

# FinFET Technology

**Pravin Zode**

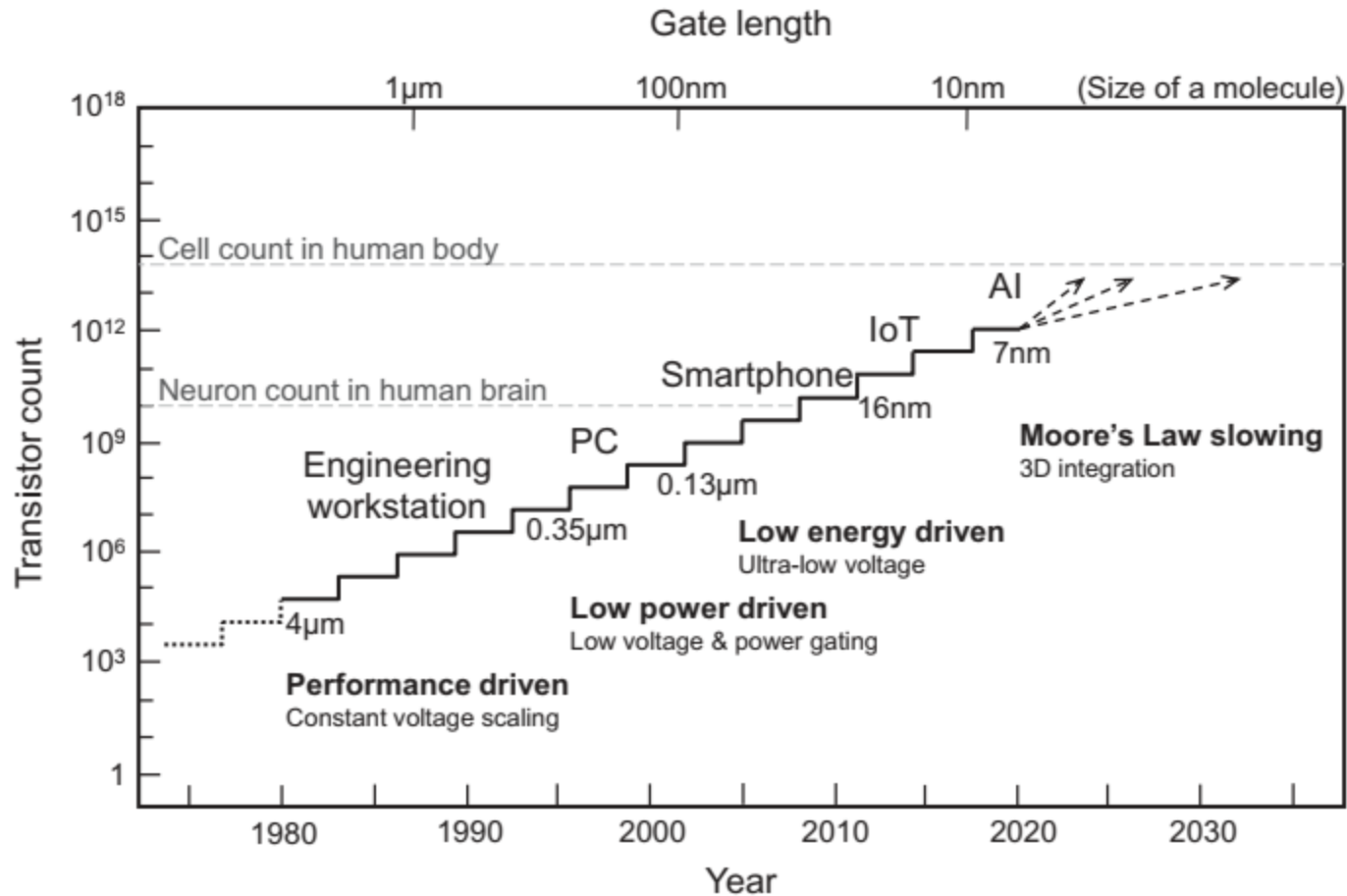
# Outline

- Basics of FinFET
- Evolution of Integrated Circuits
- MOSFET Scaling issues
- Advanced MOS Transistor Structures
- Structure of FinFET
- Double Gate and Tri Gate FinFET

