Silicon on Insulator

Brandon Dyer

ECE3080

Background

- Research started in 60s for NASA
- First put into commercial use by IBM
- Now used by IBM, AMD, Freescale and Chartered Semiconductor now use
- Intel still insistent on use of bulk silicon

Advantages

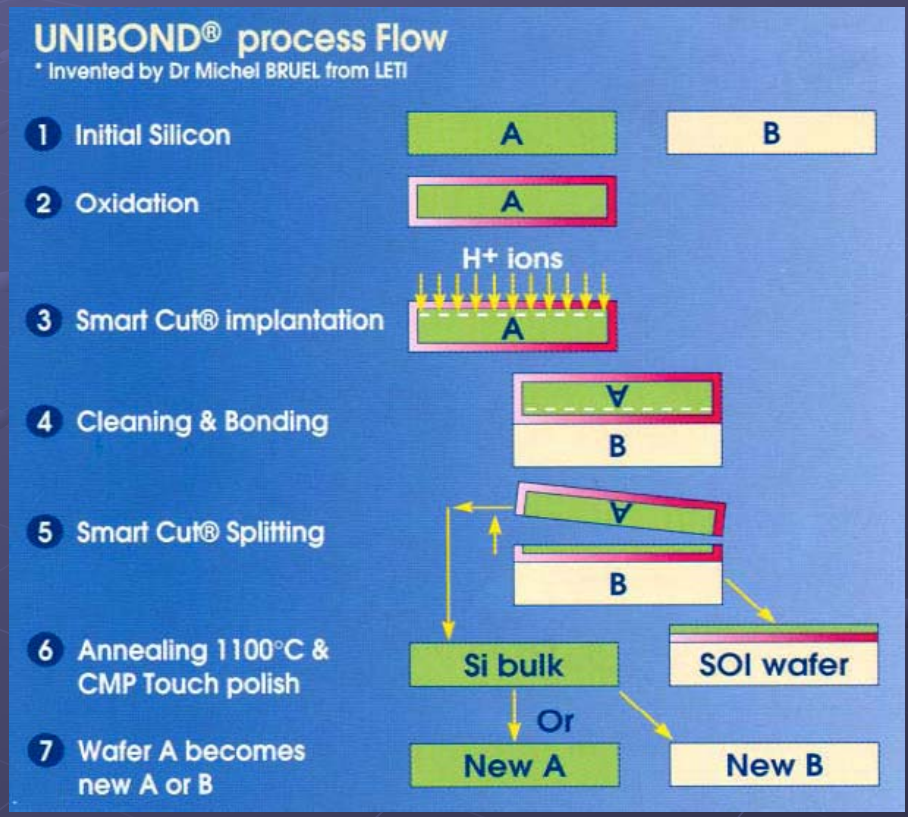
- Resistant to punch through
- Lower junction capacitances
- Better low voltage operation
- Electrical Isolation
- Functions better in Extreme Conditions

Disadvantages

- COST!!! 10 – 15% more expensive per wafer
- Self heating – insulating layer worsens heat dissapation
- Yield issues – added complexity of

Wafer Manufacturing

- SIMOX – Seperation by Implantation of Oxygen
- Eltran – uses porous silicon and water
- Smart Cut – Ion implantation to determine controlled breaks



