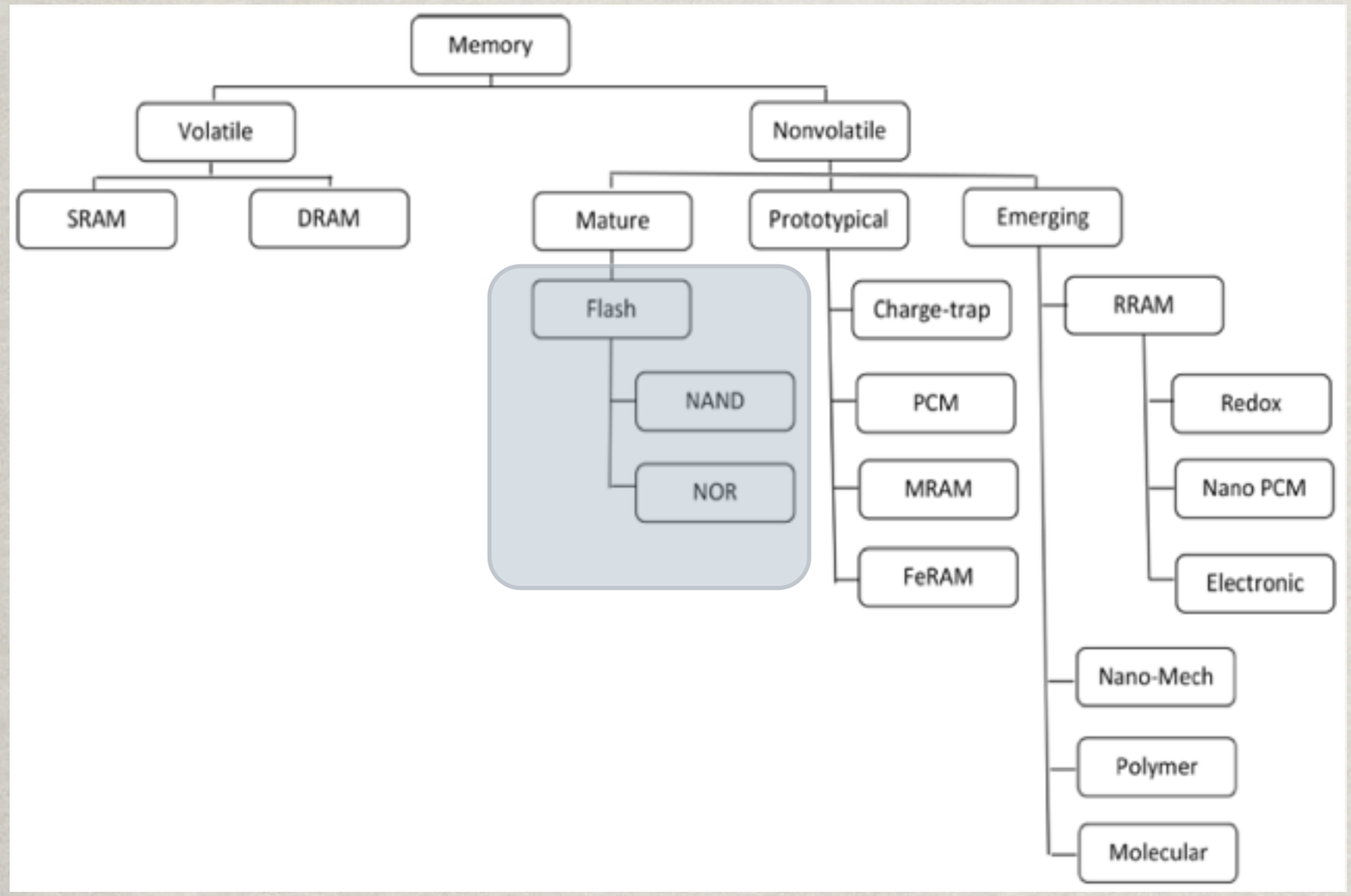
Flash Memory Reliability

EC579 Project

Jeffrey Kittredge
Peiwen Hu

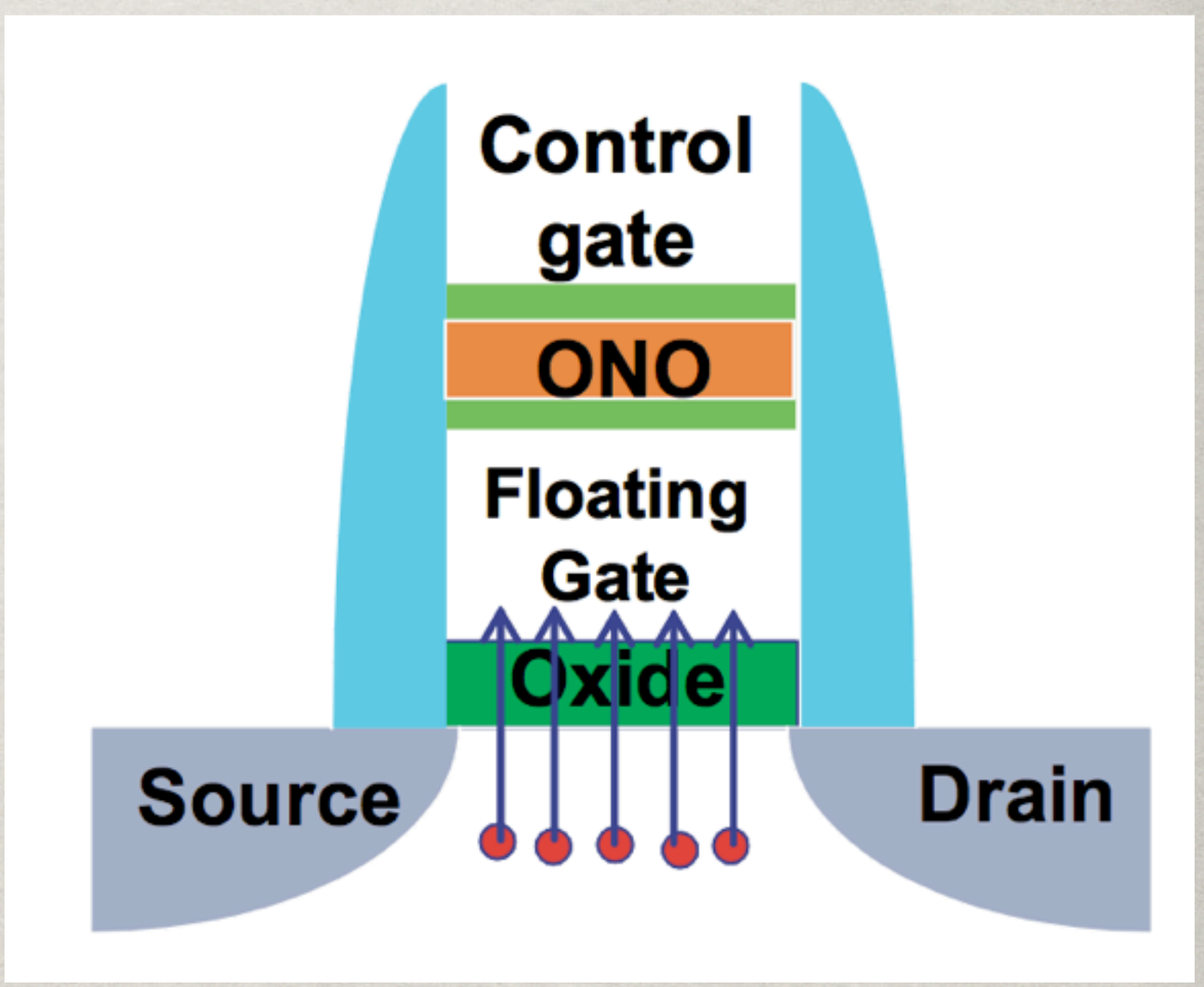
