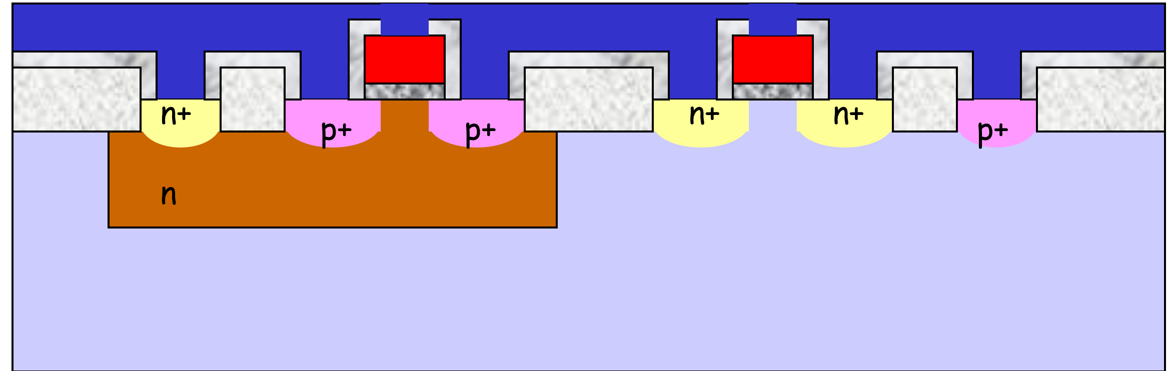


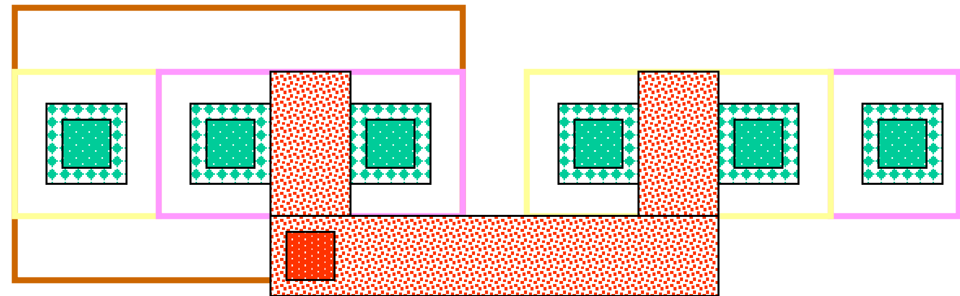


LOCOS -step 6

Form Contacts

- Deposit oxide
- Deposit photoresist
- Pattern photoresist
  - *CONTACT Mask
  - One mask for both active and poly contact shown
- Etch oxide
- Remove photoresist
- Deposit metal1
  - immediately after opening contacts so no native oxide grows in contacts
- Planerize
  - make top level