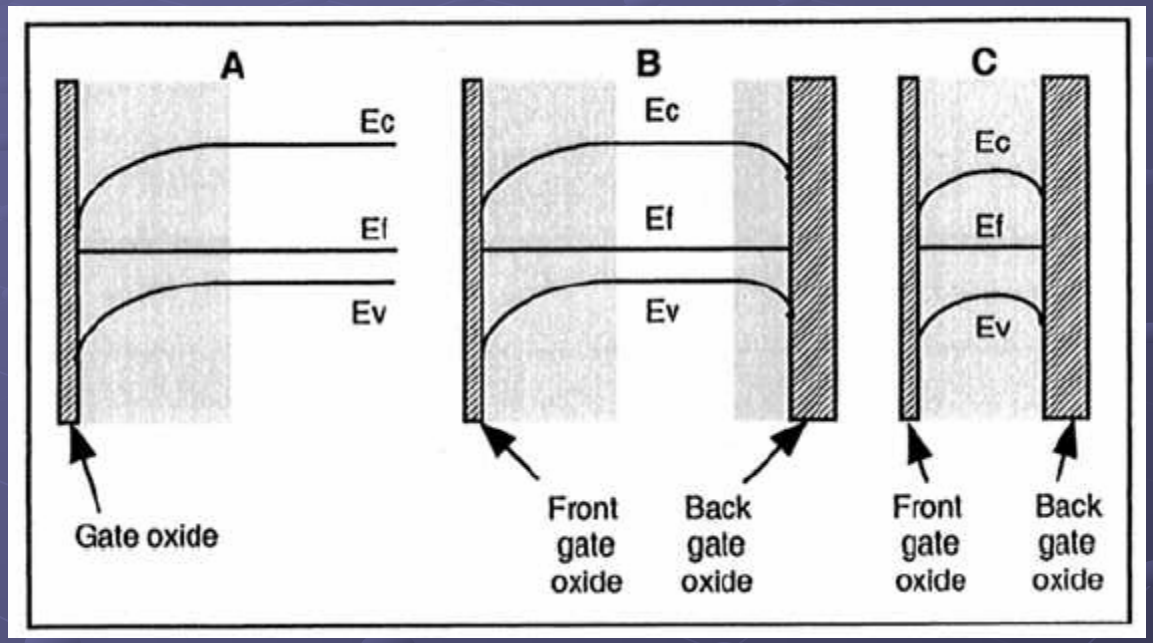
Types of SOI

Partially Depleted

- Si film thickness greater than twice depletion width
- Floating body issues
- Easier to manufacture
- Much like bulk transistors

Fully Depleted

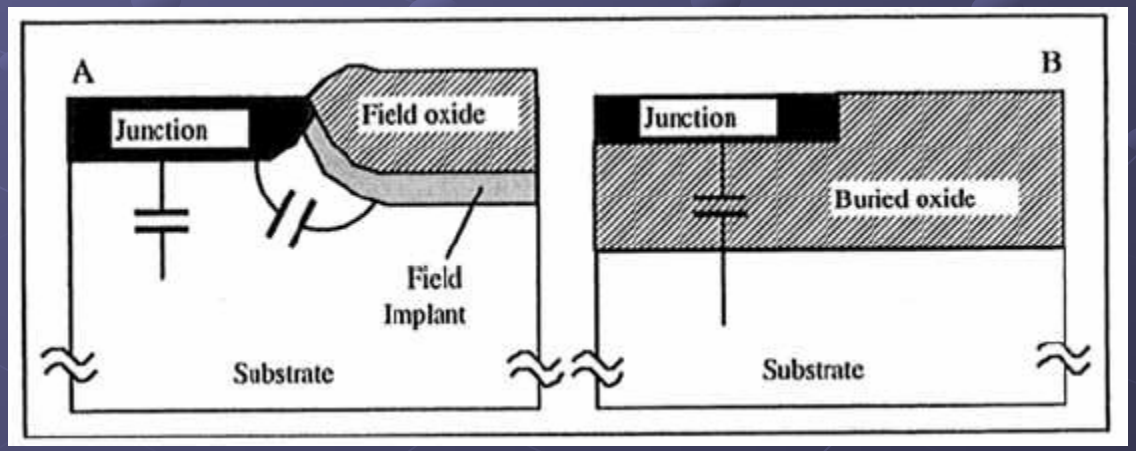
- Si film thickness smaller than depletion width
- No floating body issues
- Up to 9 modes of operation


A
Ec
Ef
Ev
Gate oxide
B
Ec
Ef
Ev
Front gate oxide
Back gate oxide
C
Ec
Ef
Ev
Front gate oxide
Back gate oxide

Junction Capacitances

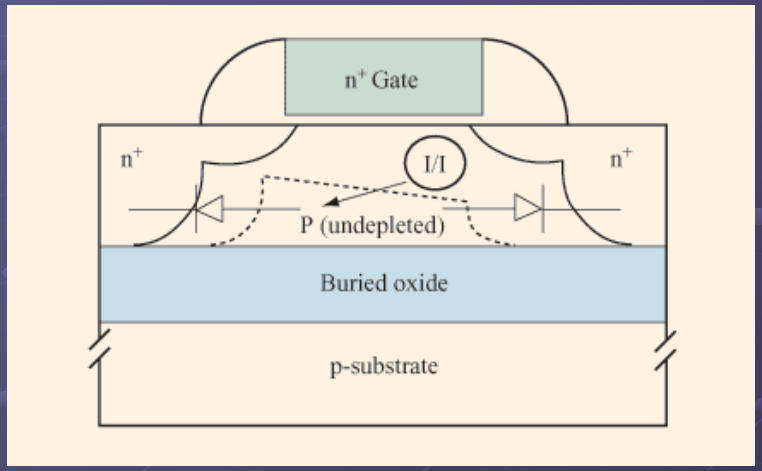
- Source/drain-substrate capacitance lowered
- Higher switching speed
- Less dynamic power dissapation