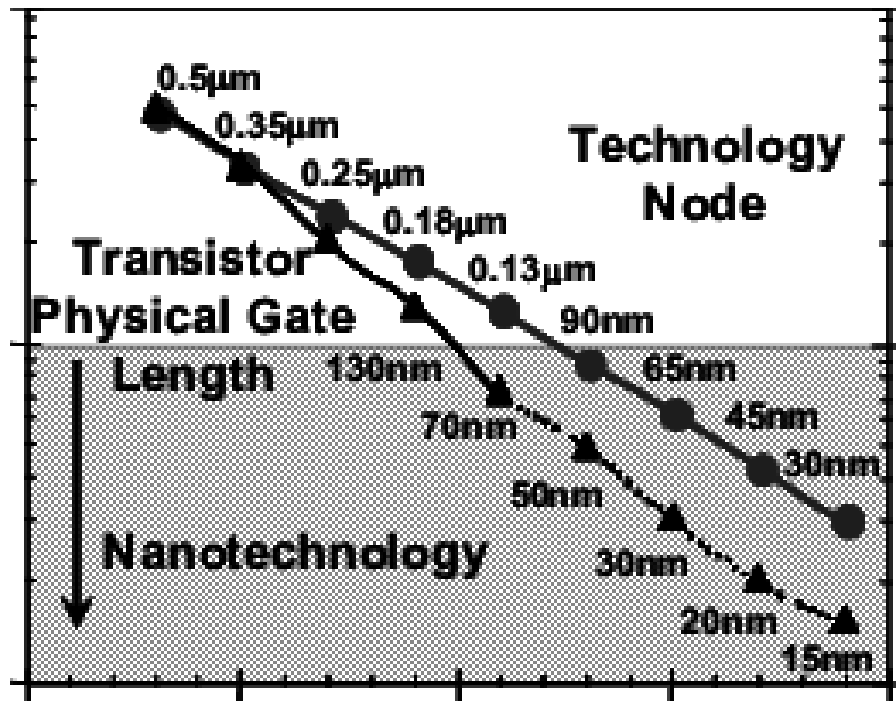
# Introduction

- **FinFET** (Fin Field-Effect Transistor) is a 3D transistor design used in modern integrated circuits.
- It overcomes the limitations of planar CMOS technology, particularly in scaling to smaller technology nodes.
- FinFETs feature a thin, vertical silicon fin that forms the transistor channel, with the gate wrapped around it for enhanced control.

# Evolution of IC

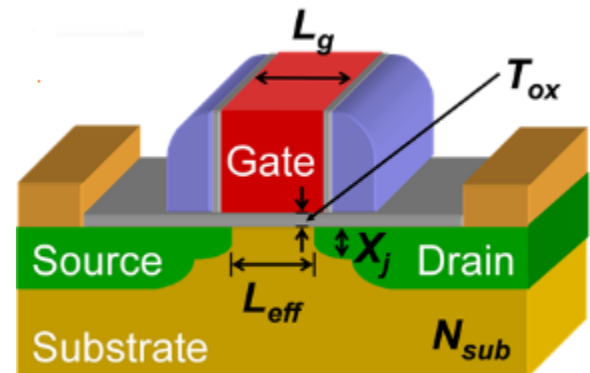
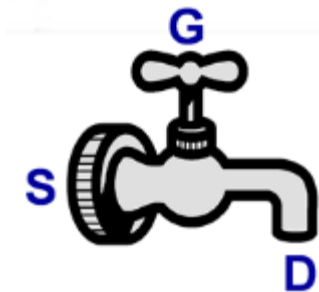


# MOSFET Scaling



# MOSFET Scaling Issues

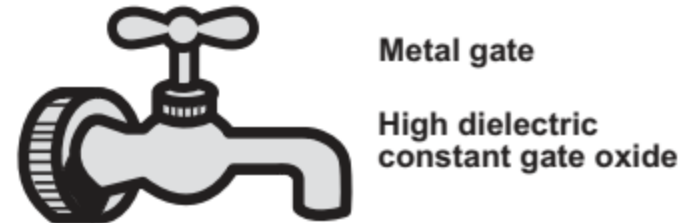
- Leakage current is primary barrier to scaling
- To suppress leakage current
  - Higher body doping
  - Thinner gate dielectric
  - Ultra Shallow S/D Junctions



