

MEMORY

ECE 2534

Solid-state Memory: Fundamental Types

❑ **RAM: Random-Access Memory**

- Can **read/write** any memory word
- “Random”: access time is the same for all locations
- **Volatile**
- Can be used for storing variables
- Can also store instructions and constants, but these must be loaded into memory after power-up

❑ **ROM: Read-Only Memory**

- Can read any memory word
- Access is also “random”: (read time is the same for all locations)
- **Nonvolatile**
- Cannot be used to store variables (!)
- Great for storing things that never change, esp. instructions and constants
- Code placed here is sometimes called “firmware”

Close Relatives

❑ RAM: Random-Access Memory

- SRAM: Static RAM
- DRAM: Dynamic RAM
- . . .
- DDR SDRAM:
Double Data Rate
Synchronous Dynamic RAM

❑ ROM: Read-Only Memory

- Can only be written once, in the factory
- Economically viable only for large quantities

❑ PROM: Programmable ROM

- Can only be written once
- Can be written essentially anywhere, using special (but inexpensive) equipment



❑ Erased ROM

- EPROM: Erasable Programmable ROM
(typically erased using UV light)
- EEPROM: Electrically Erasable Programmable ROM
(typically erased and re-written without removing from circuit board)
- FLASH MEMORY

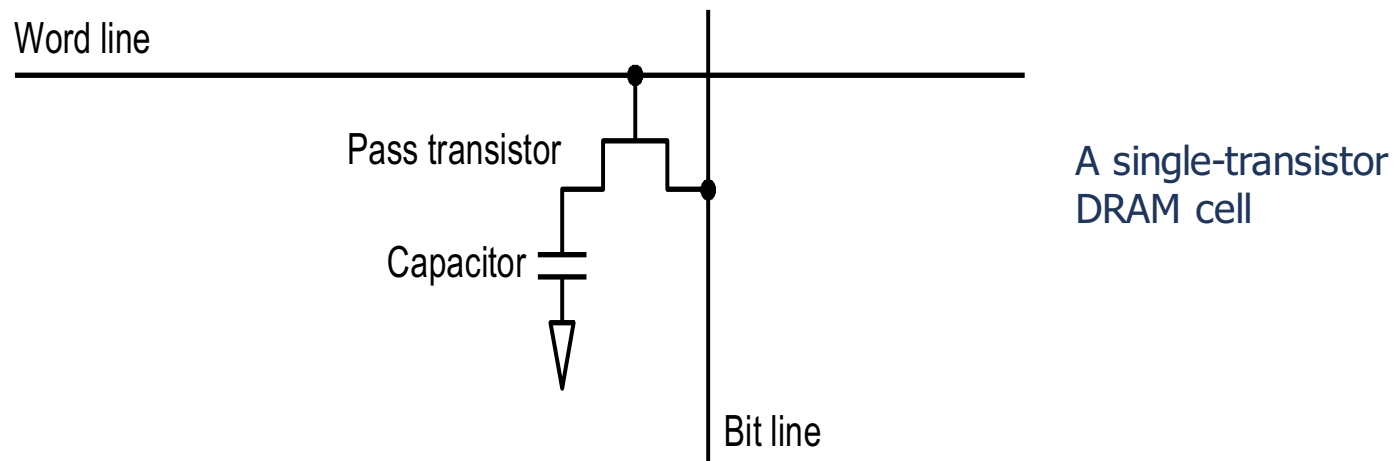
SRAM vs. DRAM

❑ Static random access memory (SRAM)