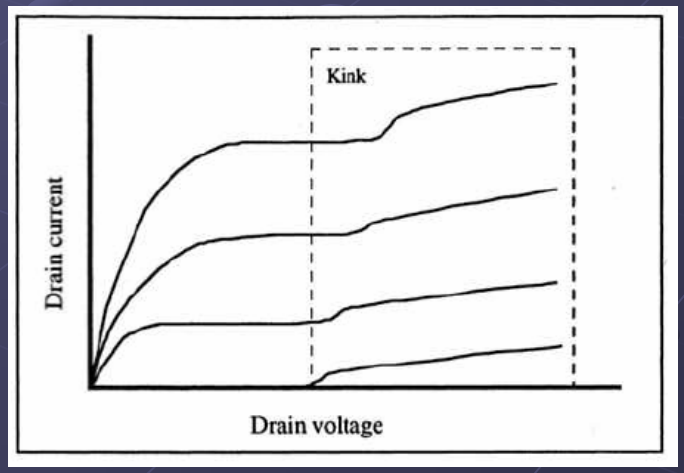
$$P = .5*f*C*V^2$$



Floating Body Effects

- Present mostly in PD-SOI
- Impact Ionization creates holes
- Holes flow to undepleted region
- Kink Effect – Charge lower V_T creating kinks in I-V curve

