EE 434
Lecture 8

Process Technology

Diffusion

Oxidation

Epitaxy

Polysilicon

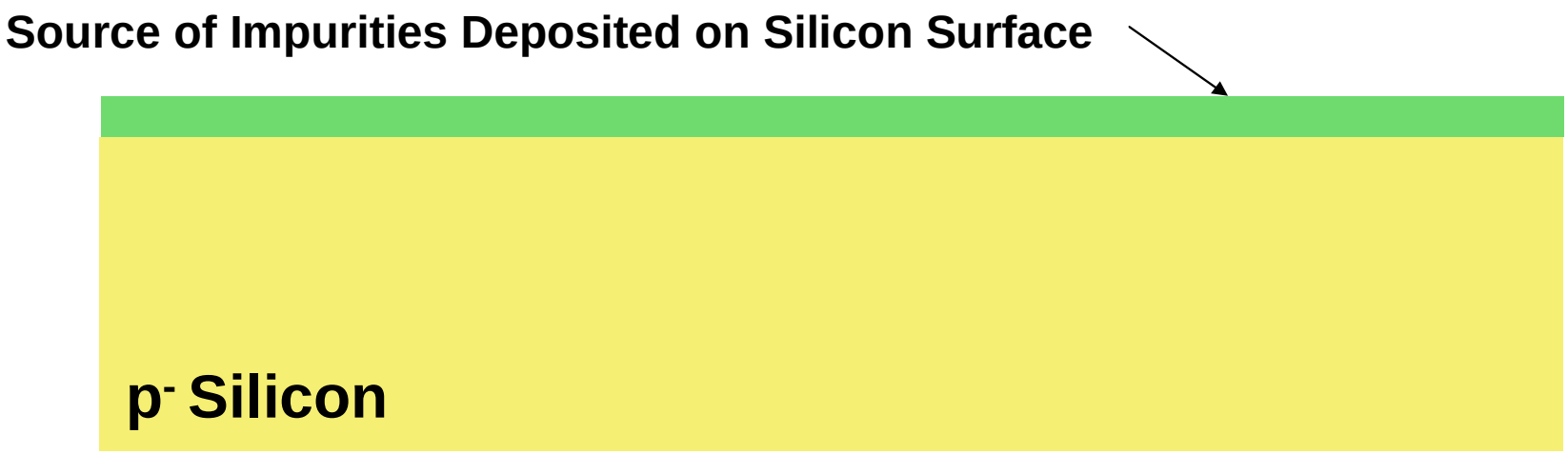
Diffusion

- Controlled Migration of Impurities
  - Time and Temperature Dependent
  - Both vertical and lateral diffusion occurs
  - Crystal orientation affects diffusion rates in lateral and vertical dimensions
  - Materials Dependent
  - Subsequent Movement
  - Electrical Properties Highly Dependent upon Number and Distribution of Impurities
  - Diffusion at 800^{o}C to 1200^{o}C
- Source of Impurities
  - Deposition
  - Ion Implantation
    - Only a few A^{o} deep
    - More accurate control of doping levels
    - Fractures silicon crystaline structure during implant
    - Annealing occurs during diffusion

IC Fabrication Technology

- Crystal Preparation
- Masking
- Photolithographic Process
- Deposition
- Etching
- Diffusion
- Oxidation
- Epitaxy
- Polysilicon
- Contacts, Interconnect and Metalization
- Planarization