Introduction



- Flash memory: non-volatile
- Major storage device widely used

STRUCTURE

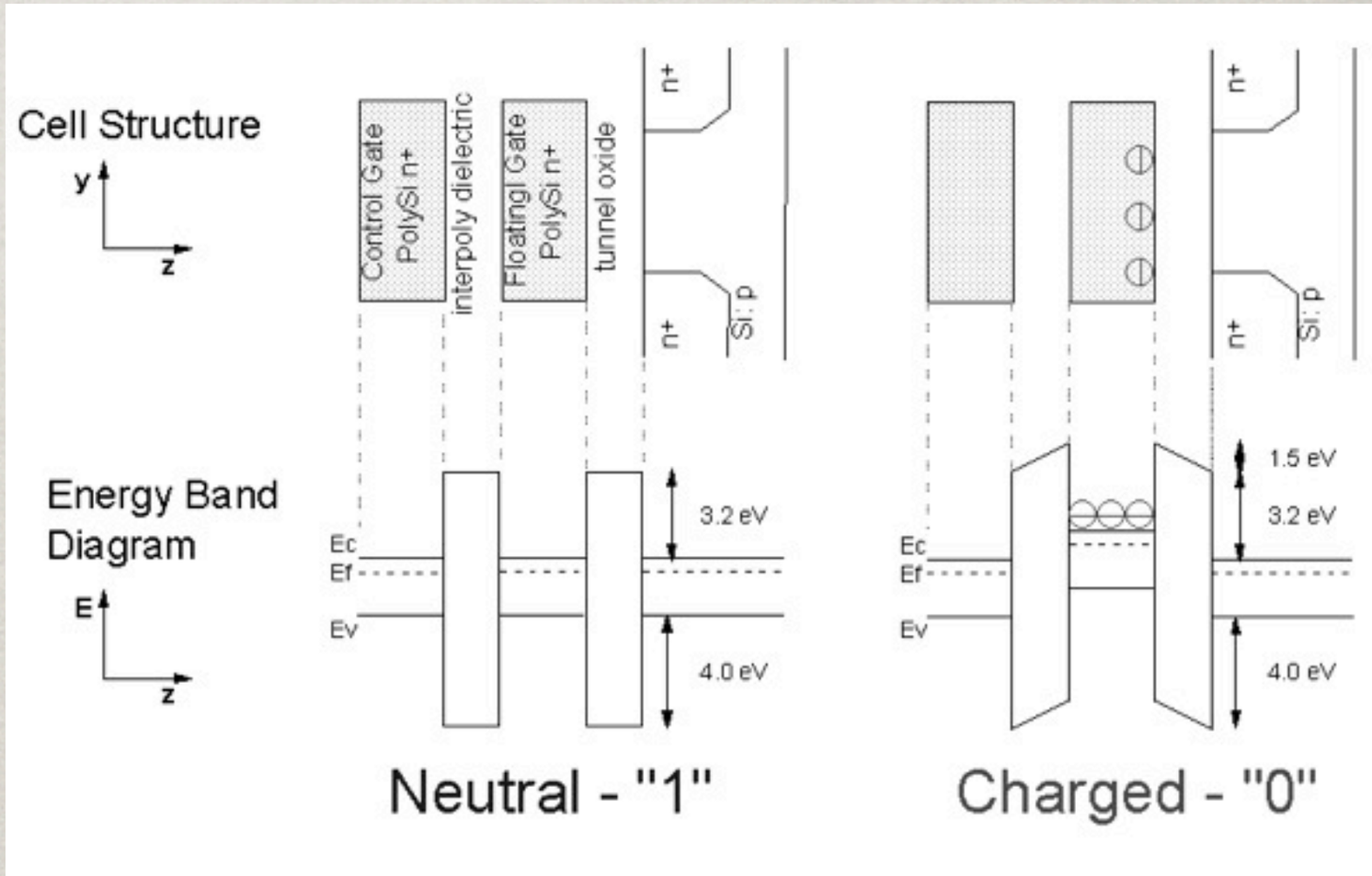
- MOS transistor + Floating Gate
- Floating Gate: a charge well
- Electrons go through “Tunnel Oxide”



States: ”1” and ”0”