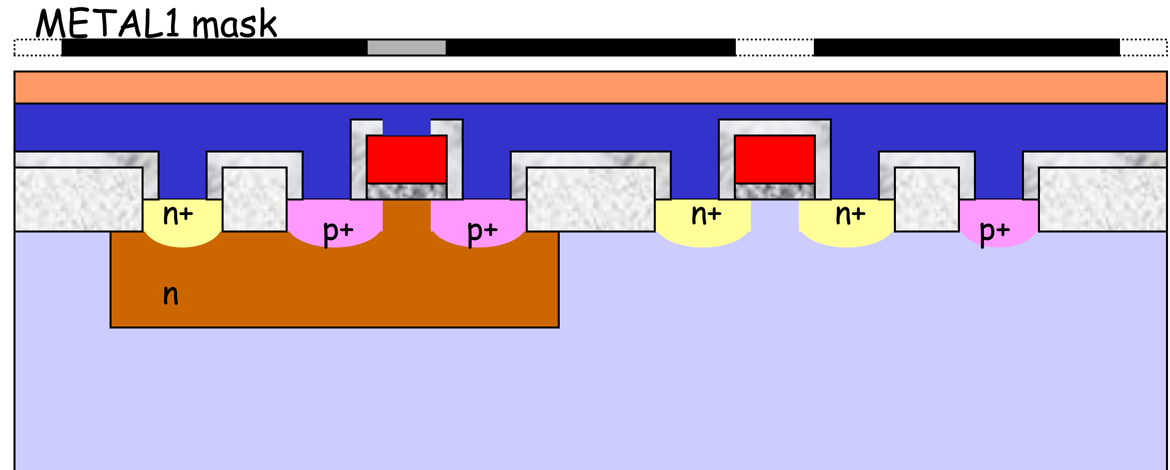


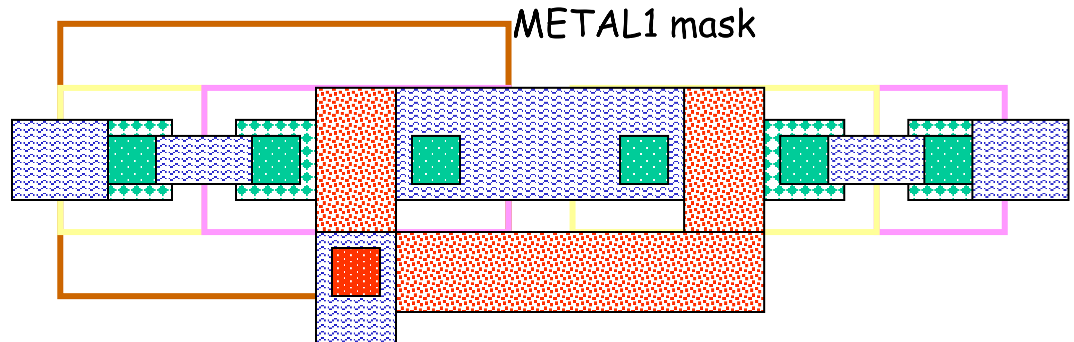


LOCOS -step 7

Form Metal 1 Traces

- Deposit photoresist

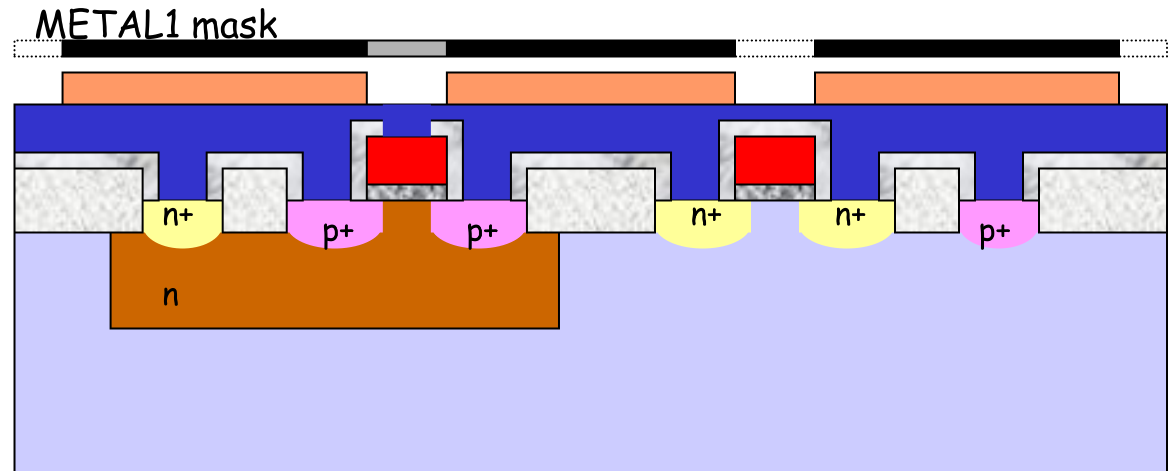


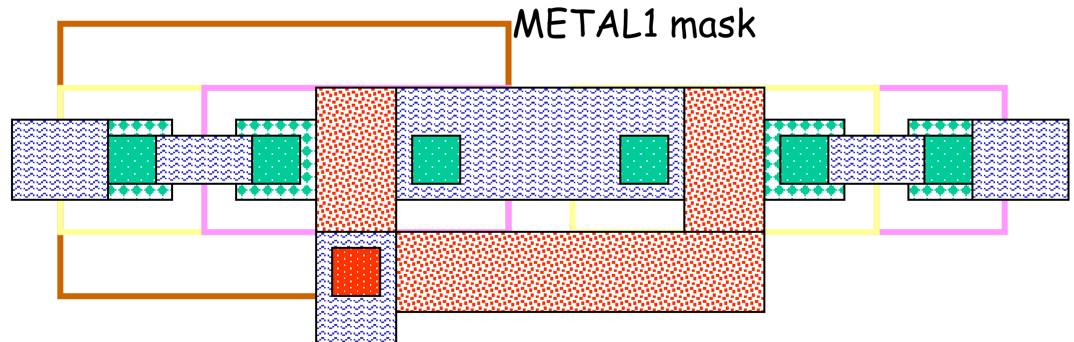


LOCOS -step 7

Form Metal 1 Traces

- Deposit photoresist
- Pattern photoresist
  - *METAL1 Mask

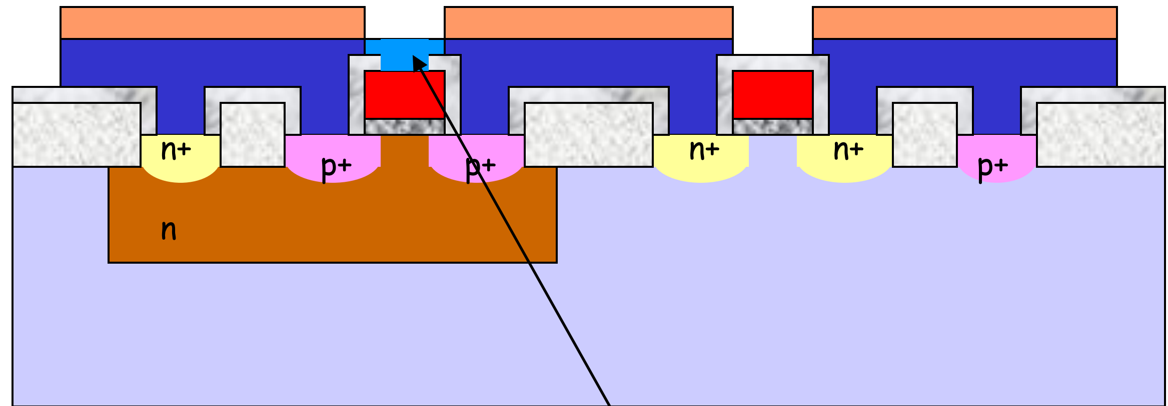