Diffusion



Before Diffusion

After Diffusion

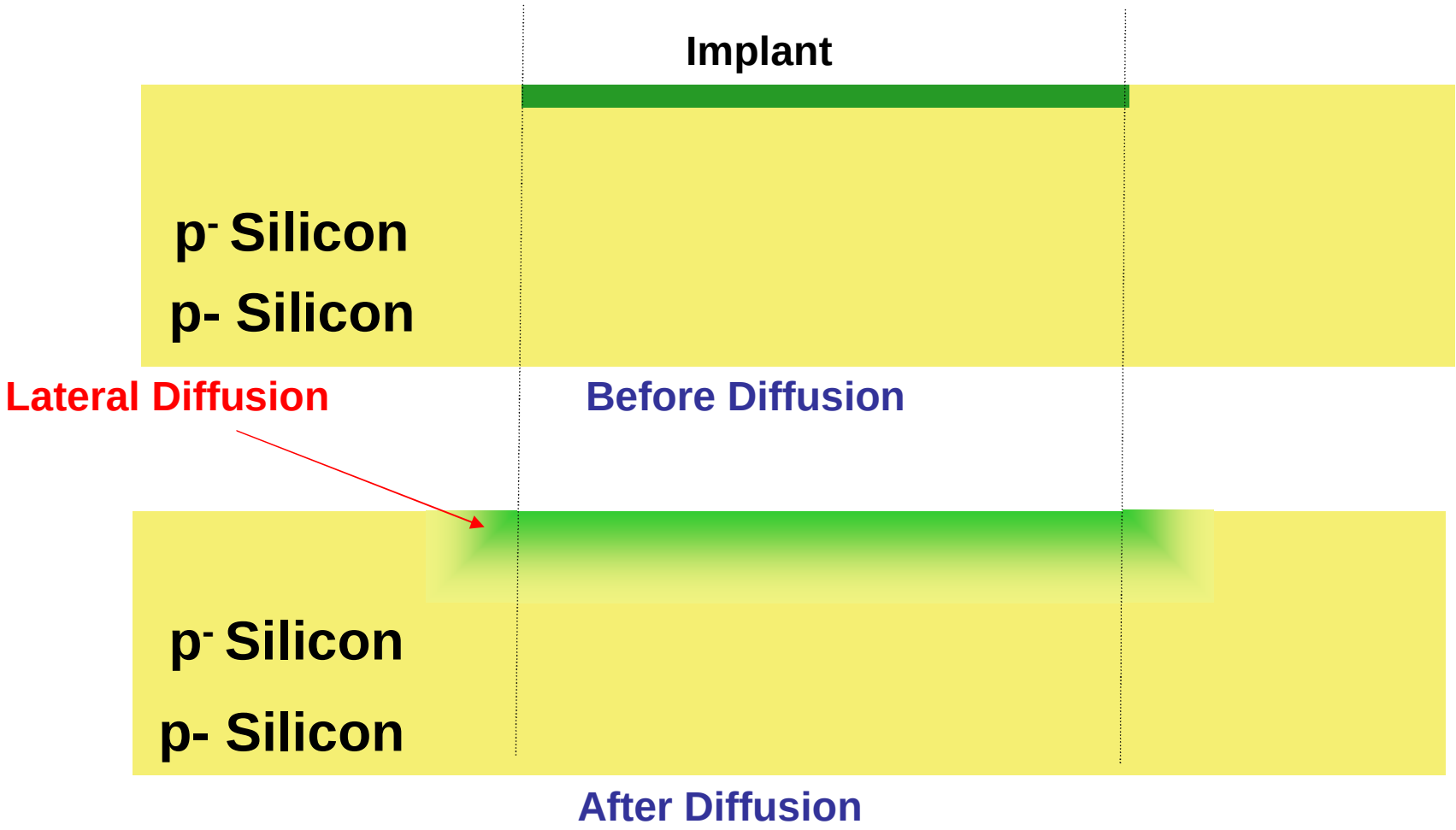
Diffusion

Source of Impurities Implanted in Silicon Surface

Before Diffusion

After Diffusion

Diffusion


Implant
p- Silicon
p- Silicon
Lateral Diffusion
Before Diffusion
p- Silicon
p- Silicon
After Diffusion

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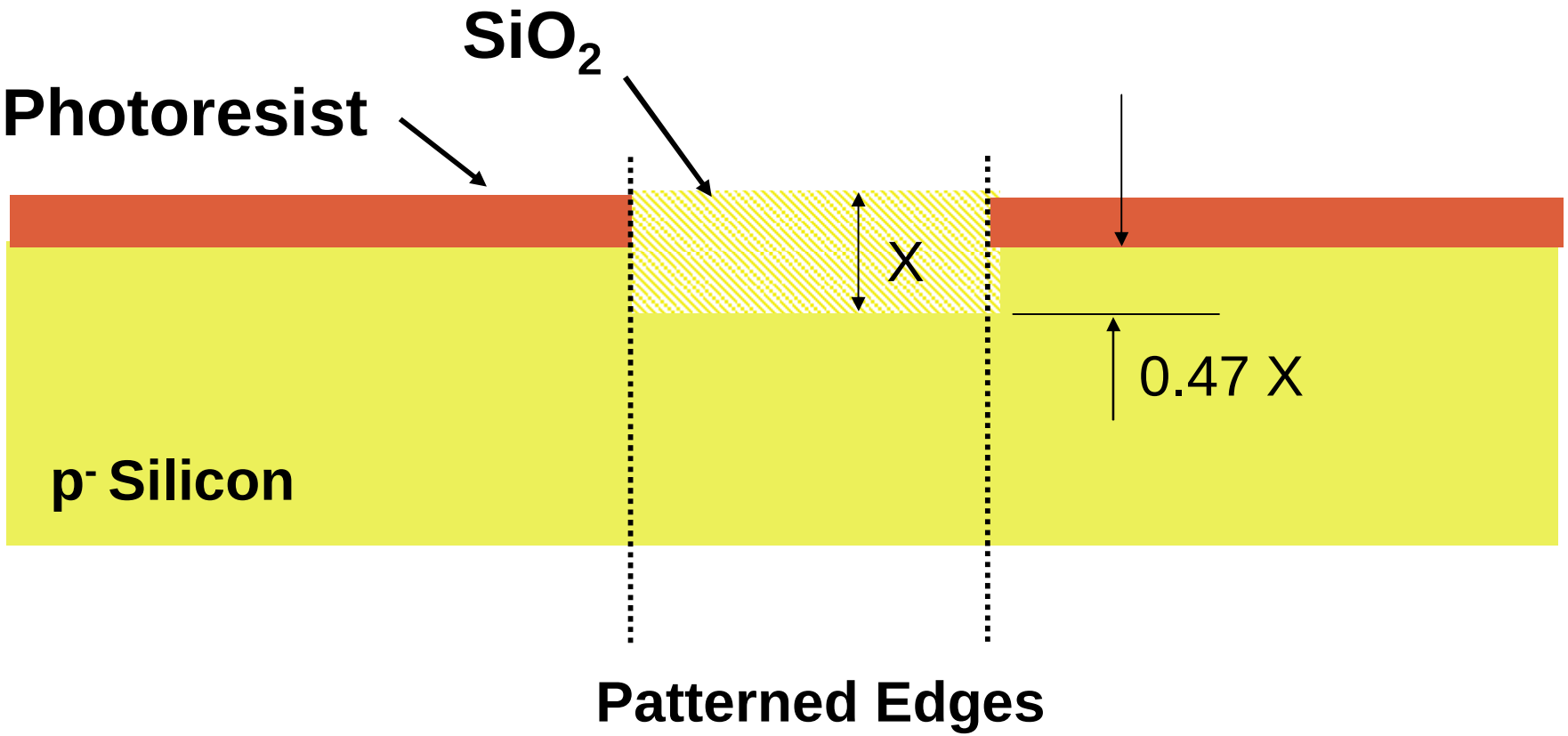
Oxidation

