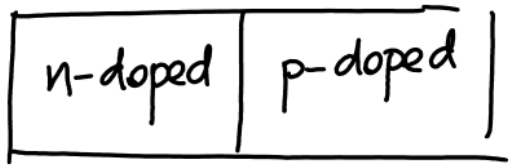
Semiconductor devices

Lecture 3 Semicondutors

Recap

p-n Junction



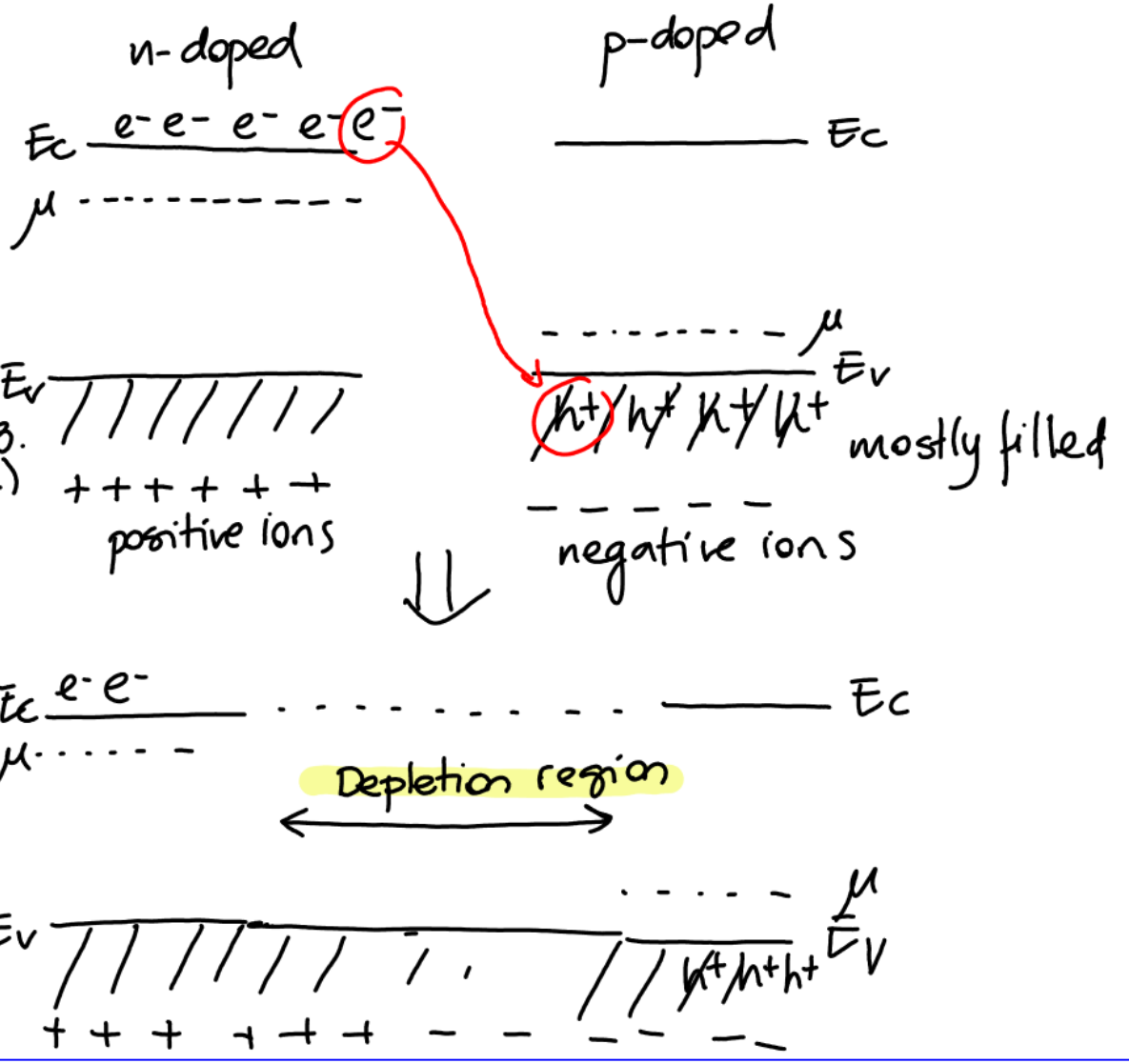
When the 2 materials are brought together, e^- in C.B. will fall in the V.B. to annihilate holes