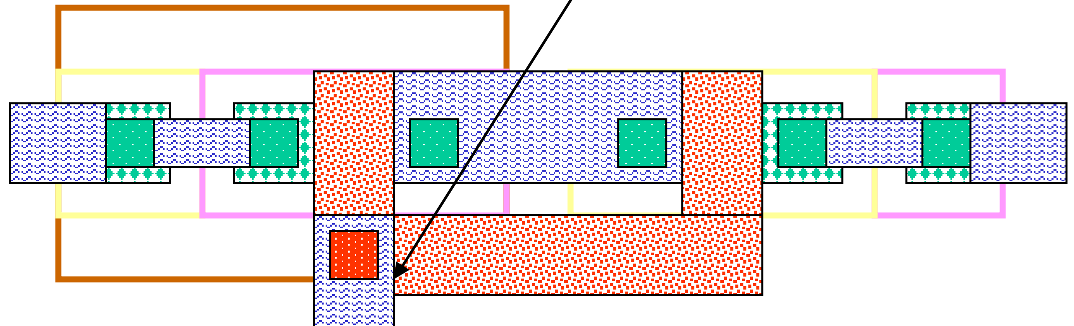
LOCOS -step 7

Form Metal 1 Traces

- Deposit photoresist
- Pattern photoresist
  - *METAL1 Mask
- Etch metal



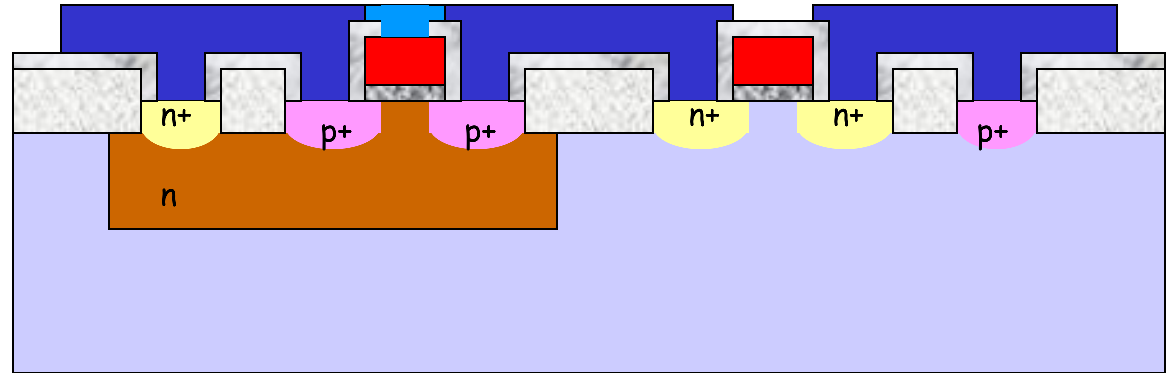
metal over poly outside of cross section

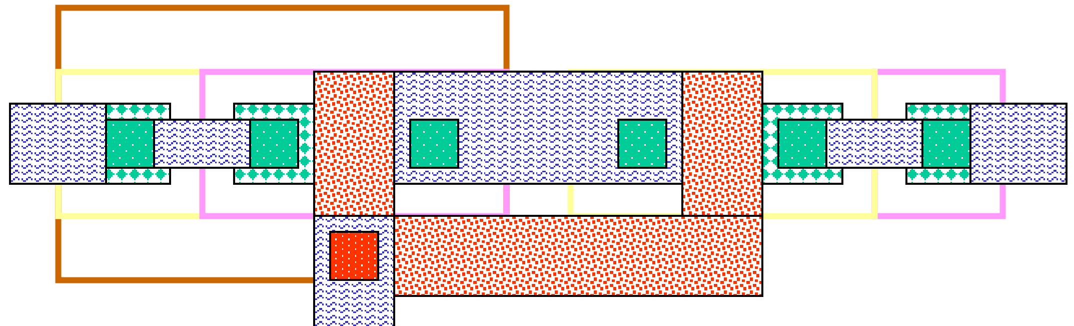


LOCOS -step 7

Form Metal 1 Traces

- Deposit photoresist
- Pattern photoresist
  - *METAL1 Mask
- Etch metal
- Remove photoresist