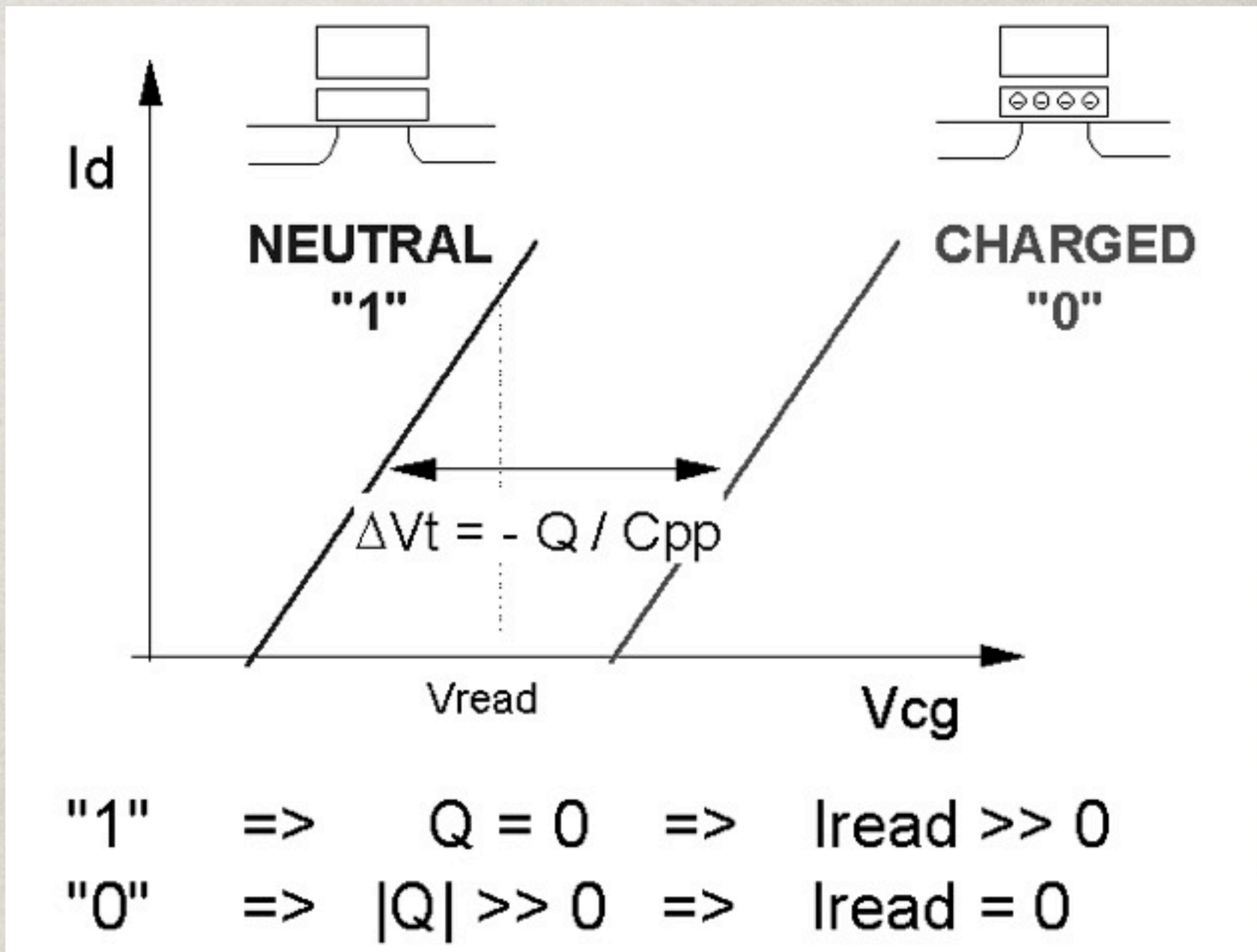
Floating-gate charge

- Neutral: ”1”
- Negative: ”0”