→ this annihilating process gains an energy E_{gap}

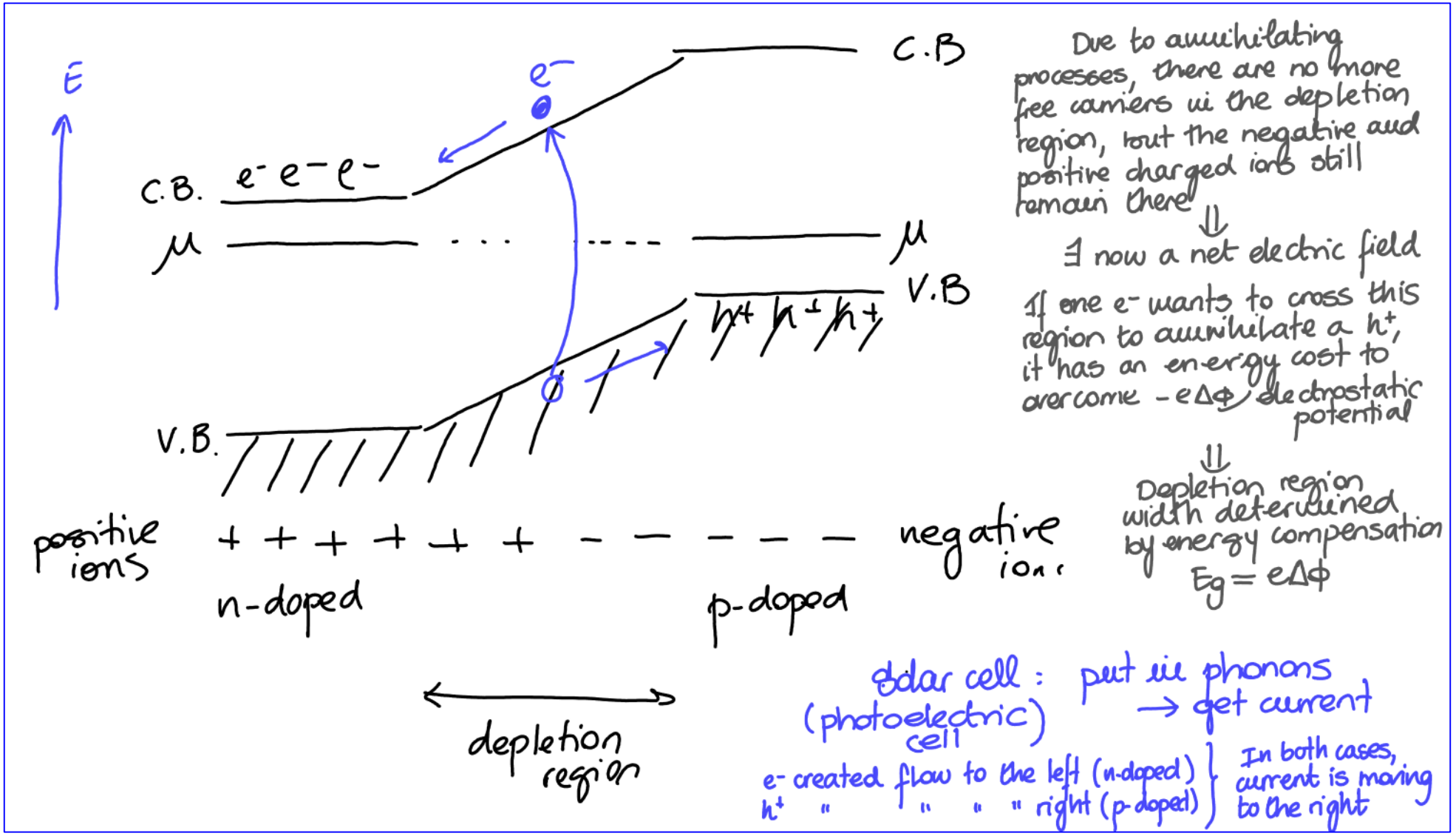
⇓

As a result, there will be a region close to the interface where there are no more free carriers

⇒ "depletion region" or "space charge region"



Recap



Due to annihilating processes, there are no more free carriers in the depletion region, but the negative and positive charged ions still remain there

⇓

∃ now a net electric field

If one e⁻ wants to cross this region to annihilate a h^+, it has an energy cost to overcome $-e\Delta\Phi$ electrostatic potential

