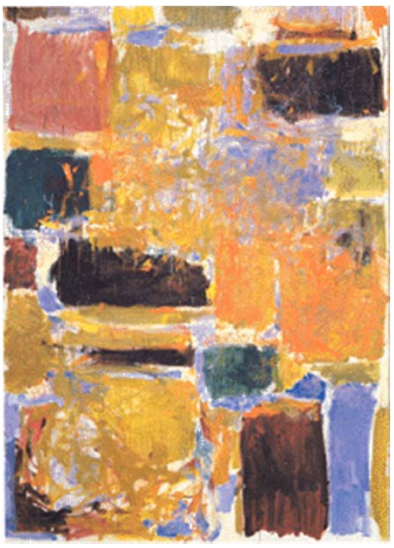


EE141-Fall 2012 Digital Integrated Circuits

Lecture 27
Flash and DRAM

Announcements

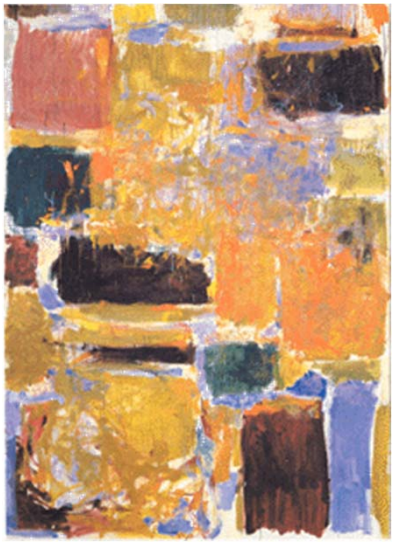
- Project phase 3 final report due Friday
  - Send posters and reports to mailing list
- Final exam
  - Wed. Dec. 12th, 8-11am, Room TBA (see piazza)
  - Review session: Tues. Dec. 11th (stay tuned)
- HKN surveys end of class today

Announcements

- GSI final review on Friday, Monday
- Look out for office hours announcements on the web

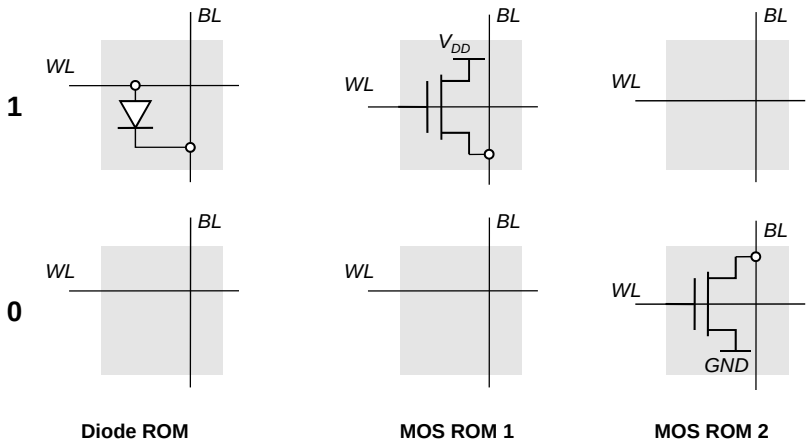
Class Material

- Last lecture
  - I/O, power distribution
- Today's lecture
  - Flash memory
  - DRAM