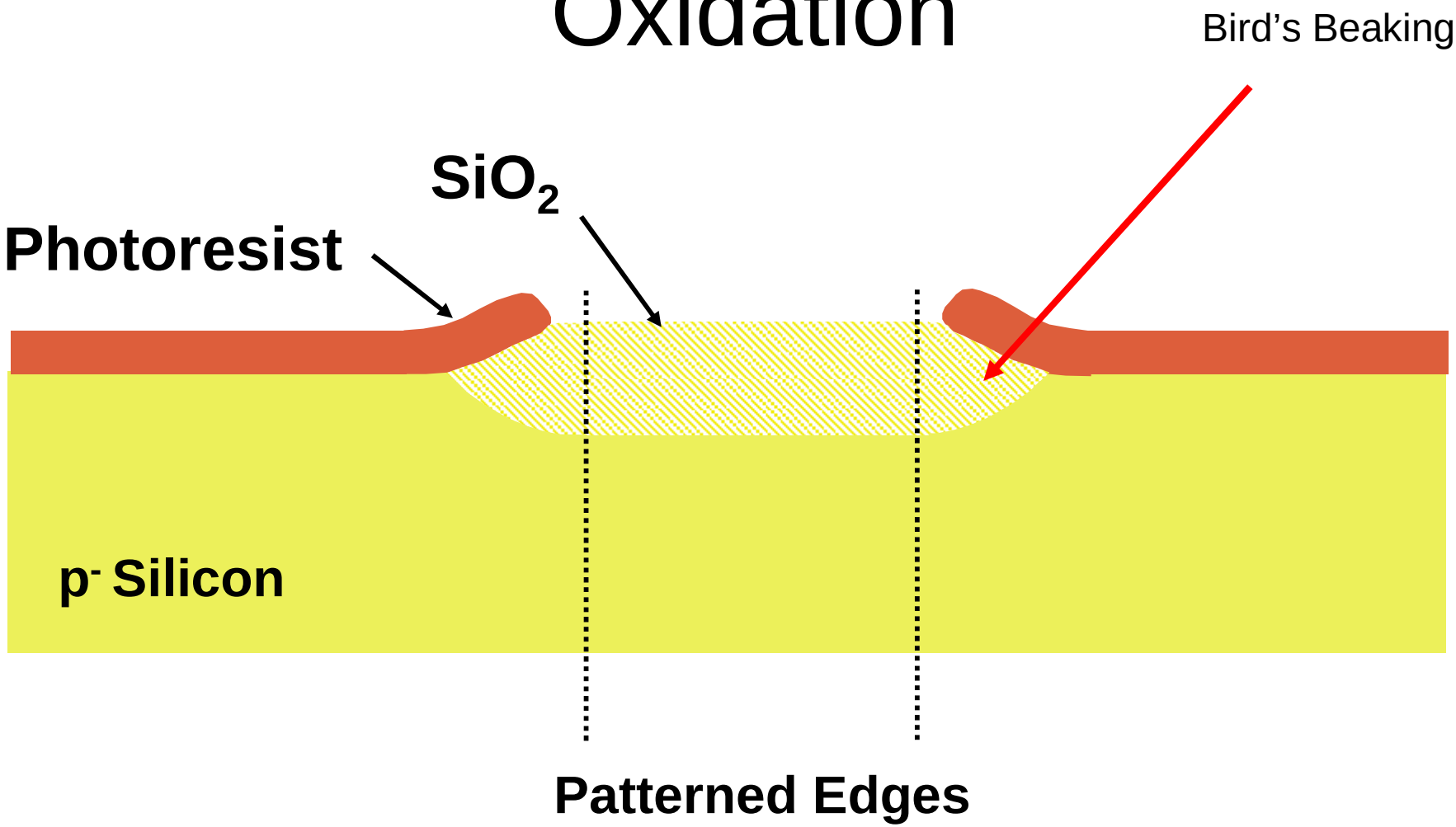
- SiO_2 is widely used as an insulator
  - Excellent insulator properties
- Used for gate dielectric
  - Gate oxide layers very thin
- Used to separate devices by raising threshold voltage
  - termed field oxide
  - field oxide layers very thick
- Methods of Oxidation
  - Thermal Growth (LOCOS)
    - Consumes host silicon
    - x units of SiO_2 consumes .47x units of Si
    - Undercutting of photoresist
    - Compromises planar surface for thick layers
    - Excellent quality
  - Chemical Vapor Deposition
    - Needed to put SiO_2 on materials other than Si