⇓

Depletion region width determined by energy compensation

$E_g = e\Delta\Phi$

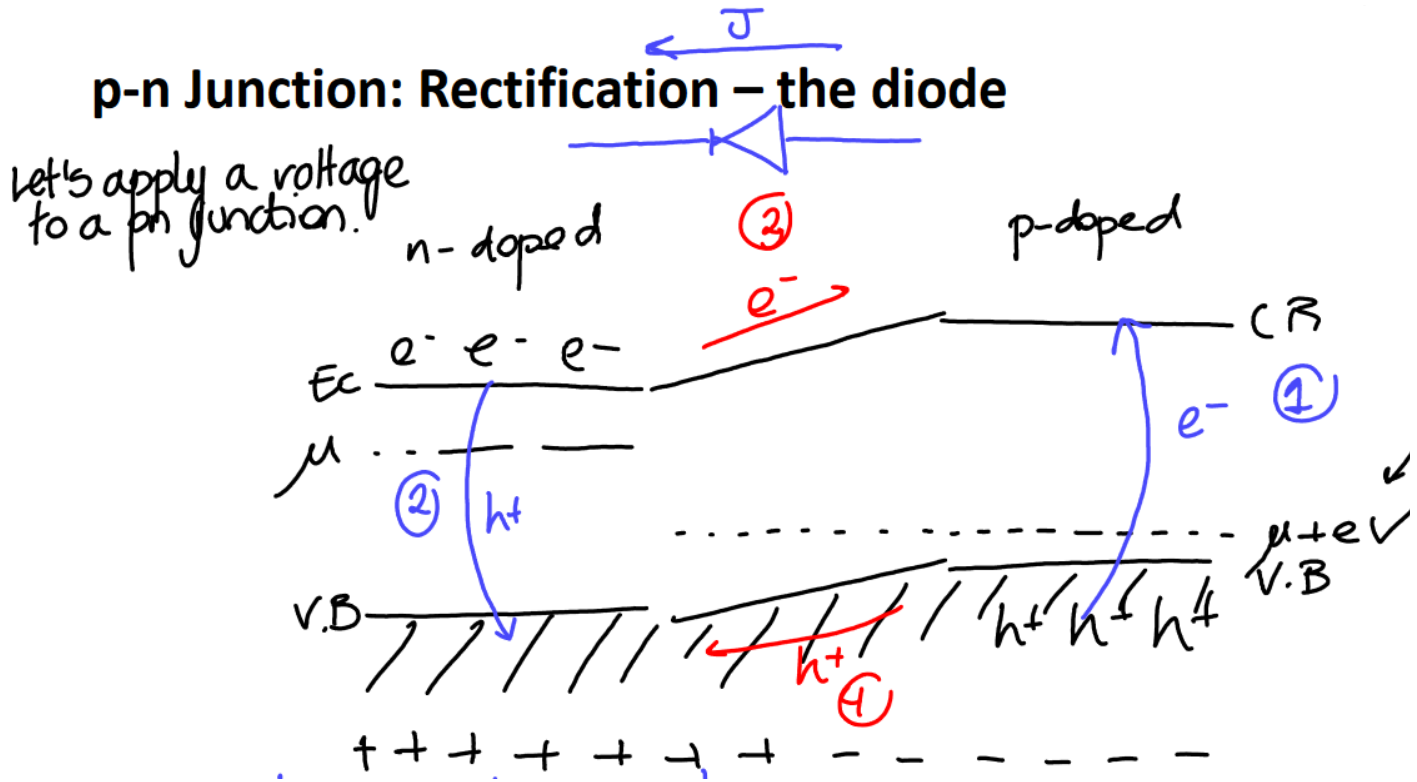
Solar cell : (photoelectric cell) put in phonons → get current

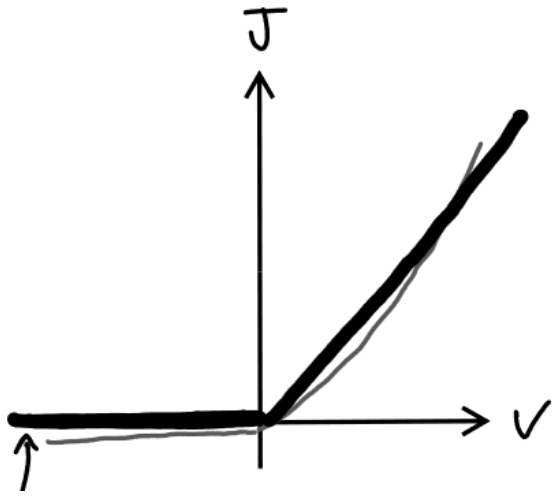
e⁻ created flow to the left (n-doped)
h^+ " " " " right (p-doped)