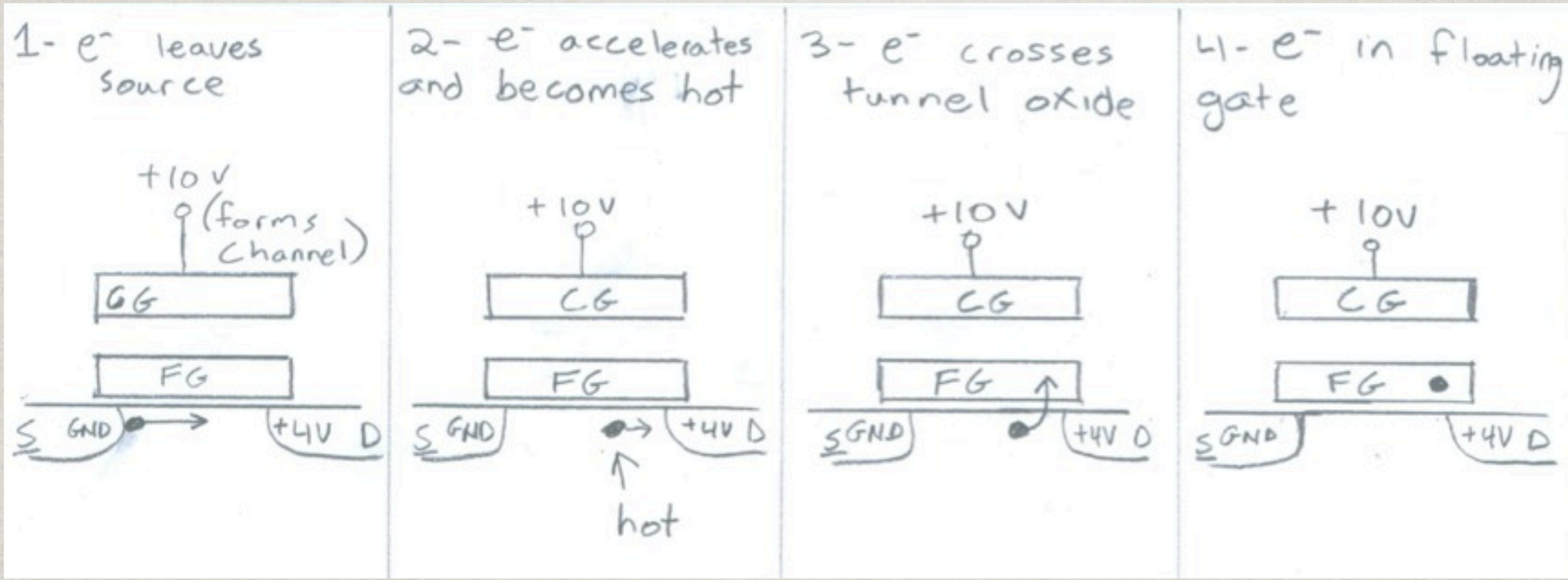


OPERATIONS:READING

- Logic states:
  - “1”:Neutral
  - “0”:Negative
- Threshold Voltage in between

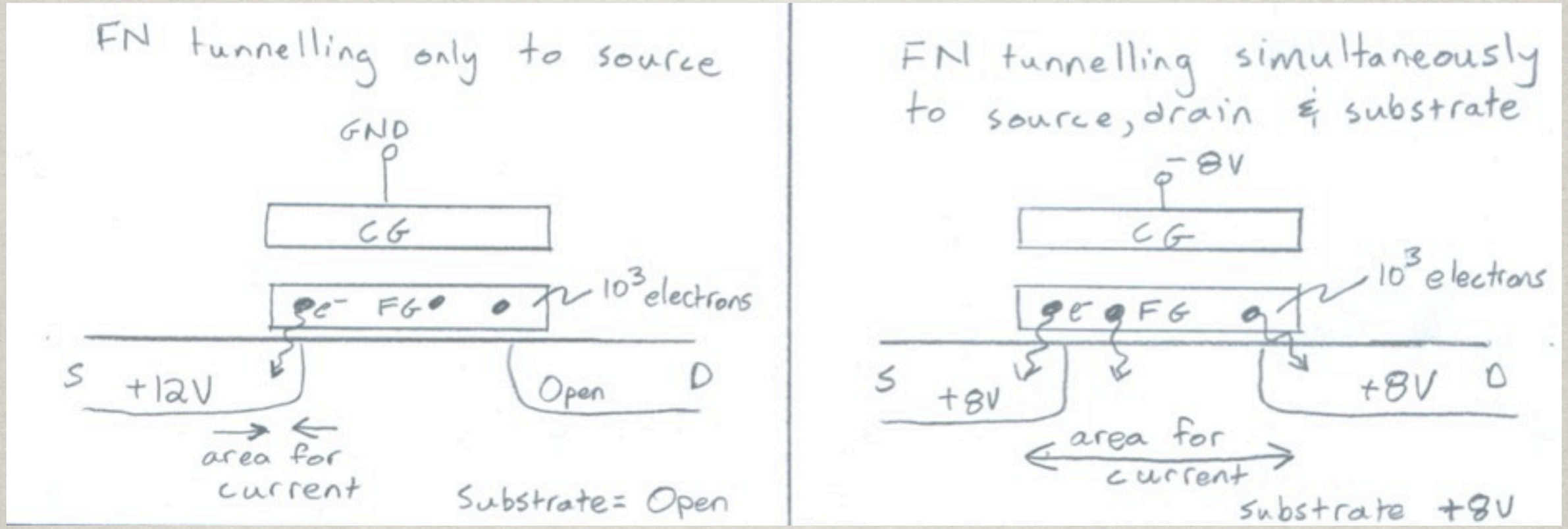


WRITING:CHANNEL HOT ELECTRON



- ~4V from drain to source for **accelerating**
- Attract electrons overcoming barrier