Oxidation



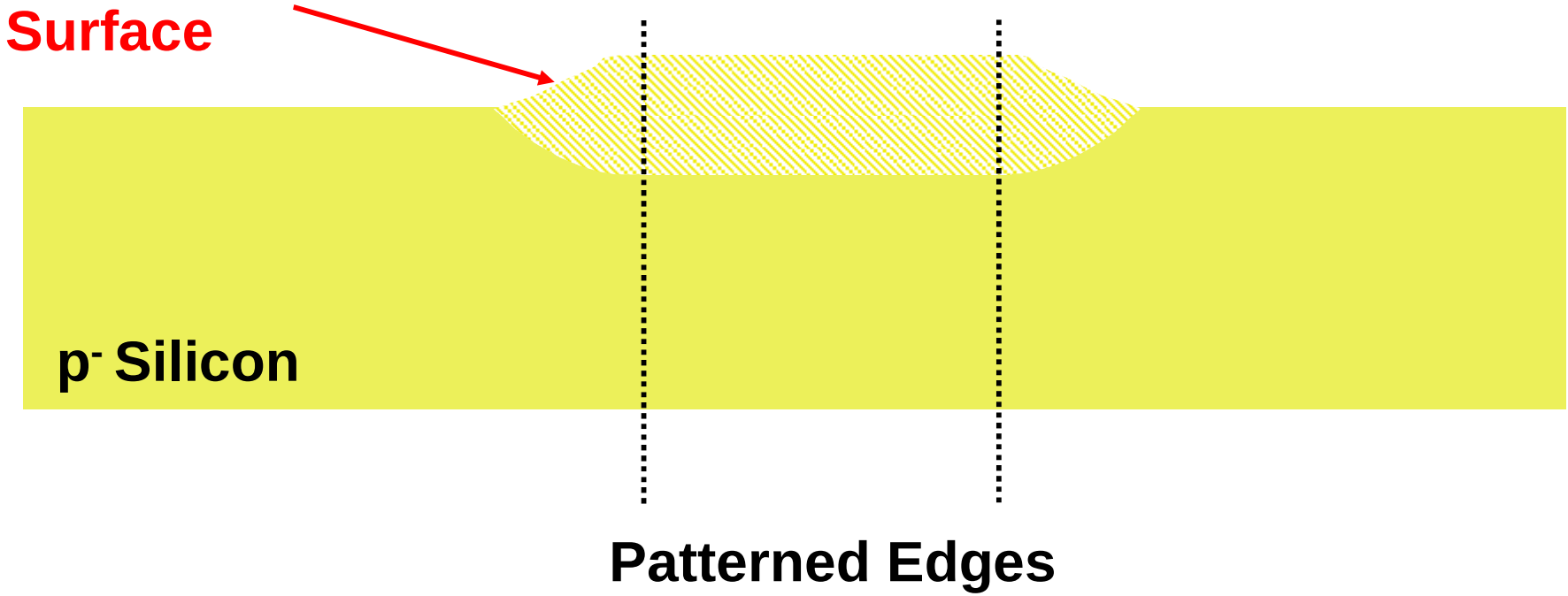
Thermally Grown SiO_2 - desired growth

Oxidation



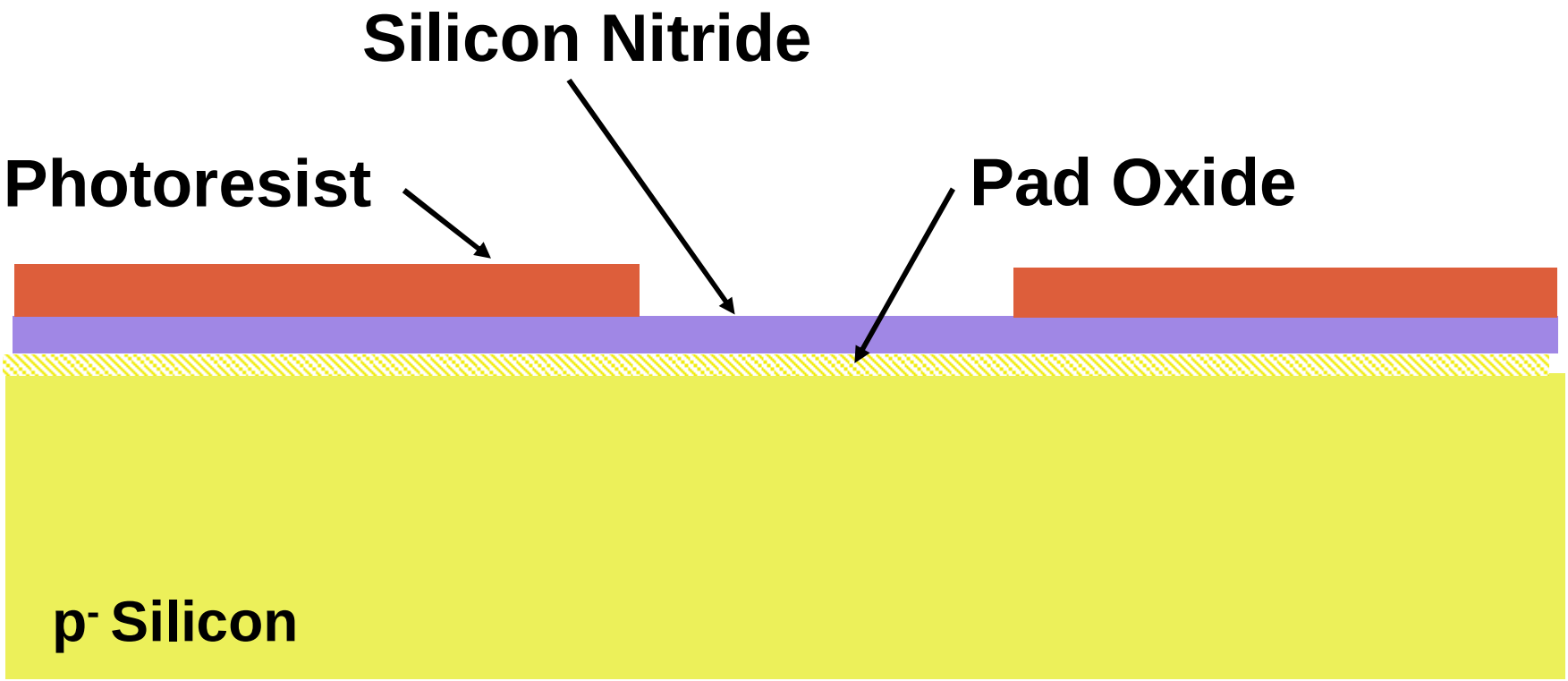