} In both cases, current is moving to the right

Recap

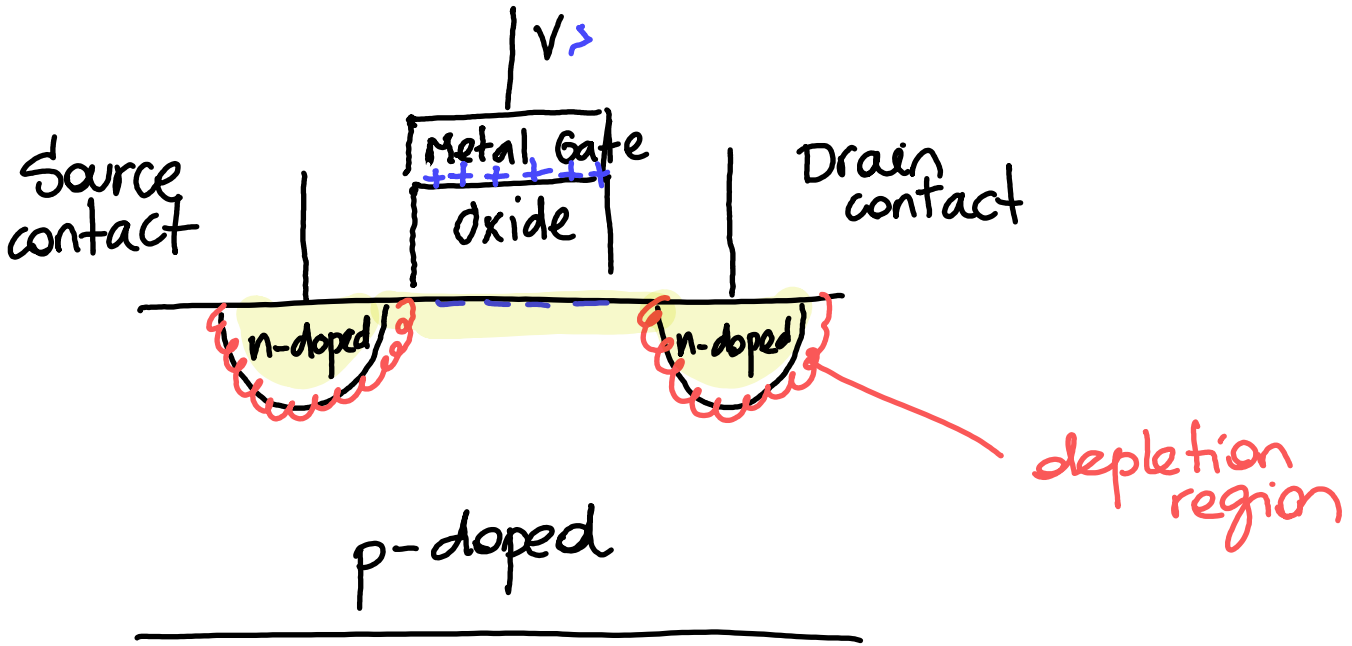
p-n Junction: Rectification – the diode

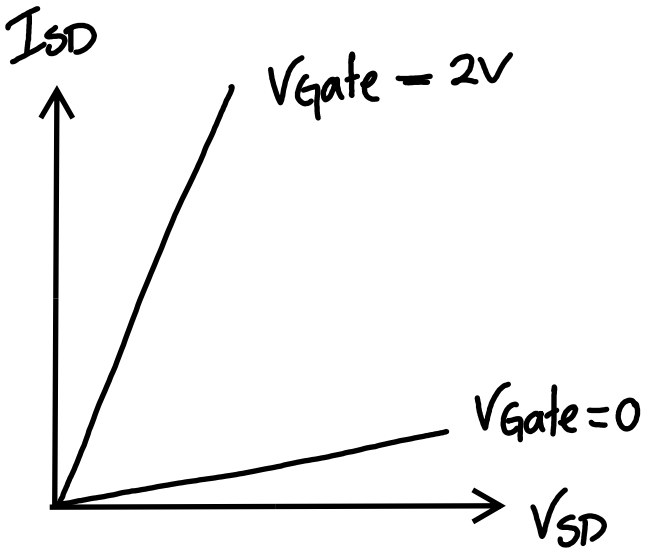




The transistor

- there are many type of transistors
- Here, focus on MOSFET: "metal-oxide-semiconductor field effect transistor"