# Leakage and Gate Control



Solution 1) New materials

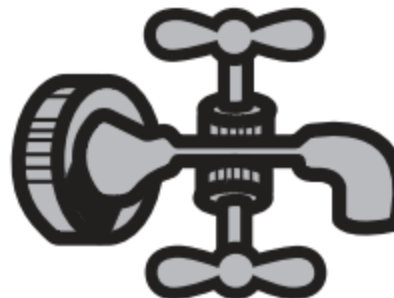


Solution 2) New process  
Strained silicon with increased  $I_{on}$

Solution 3) New construction - increased gate control



Ultra thin body  
SOTB



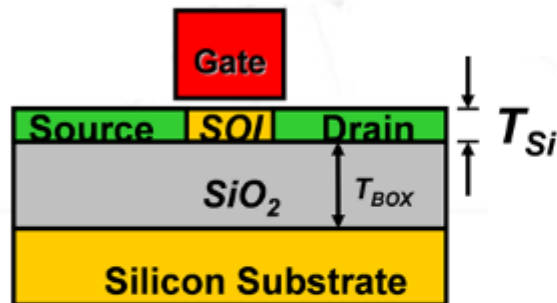
Nanowire



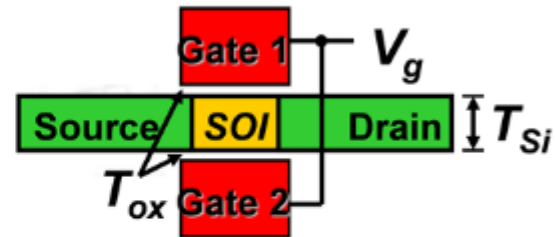
# Advanced MOS Structures

- Leakage can be suppressed by using thin body

Ultra-Thin Body



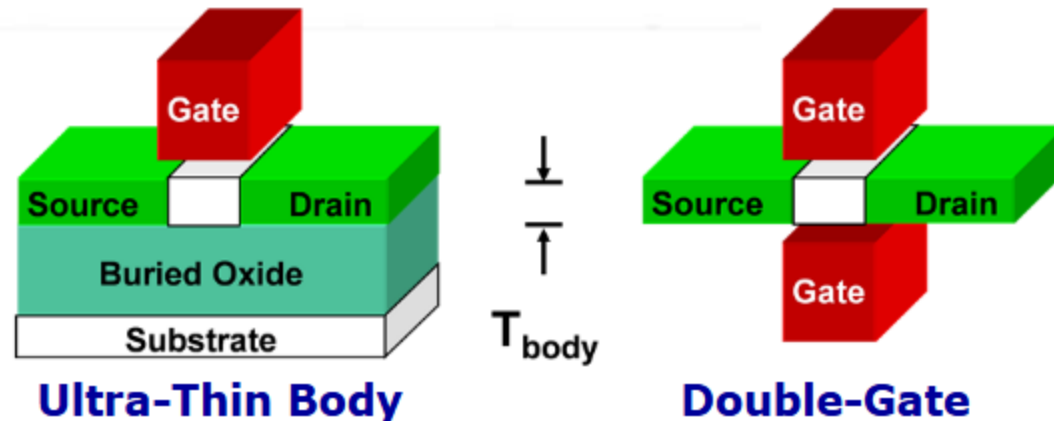
Double Gate



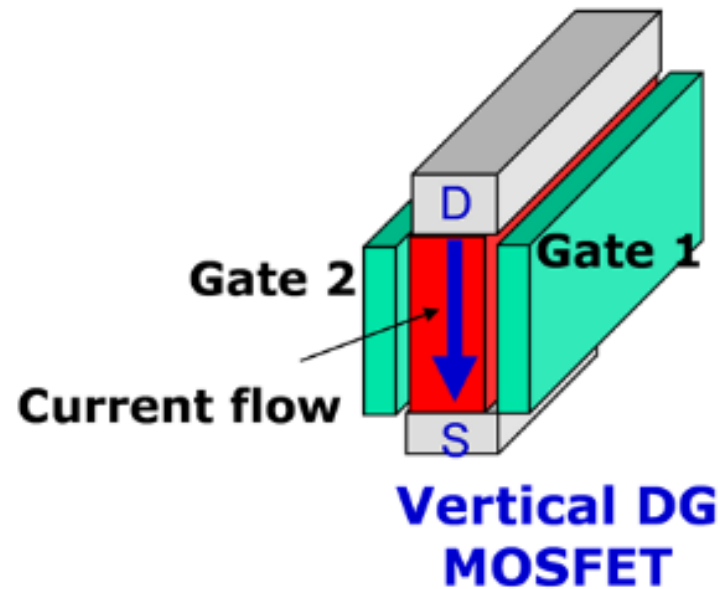
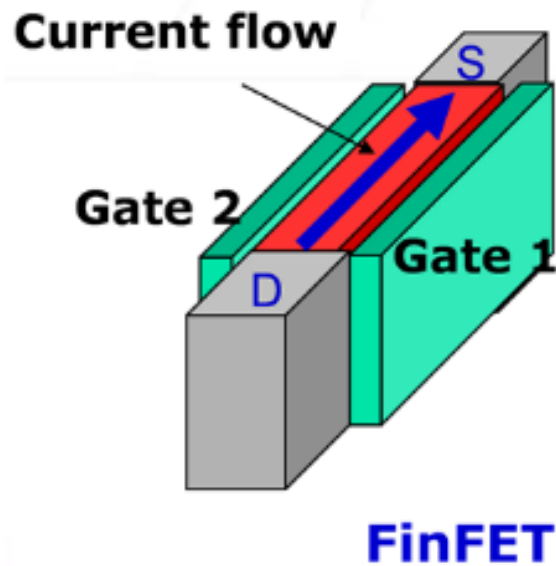
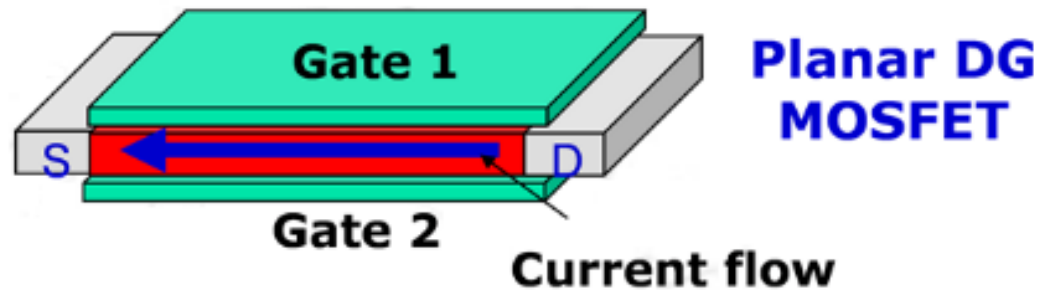


# Thin Body MOSFETs

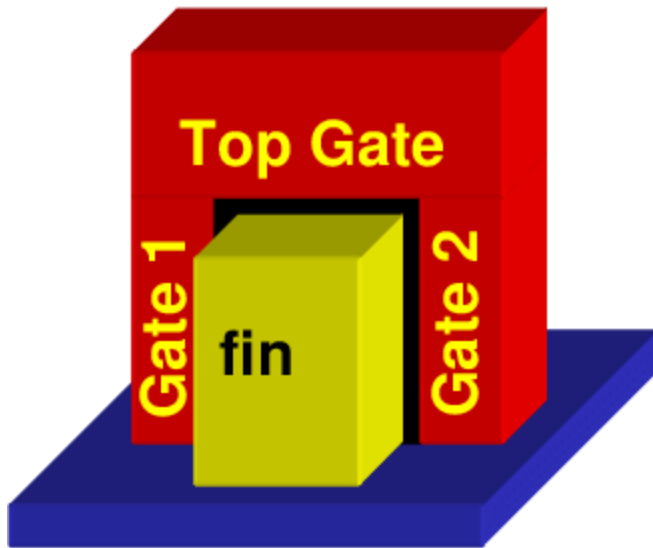
- Controlled short channel effect with Thin body
  - No channel doping needed
- Double gate is more effective



# Double Gate MOSFETs



# Trigate Gate MOSFETs



- 3D structure where the gate wraps around three sides of the conducting channel (fin)
- Overcomes scaling limitations of planar CMOS by improving control over the channel
- Suitable for technology nodes below 22nm
- Better control over off-state current
- Operates effectively at lower voltages
- Higher switching speed due to better electrostatic control

# Working Principle of FinFET

- Gate wraps around the fin to control channel formation.
- Enhanced electrostatic control reduces short-channel effects.
- Better suppression of leakage currents.
- Higher ON current (performance) and lower OFF current (efficiency).