Thermally Grown SiO_2 - actual growth

Oxidation



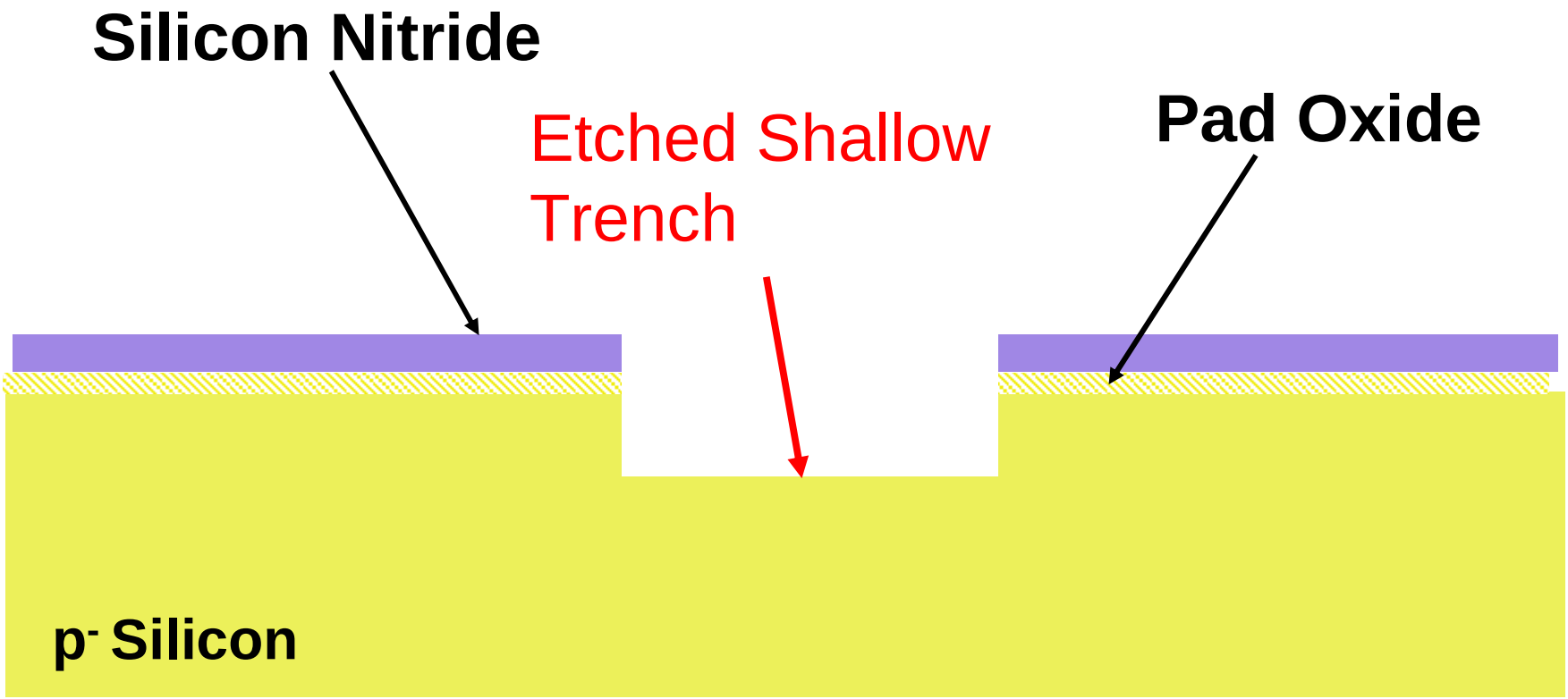
Thermally Grown SiO_2 - actual growth