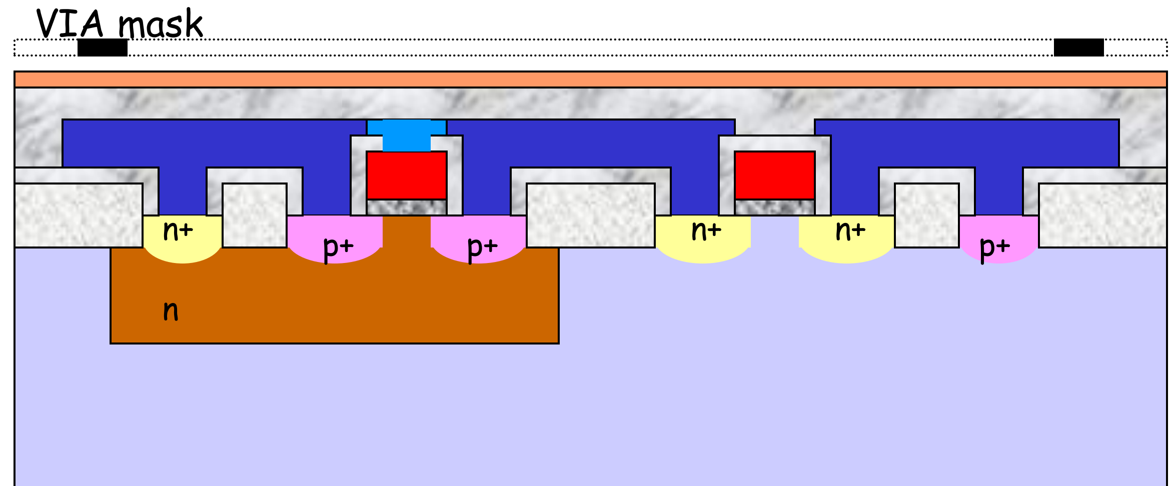


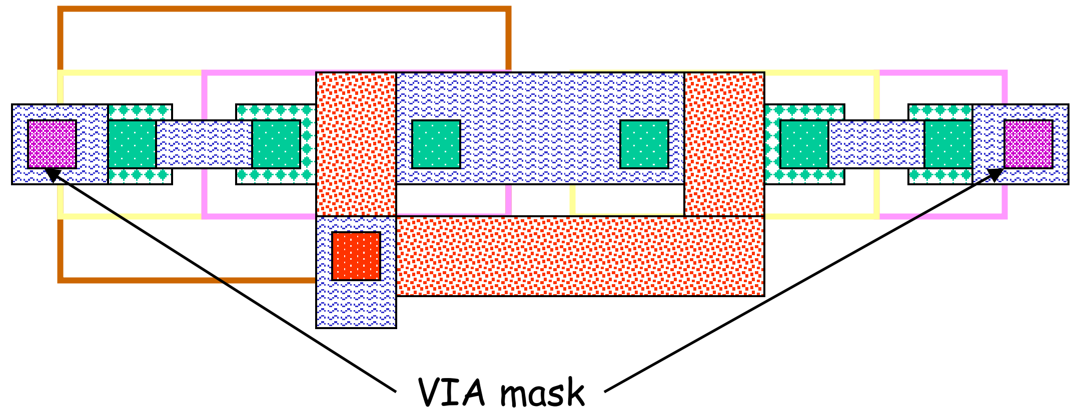


LOCOS -step 8

Form Vias to Metal1

- Deposit oxide
- Planerize oxide
- Deposit photoresist

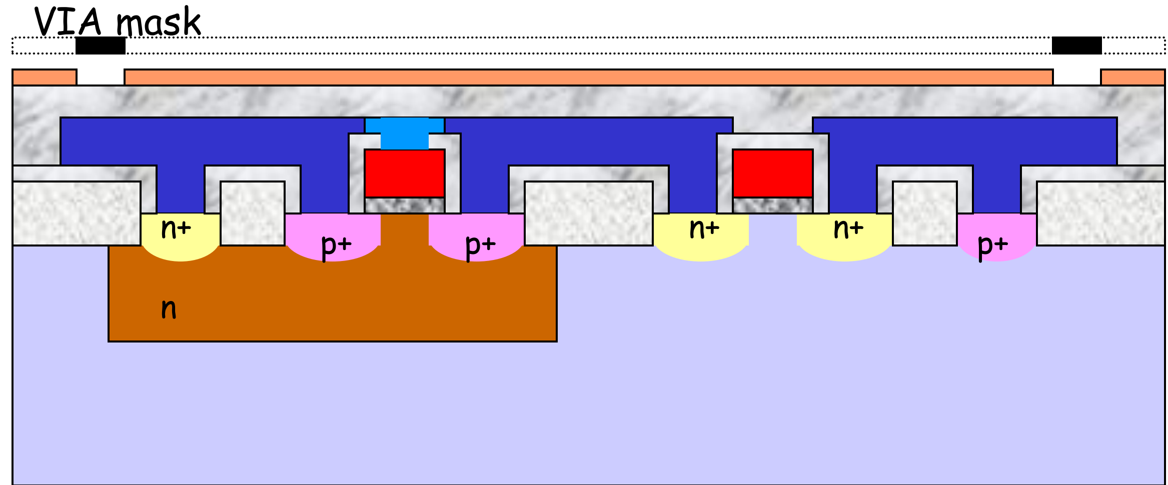


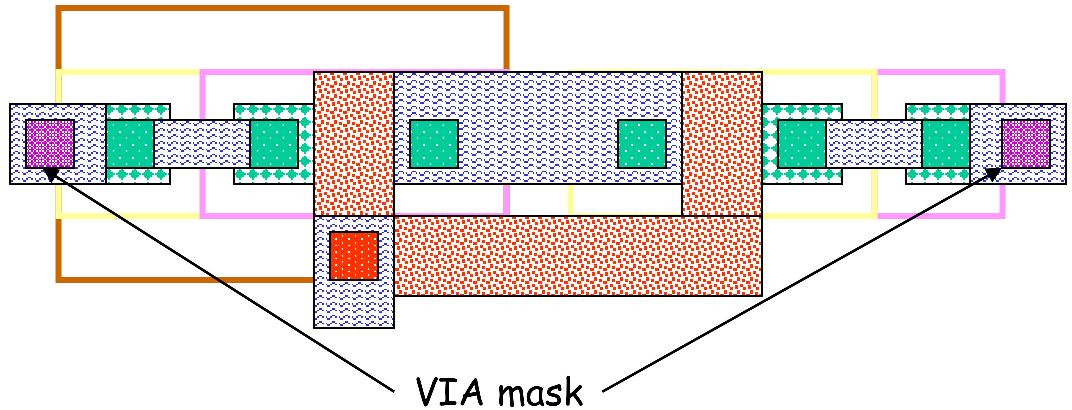


LOCOS -step 8

Form Vias to Metal1

- Deposit oxide
- Planerize
- Deposit photoresist
- Pattern photoresist
  - *VIA Mask