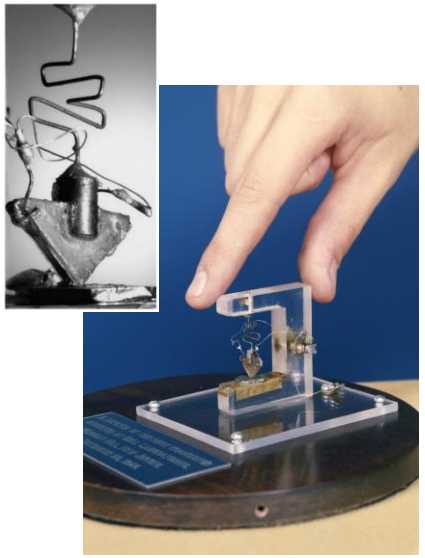




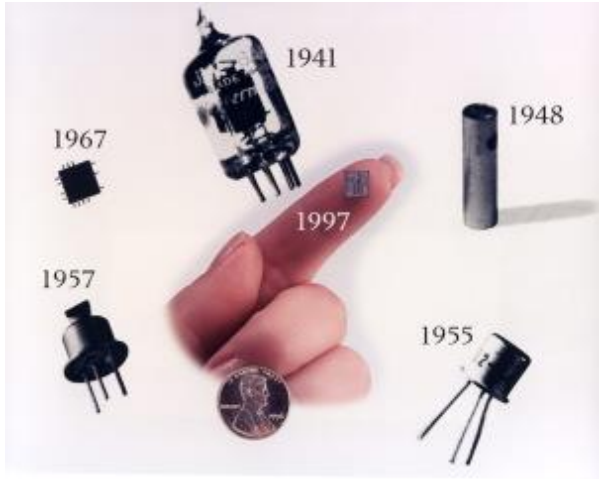
(i.e. like back to back diodes)

- Without voltage in the gate, the current cannot flow easily between source-drain
- Positive voltage in the gate attracts negative charges below the oxide (field effect)
  - → region below oxide layers becomes effectively n-doped
  - → continuous conducting channel between source-drain is formed, where current can now flow.

The transistor - evolution

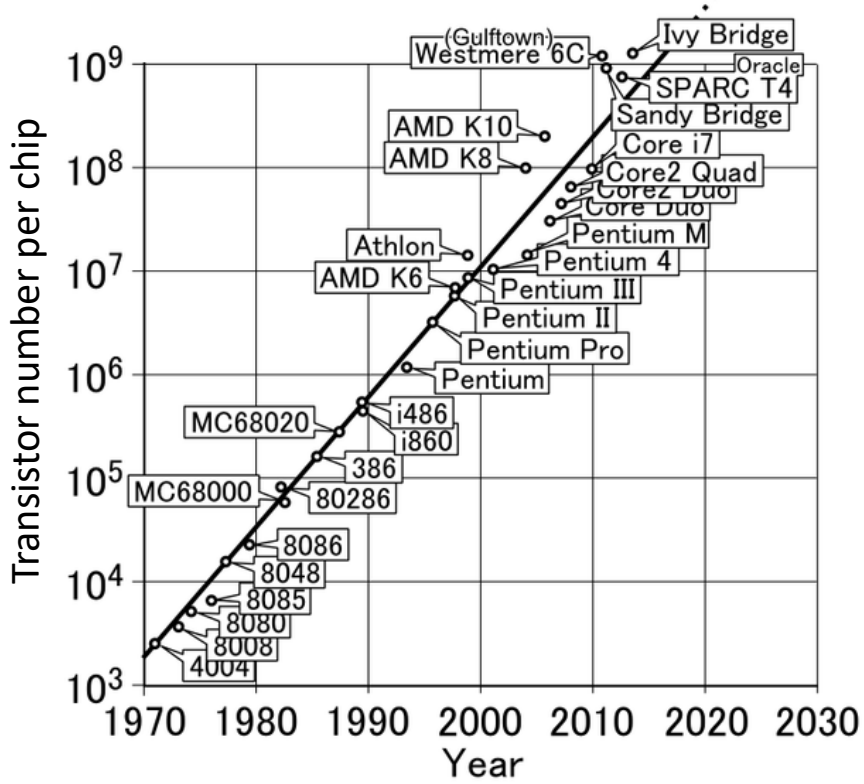


First transistor 1947

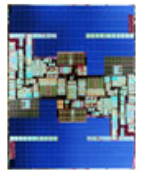


A **22nm** tri-gate transistor's is so small that you can fit more than **4000** of them across the width of a human hair! (Intel)

"Moore's Observation": "the number of transistors on integrated circuits doubles approximately every two



2000s
64-bit Microprocessor

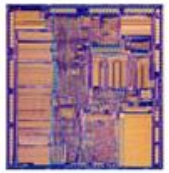


592,000,000 Transistors

1990s
32-bit Microprocessor

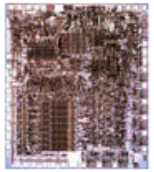
3,100,000 Transistors

1980s
32-bit Microprocessor



275,000 Transistors

1970s
8-bit Microprocessor



4500 Transistors

Creating new materials that exhibit enhanced or novel behaviours is essential to meet the technological challenges we face today!