Oxidation



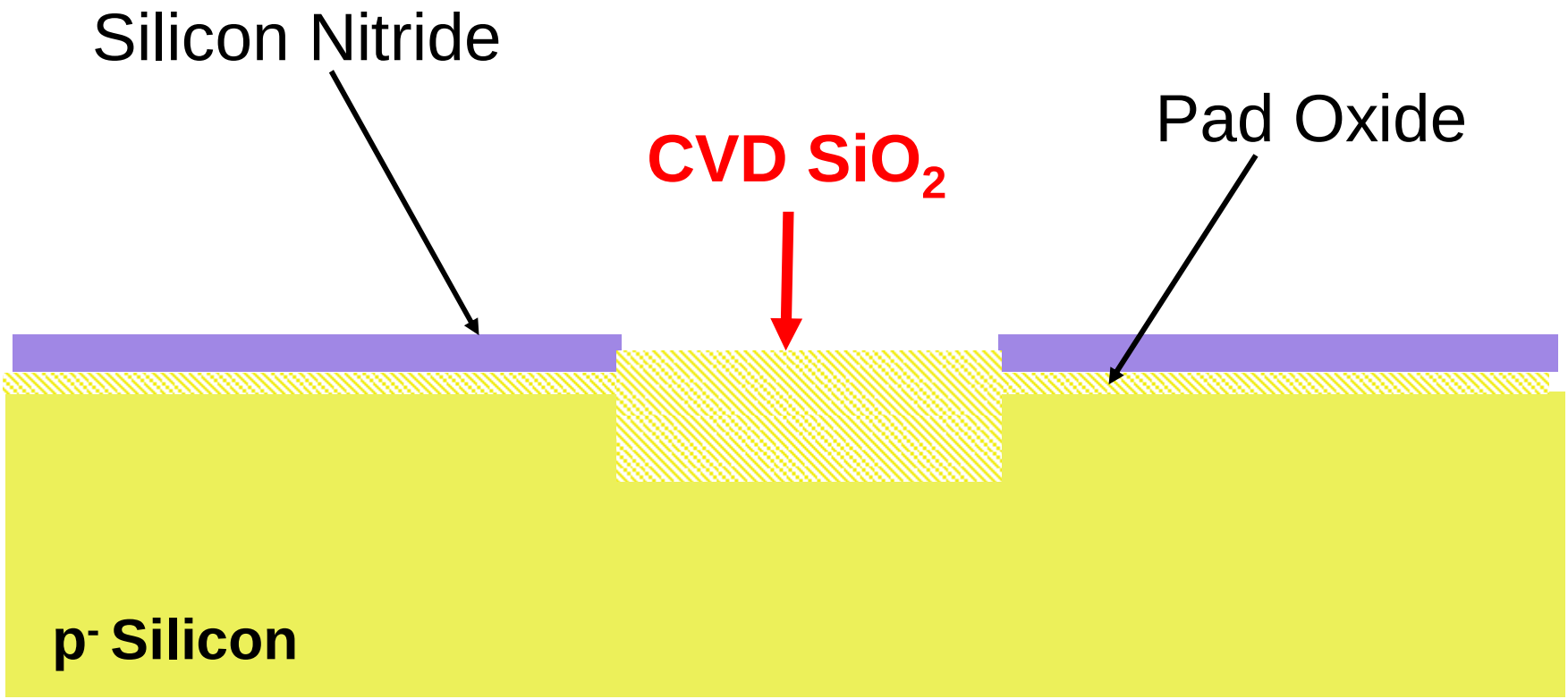
Shallow Trench Isolation (STI)

Oxidation



Shallow Trench Isolation (STI)