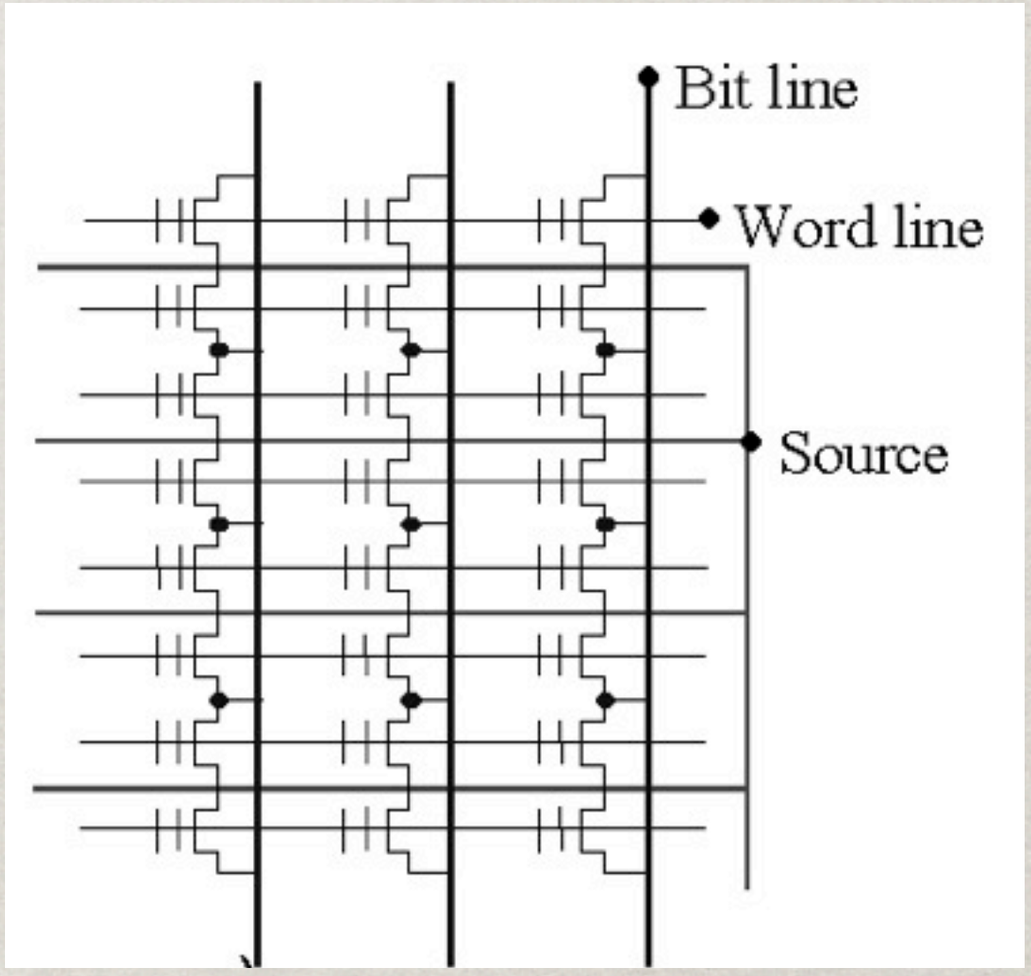
WRITING: FOWLER-NORDHEIM



- Remove electrons with **strong electric field**
- Drain,source,substrate all low: lowest current