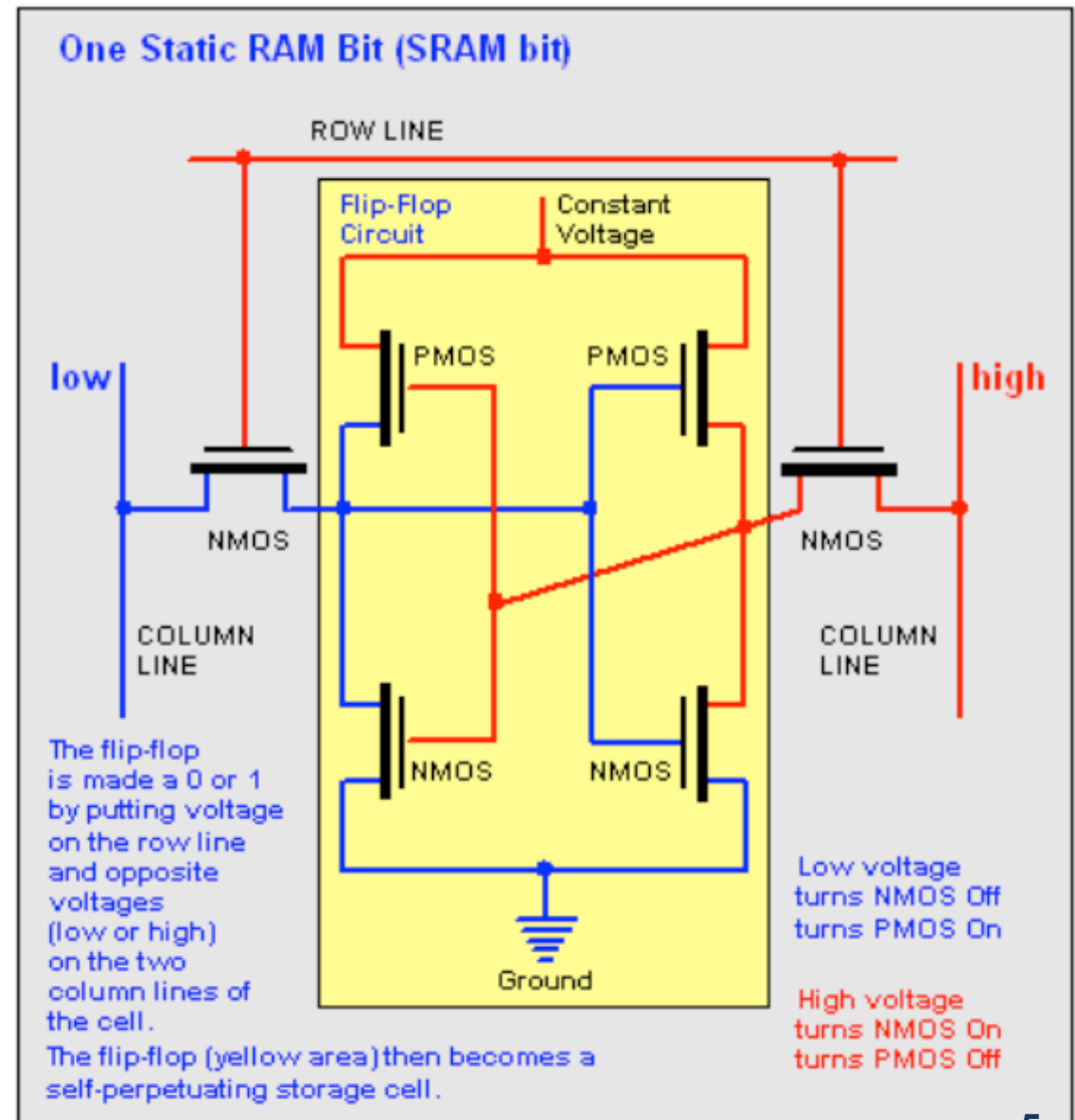
- Integrated circuits that are memory arrays, usually with a single access port that is used for write/read
- Low density, high power, expensive, *fast*
- “Static”: contents will last “forever” (until power is lost)

❑ Dynamic random access memory (DRAM)