Oxidation



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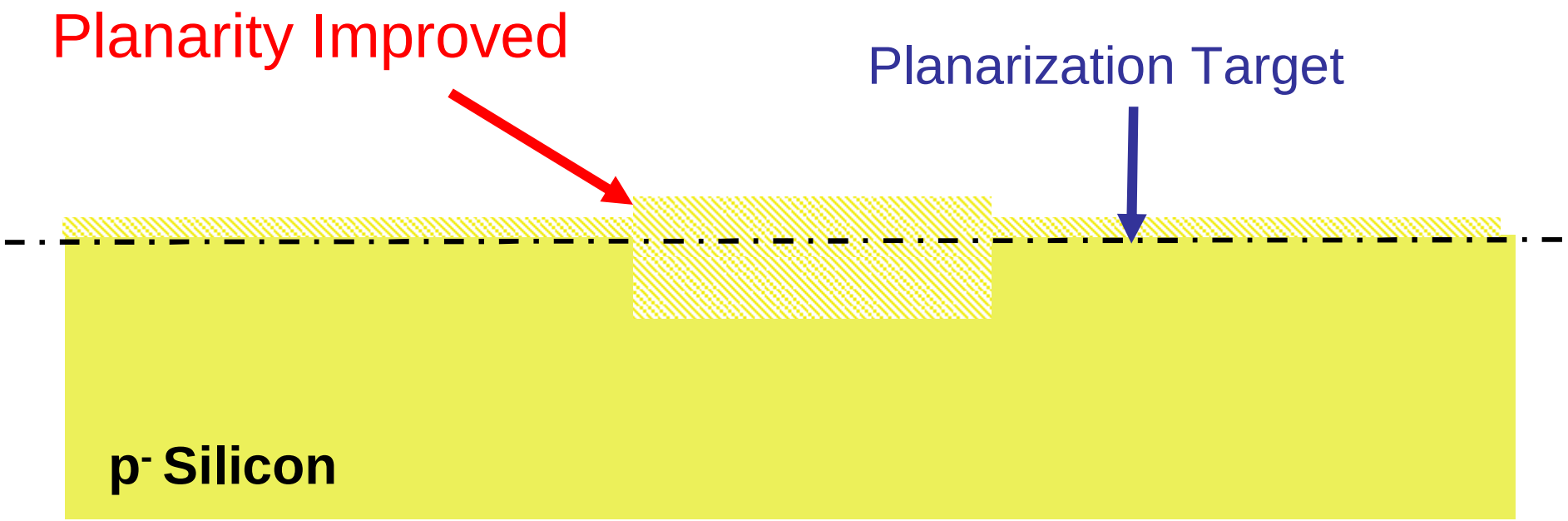
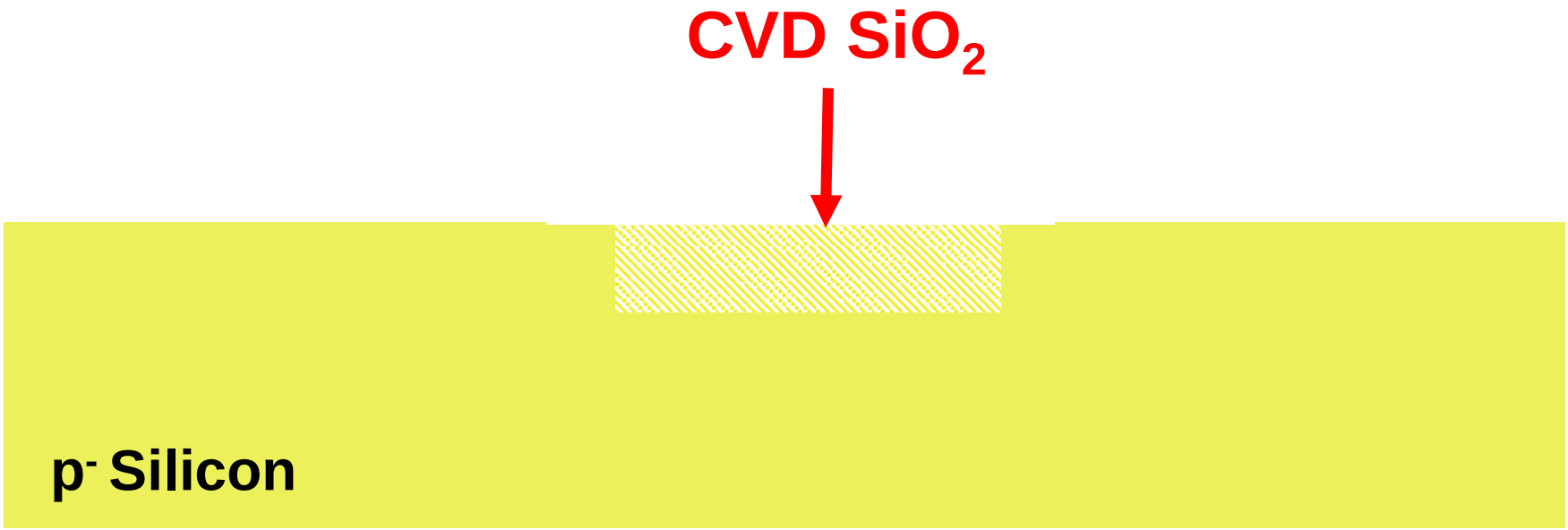
Oxidation



Shallow Trench Isolation (STI)

Oxidation

After Planarization



Shallow Trench Isolation (STI)