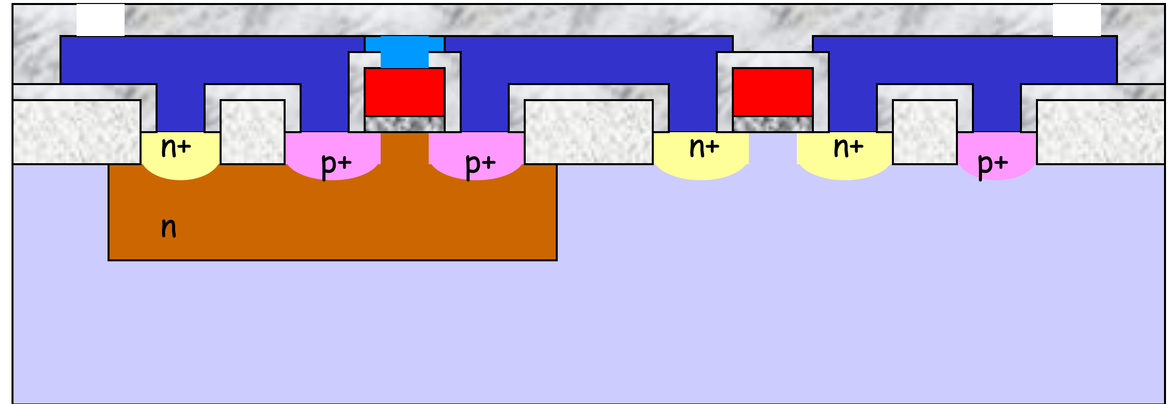


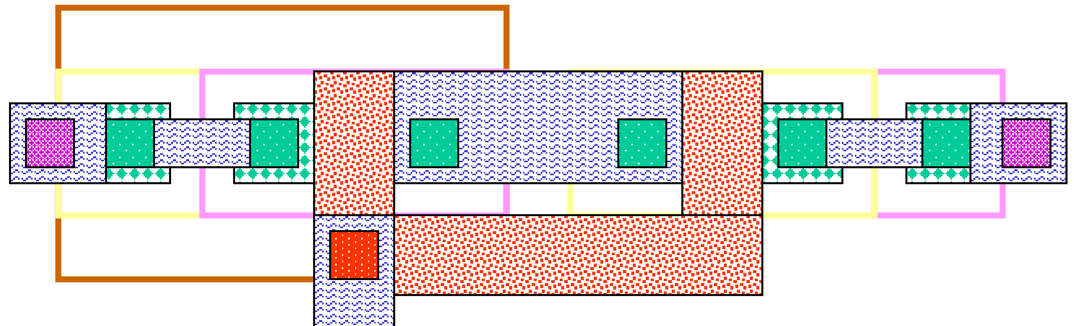


LOCOS -step 8

Form Vias to Metal1

- Deposit oxide
- Planerize
- Deposit photoresist
- Pattern photoresist
  - *VIA Mask
- Etch oxide
- Remove photoresist

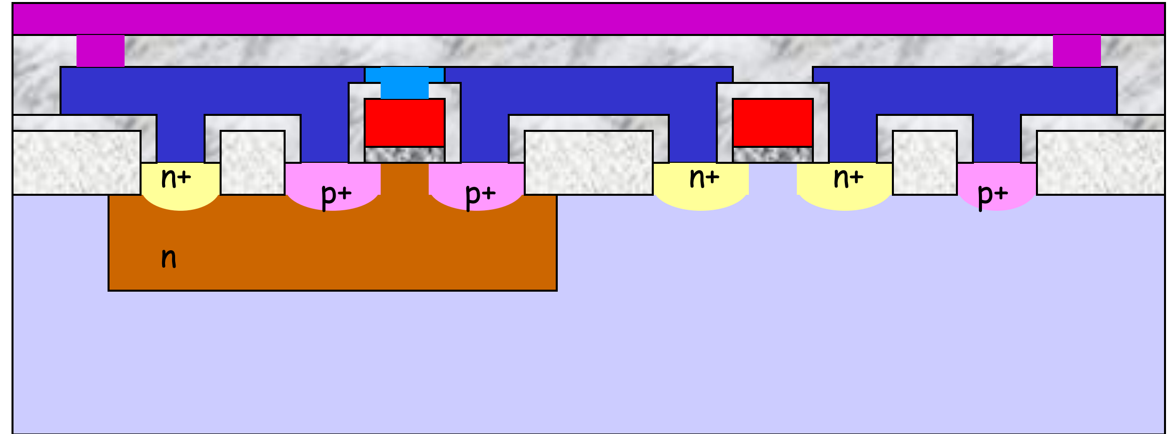


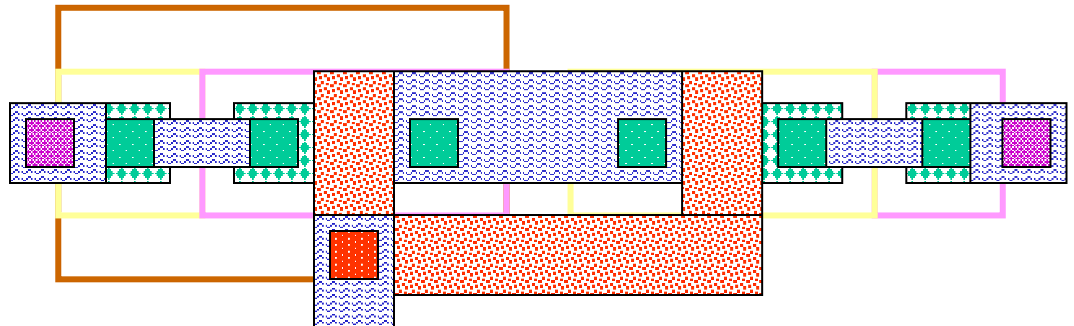


LOCOS -step 8

Form Vias to Metal1

- Deposit oxide
- Planerize
- Deposit photoresist
- Pattern photoresist
  - *VIA Mask
- Etch oxide
- Remove photoresist
- Deposit Metal2