RELIABILITY:PROGRAM DISTURB

- Shared bit lines
- Shared word lines
- Disturb during programming

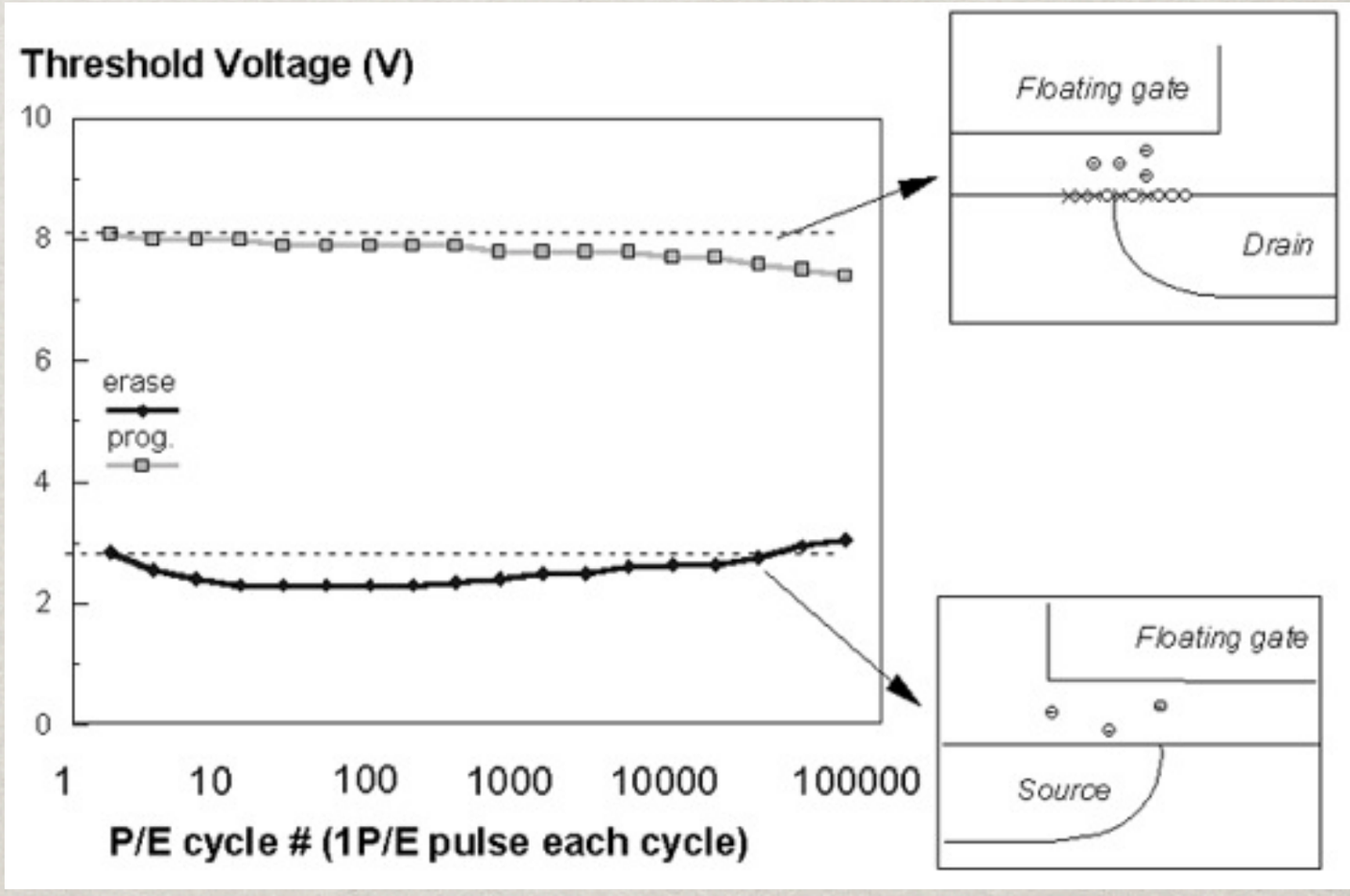


Reliability:data retention

- Defects in tunnel oxide
- Defects in the ONO layer
- Mobile ion contamination
- Release of fixed charge from insulating oxides

Reliability:Writing endurance

- Typically 5000+ writing cycles
- Main cause: tunnel oxide degradation



Improvement: Error checking code & wear leveling

- **ECC:** Error detection + Error correction
  - Append extra information
    - Detect error
    - Correct error
- **Wear leveling:** Distribute writing evenly

Improvement: FN tunneling vs. Channel Hot Electrons

- FN tunneling avoids using **hot electrons**
- FN tunneling has no high current around drain
- FN is **not for multilevel** programming due to constant control gate voltage
- FN tunneling accepts **thinner tunneling oxide**, which is prone to trap assisted tunneling

Conclusion&Future

- Different types, depending on criticality
- Early integration of software and hardware
- Reliability will increase as technology matures
- Other advances in semiconductor will benefit
- Density: 3D approaches are being investigated