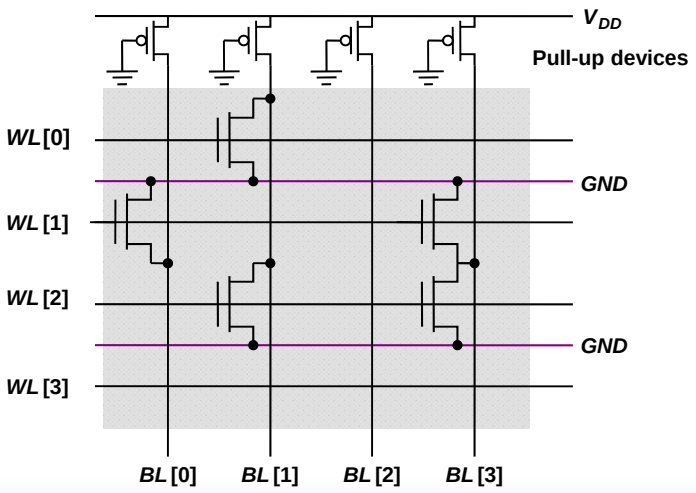


ROM and Flash

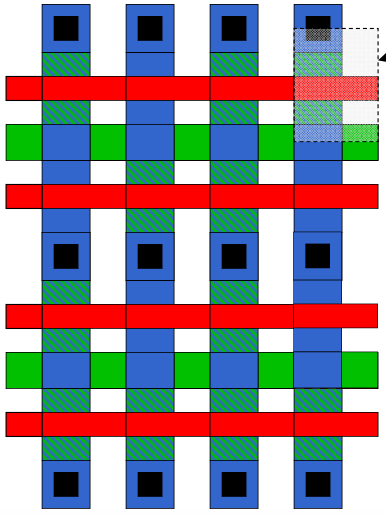
Read-Only Memory Cells



MOS NOR ROM



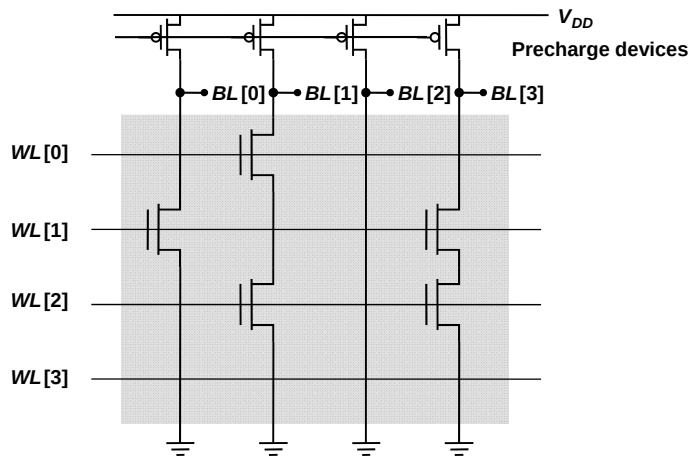
MOS NOR ROM Layout



Programmming using the Active Layer Only

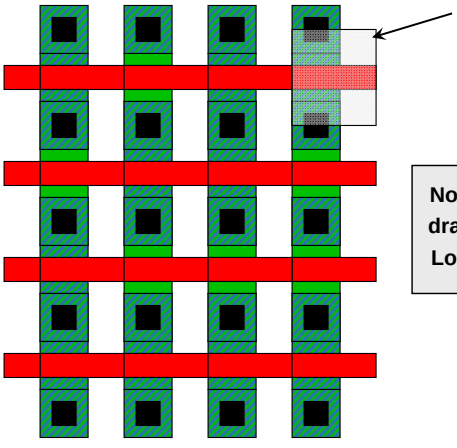
Polysilicon
Metal1
Diffusion
Metal1 on Diffusion

MOS NAND ROM



All word lines high by default with exception of selected row

MOS NAND ROM Layout

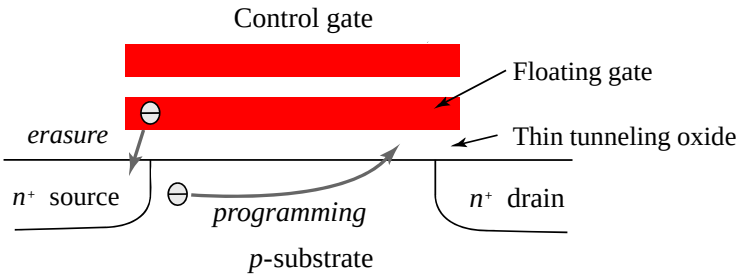


Programmming using the Metal-1 Layer Only

No contact to VDD or GND necessary; drastically reduced cell size
Loss in performance compared to NOR ROM