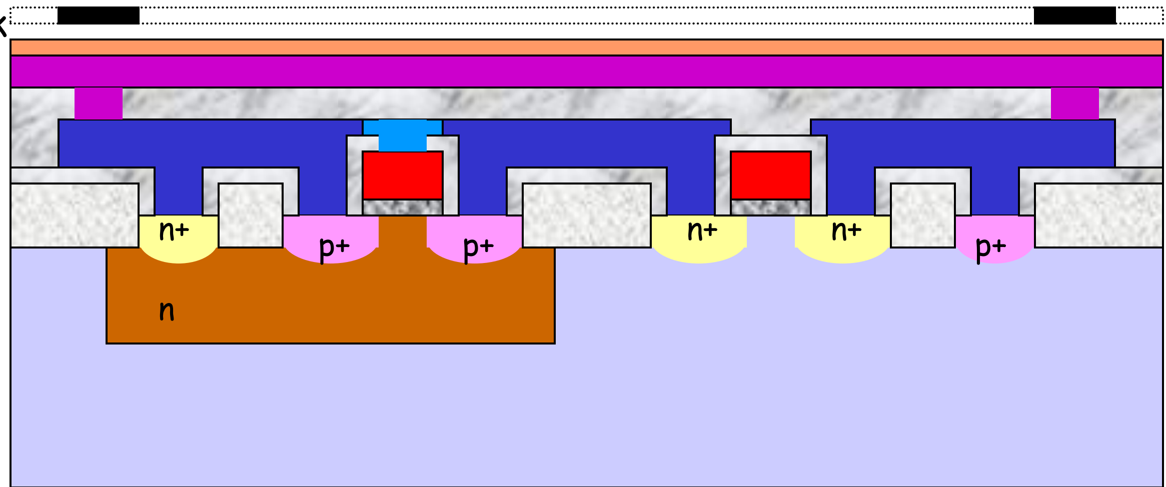


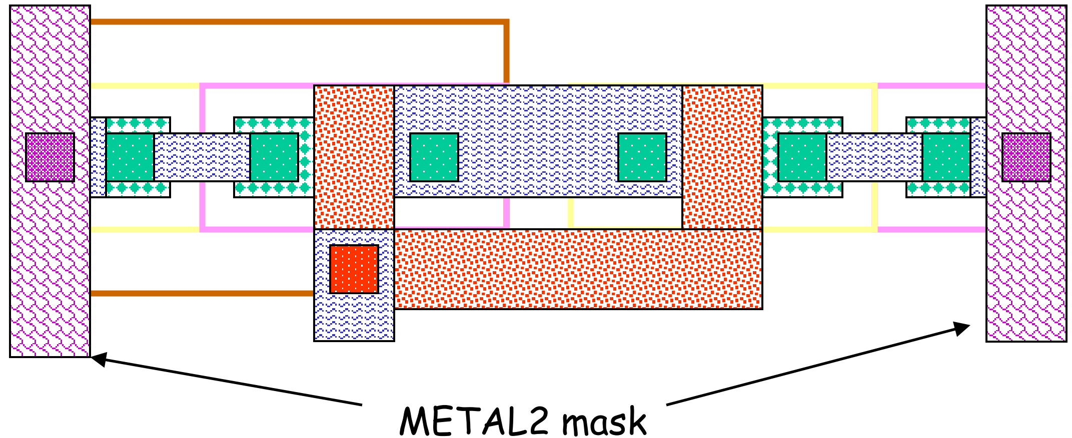


LOCOS -step 9

Form Metal2 Traces

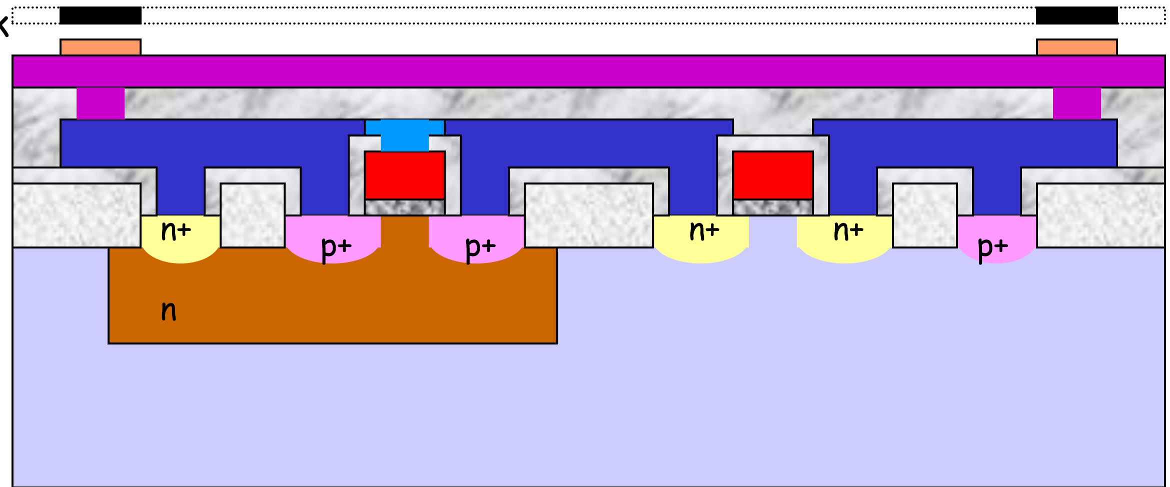
- Deposit photoresist