# Advantages

- **Improved Electrostatics:** Enhanced gate control reduces leakage currents and improves subthreshold behavior
- **Reduced Short Channel Effects:** Minimizes performance degradation due to scaling
- **Low Power Operation:** Supports lower operating voltages, reducing both dynamic and static power consumption
- **High Integration Density:** Vertical design allows more transistors per unit area
- **Better Performance:** Superior electrical characteristics improve switching speeds

# Structure of FinFET

- Fin-shaped channel wrapped by the gate.
- Multi-gate structure enhances control over the channel.
- Key parameters: Fin height, fin width, gate length.
- Comparison with planar MOSFETs: Better electrostatic control.

# Advantages of FinFET

- Improved electrostatic control reduces leakage currents.
- Reduced short-channel effects enable smaller transistors.
- Better power efficiency for portable devices.
- Enhanced performance for high-speed computing applications.

# Challenges and Limitations

- Manufacturing cost: Advanced lithography required.
- Process variability: Variations in fin dimensions affect performance.
- Thermal issues: Heat dissipation in dense designs.
- Future challenges: Scaling beyond 5nm nodes.

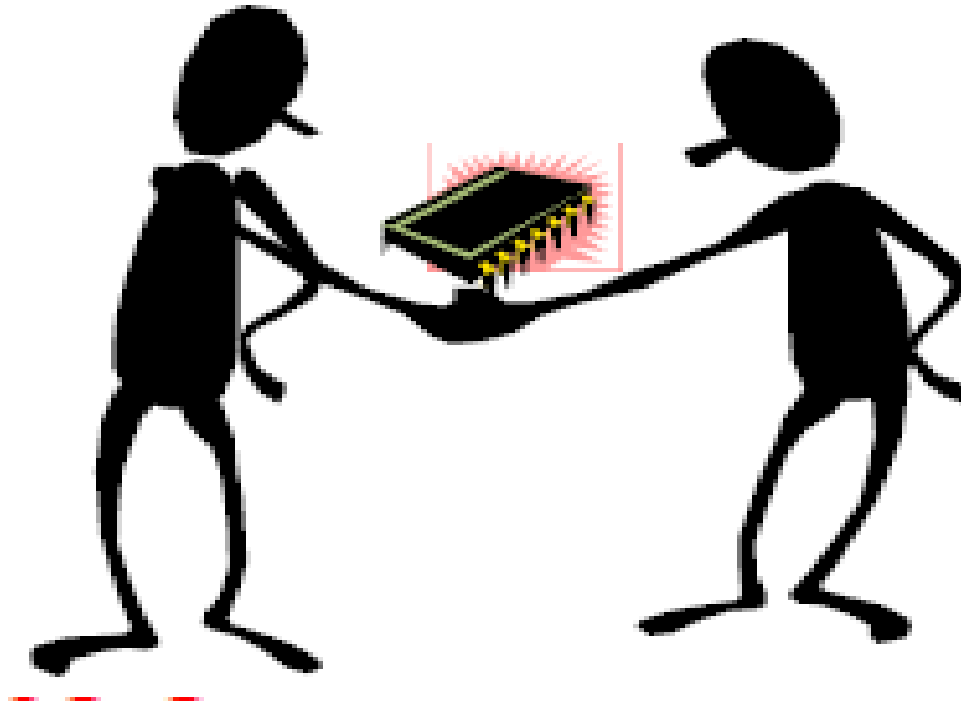


# Applications of FinFETs

- Processors: Intel, AMD, and other high-performance CPUs.
- Mobile devices: Lower power consumption extends battery life.
- AI and ML accelerators: High-performance, energy-efficient hardware.
- Data centers: Improved efficiency for large-scale computing.

# Conclusion

- FinFETs represent a key milestone in transistor technology
- They address the limitations of traditional planar MOSFETs
- Enable scaling and performance improvements for modern electronics
- Foundation for future innovations in semiconductor technology



**Thank you !**

**Happy Learning**