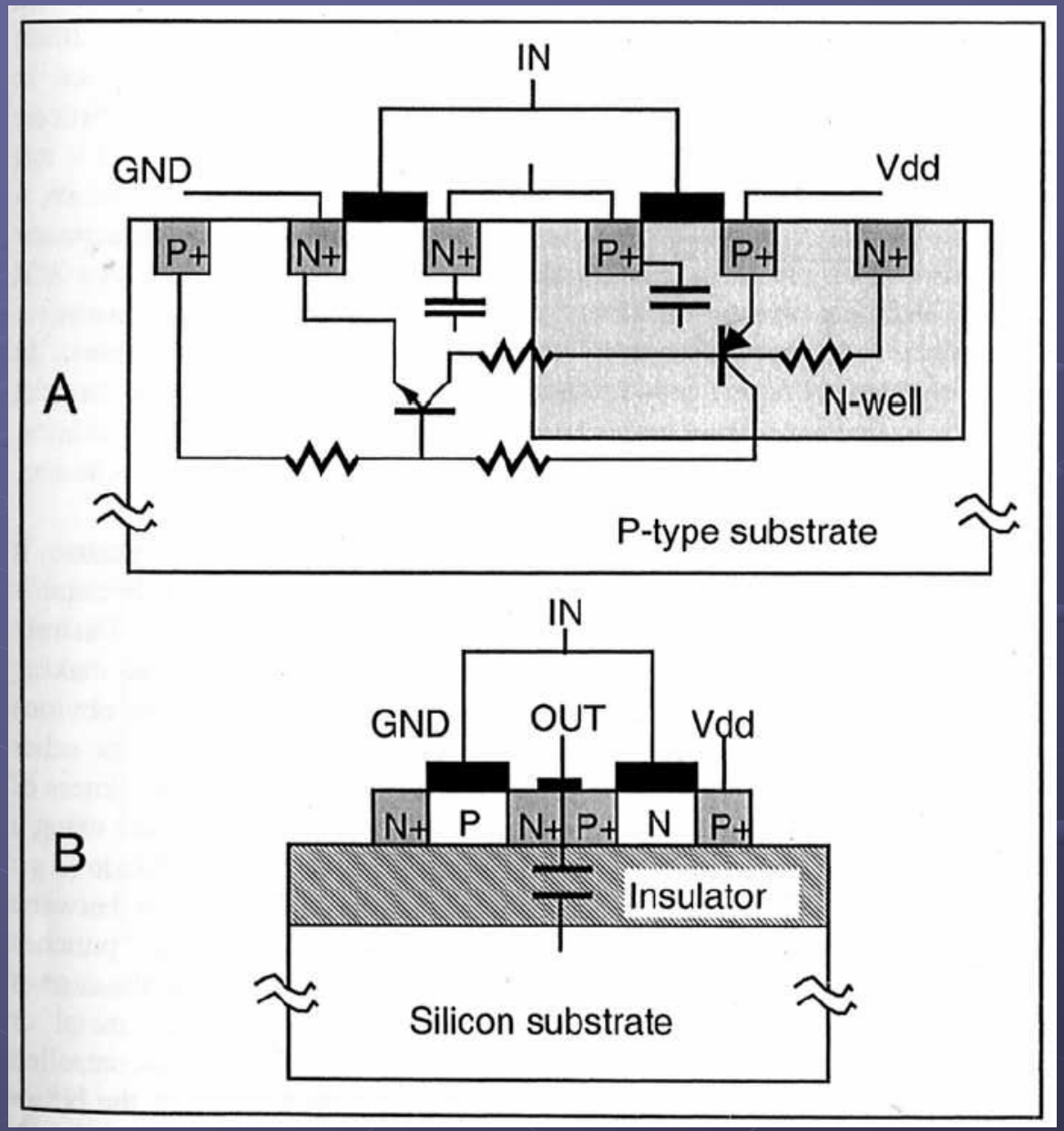




Electrical Isolation

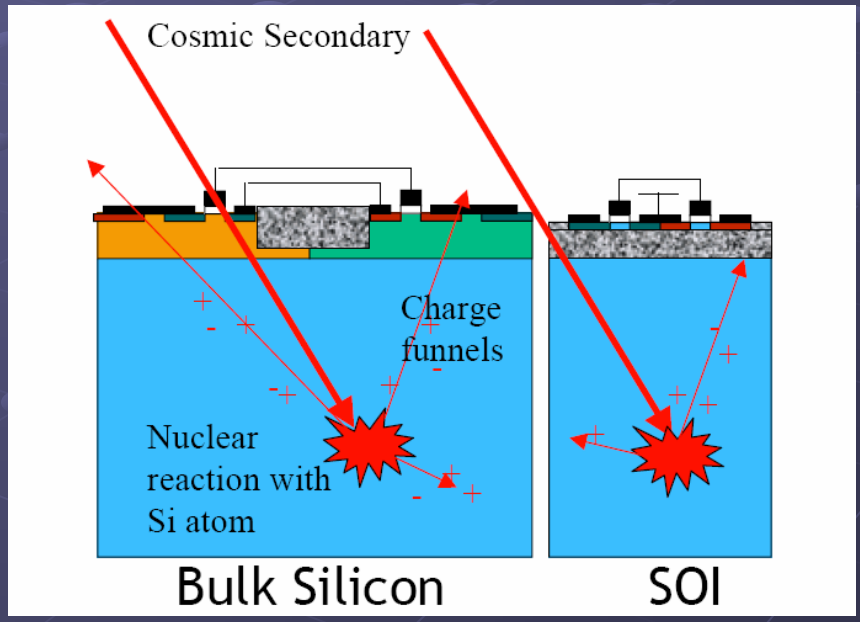
- Presence of insulating layer helps to reduce latchup

  - Latchup: presence of PNPN structure can cause current to flow until power off
- Allows for tighter packing of transistors
- Reduces soft errors due to cross talk between transistors


IN
GND
Vdd
P+
N+
N+
P+
P+
N+
A
N-well
P-type substrate
IN
GND
OUT
Vdd
N+
P
N+
P+
N
P+
B
Insulator
Silicon substrate

Soft Errors

- Changing of signal or memory state based on out side influences
- Most often caused by radiation
- Insulating layer prevents alpha particles from entering channel



Other Applications

- ZRAM

  - Uses the Floating Body Effect to store data

- Mixed Mode circuits

  - SOI advantages allow better integration of RF, analog, and digital circuitry

- High Temperature Circuits – absence of wells allows better high temp behavior

Sources

- Silicon-On-Insulator Technology: Materials to VLSI, 3rd Edition by Jean-Pierre Colinge
- Fabrication of SOI and sSOI Wafers Using Ion Implantation by Devendra K. Sadana
- SOI Technology for the GHz Era by G.G. Shahidi