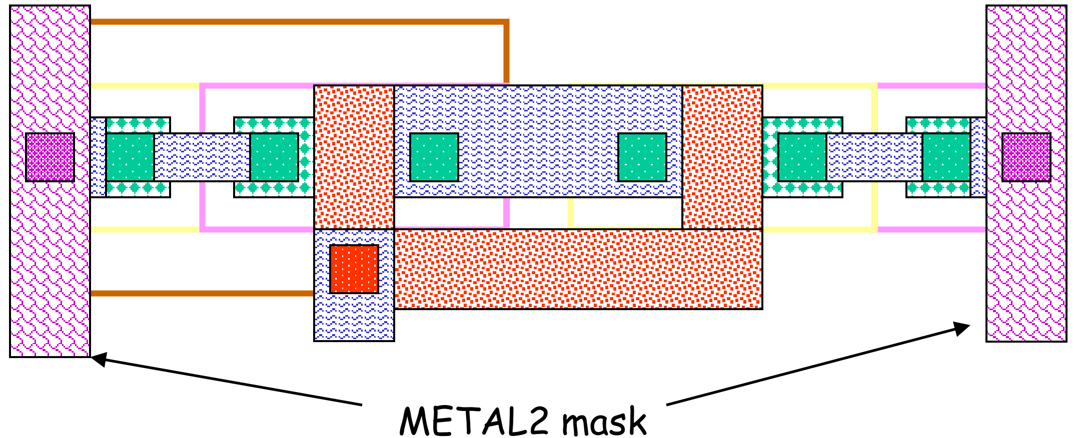
LOCOS -step 9

METAL2 mask



Form Metal2 Traces

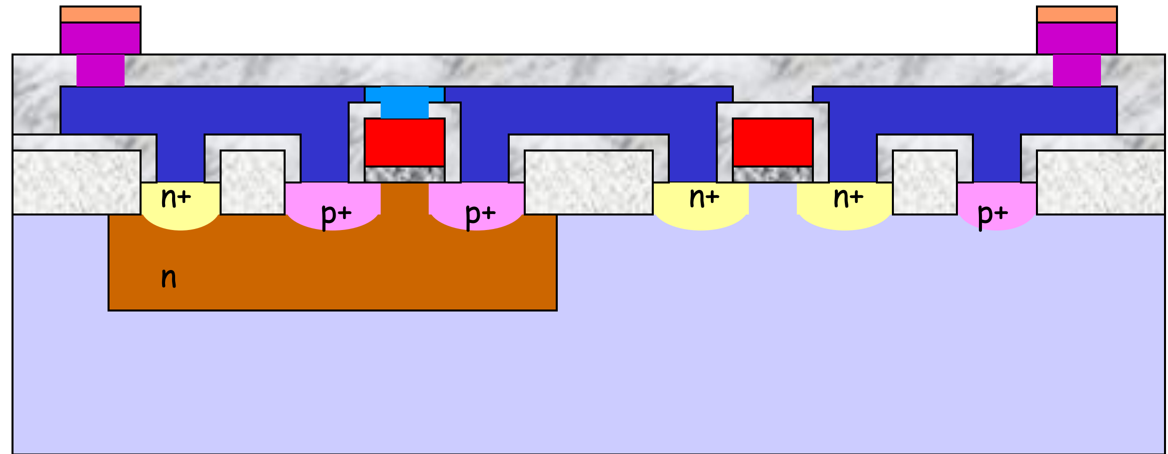
- Deposit photoresist
- Pattern photoresist
  - *METAL2 Mask