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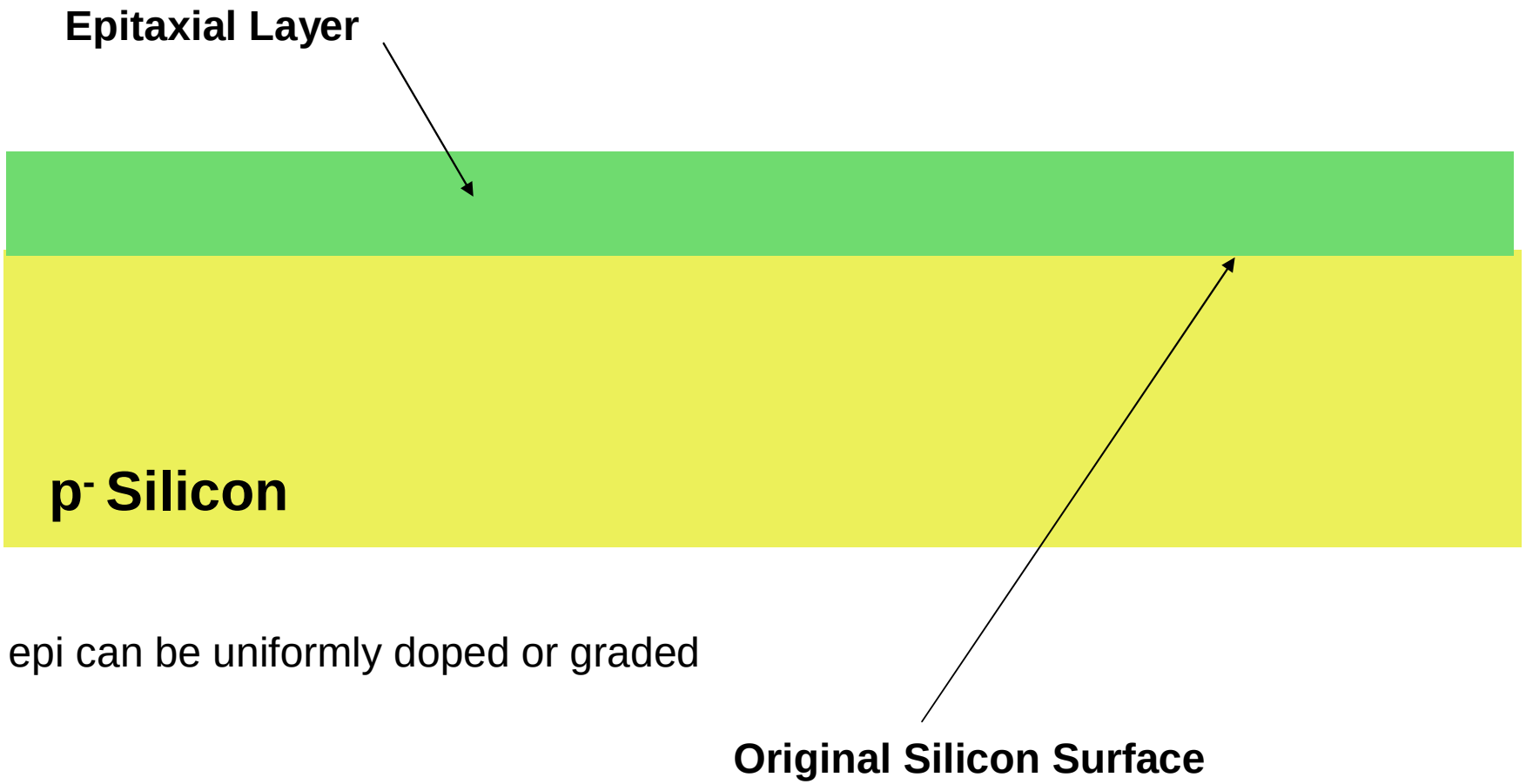
Epitaxy

- Single Crystaline Extension of Substrate Crystal
  - Commonly used in bipolar processes
  - CVD techniques
  - Impurities often added during growth
  - Grows slowly to allow alignmnt with substrate

Epitaxy



epi can be uniformly doped or graded

Question: Why can't a diffusion be used to create the same effect as an epi layer ?

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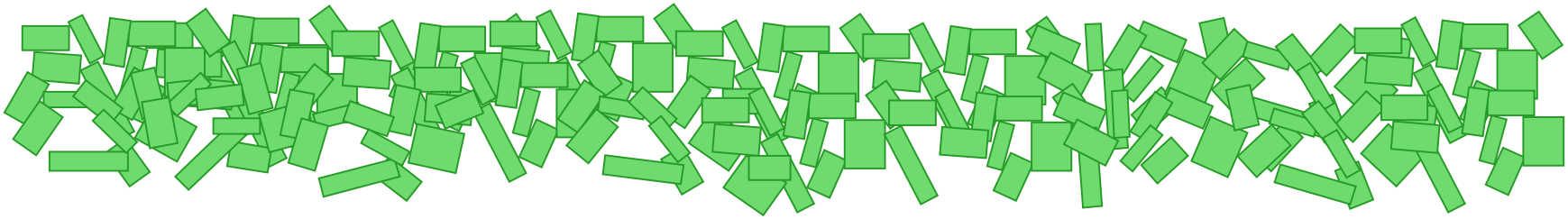
Polysilicon

- Elemental contents identical to that of single crystaline silicon
  - Electrical properties much different
  - If doped heavily makes good conductor
  - If doped moderately makes good resistor
  - Widely used for gates of MOS devices
  - Widely used to form resistors
  - Grows fast over non-crystaline surface
  - Silicide often used in regions where resistance must be small
    - Refractory metal used to form silicide
    - Designer must indicate where silicide is applied (or blocked)

Polysilicon



Polysilicon

Single-Crystaline Silicon

End of Lecture 8