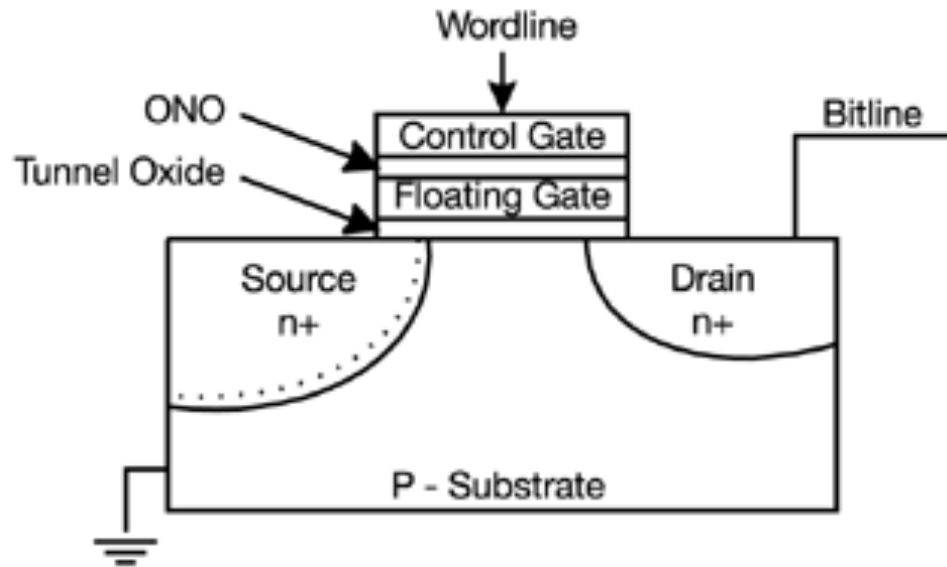
- Value is stored as a charge on a capacitor (must be refreshed)
- High density, low power, cheap, slow (factor of 5 to 10)
- “Dynamic”: contents need to be refreshed regularly, with special circuitry



6-transistor SRAM bit



Flash memory relies on “floating gates”