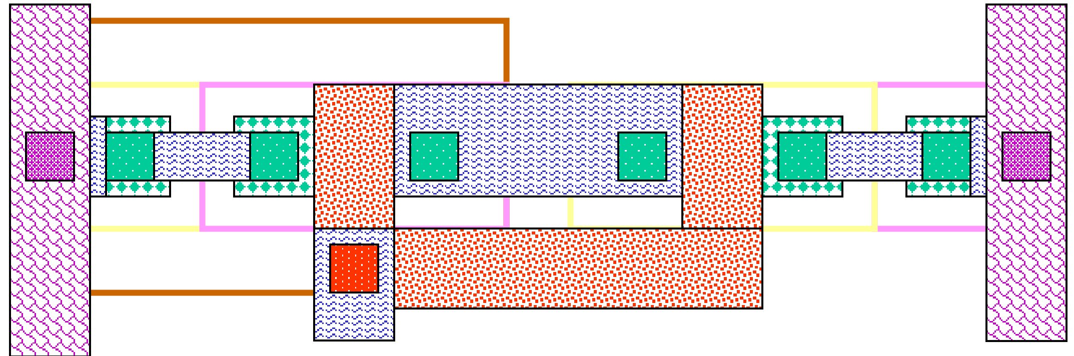


LOCOS -step 9

Form Metal2 Traces

- Deposit photoresist
- Pattern photoresist
  - *METAL2 Mask
- Etch metal

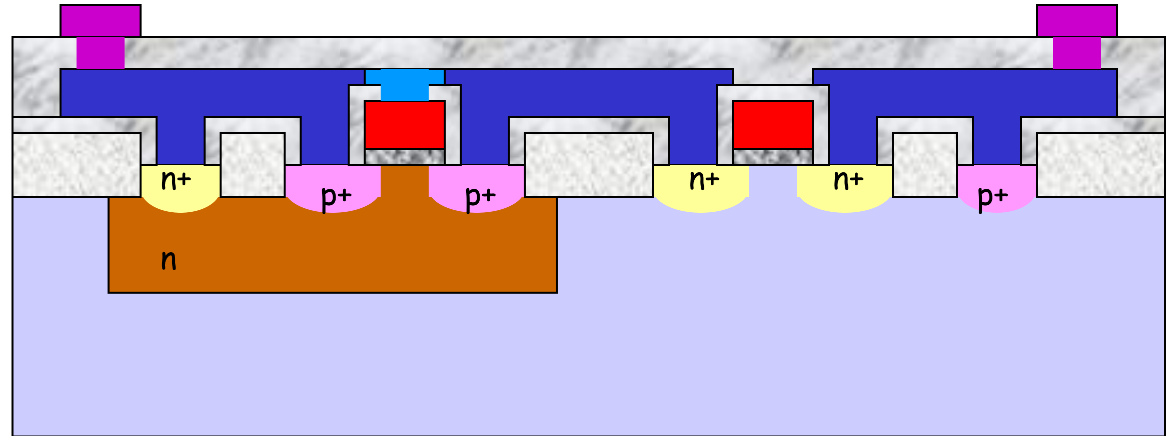


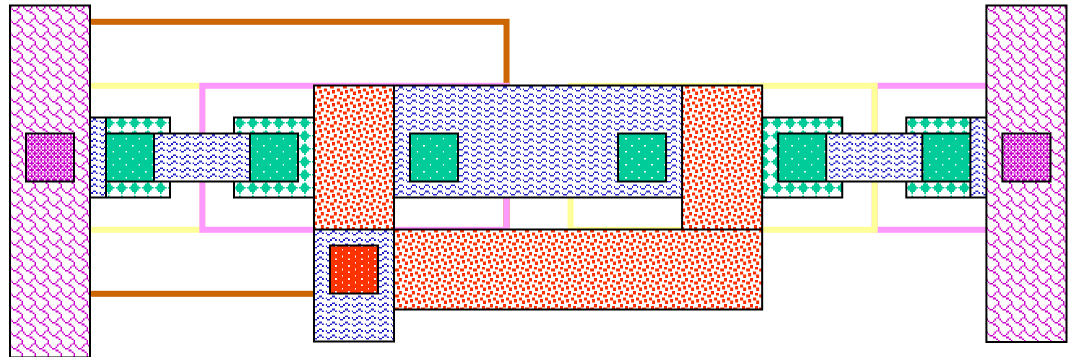


LOCOS -step 9

Form Metal2 Traces

- Deposit photoresist
- Pattern photoresist
  - *METAL2 Mask
- Etch metal
- Remove photoresist

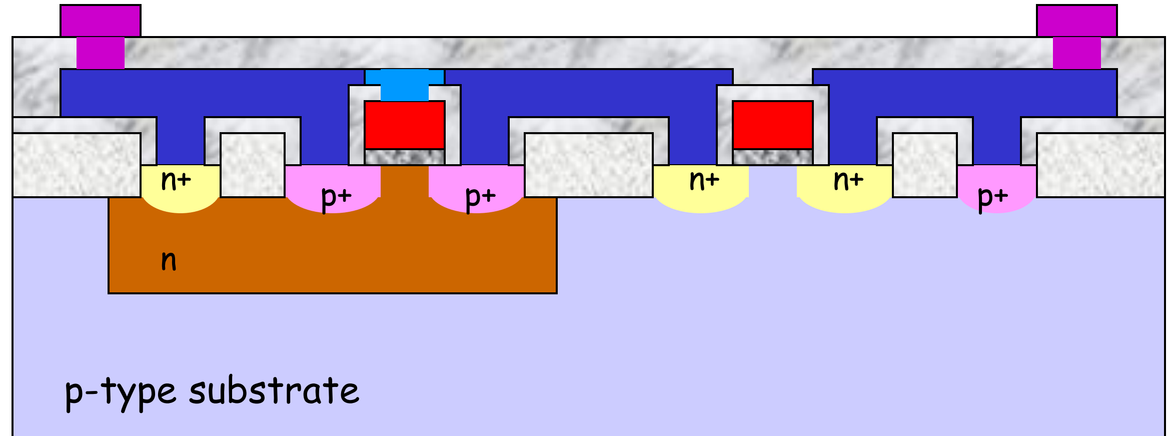


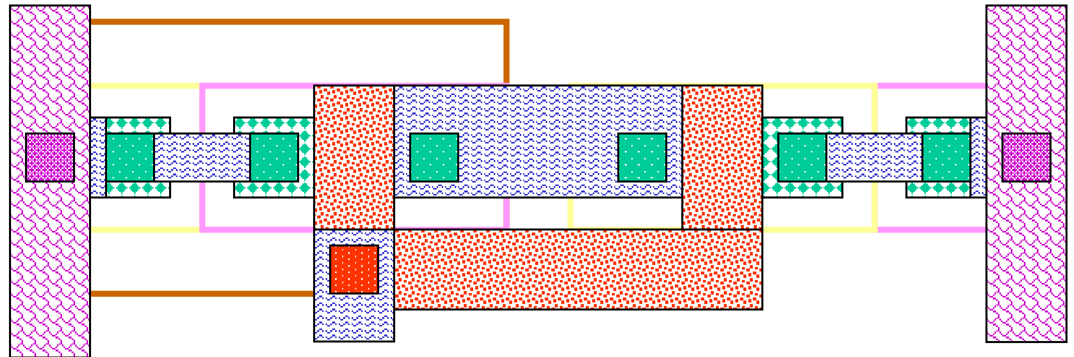


LOCOS -step 10+

Form Additional Traces

- Deposit oxide
- Deposit photoresist
- Pattern photoresist
- Etch oxide
- Deposit metal
- Deposit photresist
- Pattern photoresist
- Etch metal
- Repeat for each additional metal





Simplifications from complete process

- skipped several substrate doping steps
  - channel implant to adjust threshold voltages
  - surface implant to increase breakdown voltage
- no LDD, lightly-doped drain
- no deposition of contact interface materials
- metal patterning simplified
  - more complex "lift-off" process often used
- no overglass (thick top dielectric) layer
- no bonding pad layer
- simplified use of dark/clear field masks and positive/negative photoresist