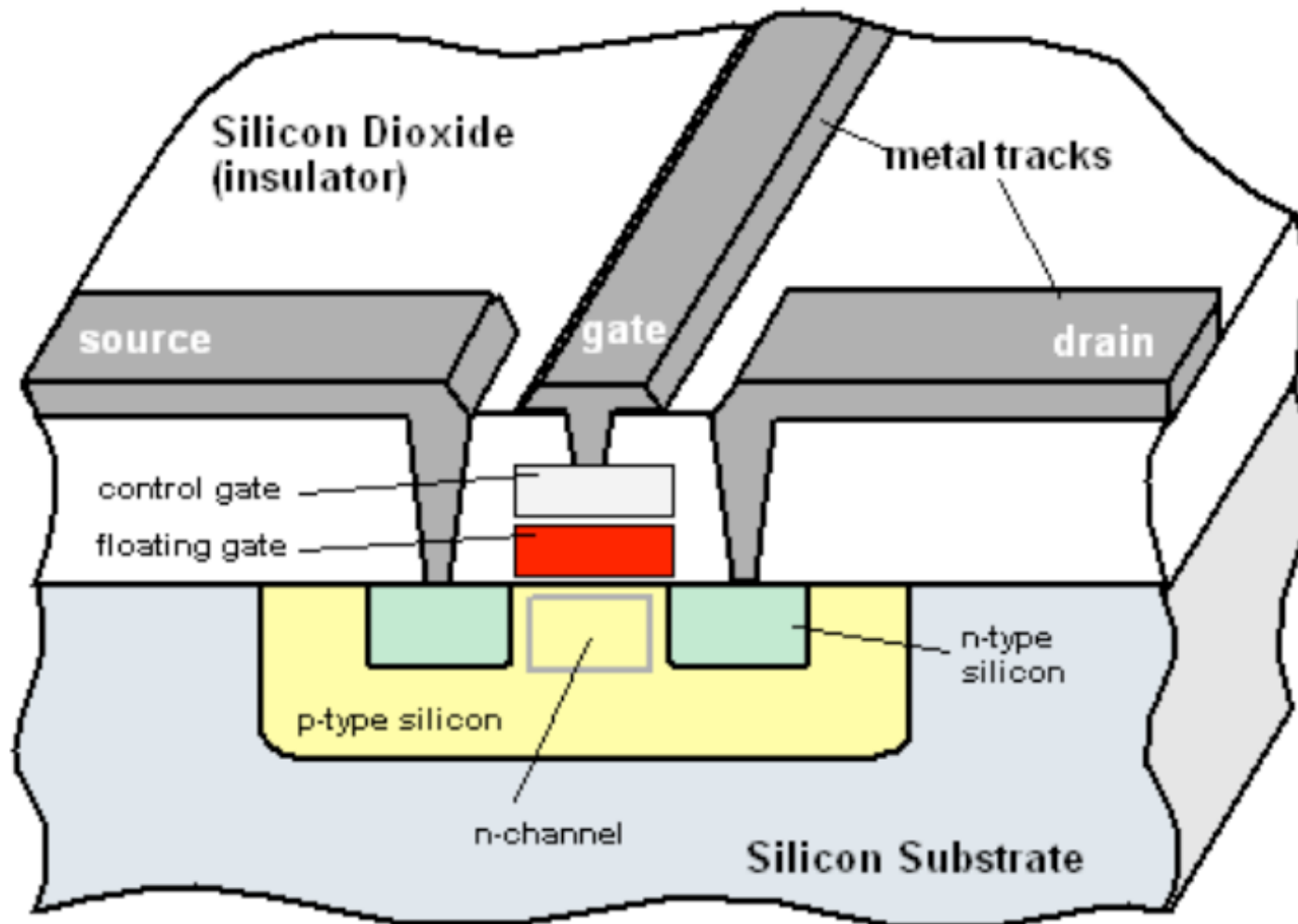


A normal transistor loses its charge (and therefore any 0/1 info) whenever the power supply is removed.

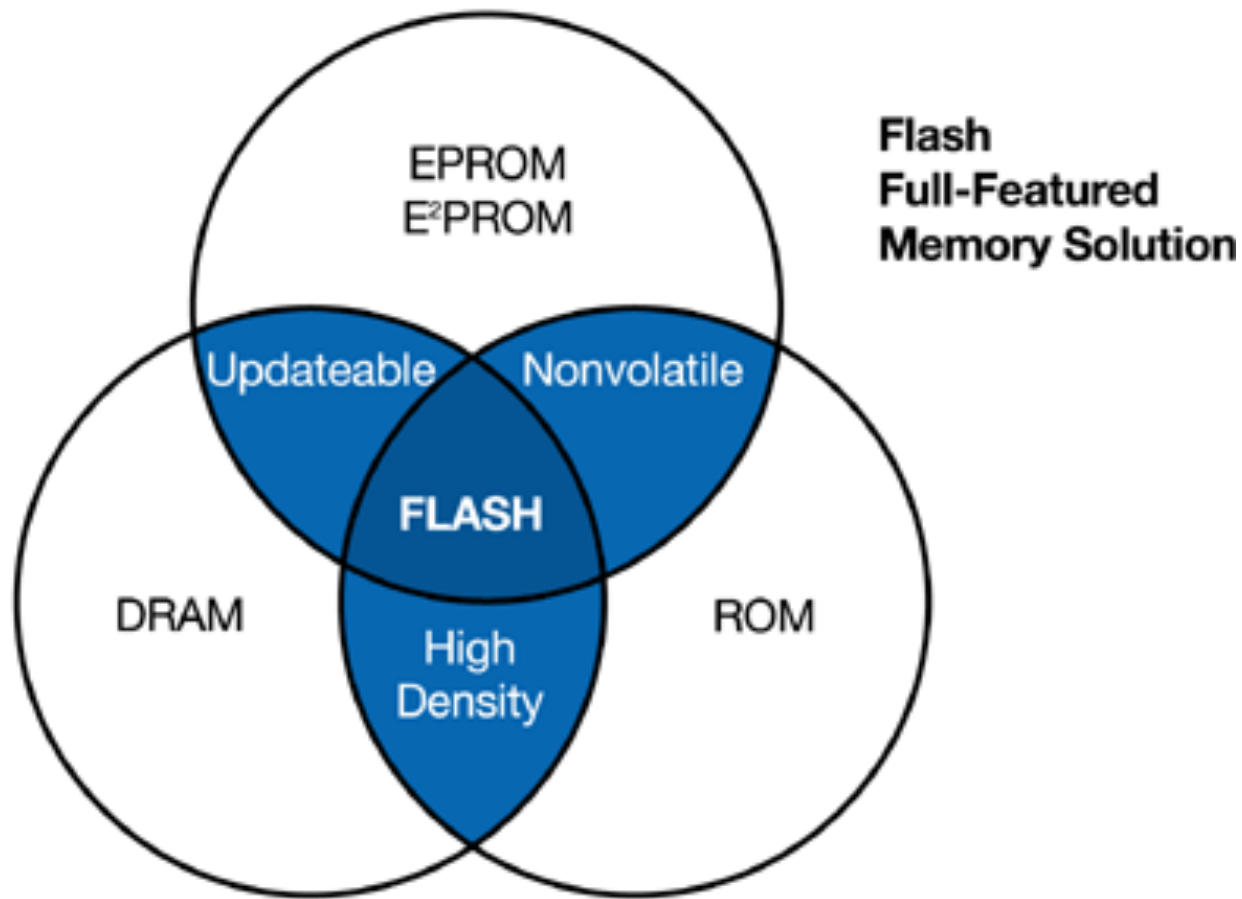
A floating-gate transistor is surrounded by insulating oxide layers that allow it to retain its charge after power is removed.

See www.explainthatstuff.com/flashmemory.html

EEPROM and Flash Transistor



Comparison



More comparison

Memory Type	Features
FLASH	Low-cost, high-density, high-speed architecture; low power; high reliability
ROM Read-Only Memory	Mature, high-density, reliable, low cost; time-consuming mask required, suitable for high production with stable code
SRAM Static Random-Access Memory	Highest speed, high-power, low-density memory; limited density drives up cost
EPROM Electrically Programmable Read-Only Memory	High-density memory; must be exposed to ultraviolet light for erasure
EEPROM or E² Electrically Erasable Programmable Read-Only Memory	Electrically byte-erasable; lower reliability, higher cost, lowest density
DRAM Dynamic Random Access Memory	High-density, low-cost, high-speed, high-power

Flash Memory on the Digilent Board

❑ Microchip 24LC256

- 256 Kbit (32K x 8)
- I2C-compatible
- SCK can operate up to 400 kHz
- 64-byte “pages”
- 5 ms maximum write cycle

❑ In addition, our **PIC32** processor contains . . .

- 512 KByte internal program flash memory
- 12 KByte boot flash memory
- (also 128 KByte internal SRAM)

Warning

- * Flash memories can *wear out*.
- * Flash cycle: changing a bit from a '1' to a '0'
- * Microchip guarantees that the 24LC256 will function properly for at least 1,000,000 write/erase cycles
- * Not a good idea to put your code in a tight loop that cycles memory!

SUMMARY

- ❑ In the beginning, there was RAM and ROM
- ❑ Today, several choices are available
 - Consider trade-offs
 - Some of the nonvolatile alternatives resemble RAM more and more
- ❑ Flash memory:
 - A good choice for low-cost, nonvolatile storage when memory updates (=writes) are relatively rare
 - Write cycles involve additional complexity, and the number of cycles is limited
 - Serial designs are attractive for low-speed applications (e.g., audio)