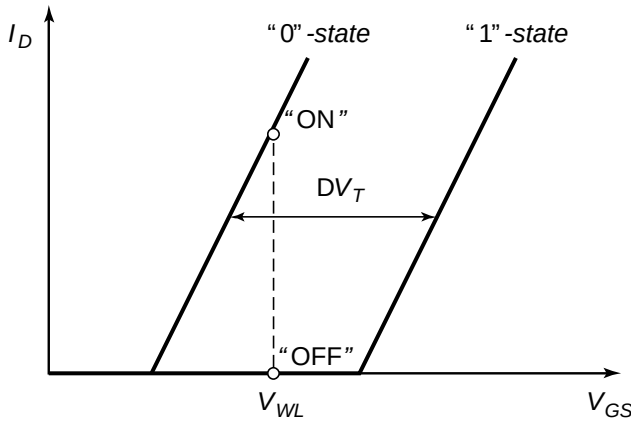
Polysilicon
Diffusion
Metal1 on Diffusion

Floating Gate Transistor

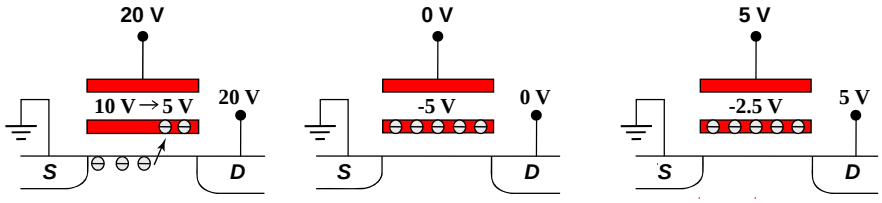


Many other options …

Programmable-Threshold



Floating-Gate Transistor Programming



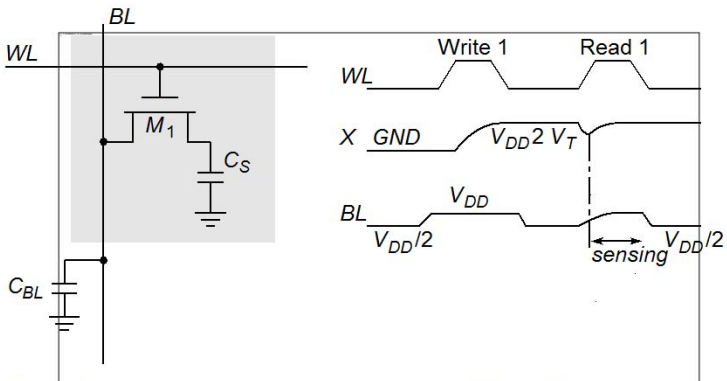
Avalanche injection

Removing programming voltage leaves charge trapped

Programming results in higher V_T.

DRAM

1-Transistor DRAM Cell



Write: C_S is charged or discharged by asserting WL and BL.
Read: Charge redistribution takes places between bit line and storage capacitance

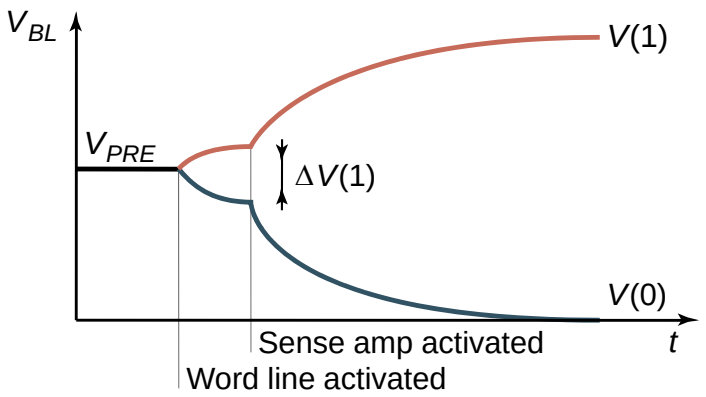
$$\Delta V = V_{BL} - V_{PRE} = \left(V_{BIT} - V_{PRE}\right) \frac{C_S}{C_S + C_{BL}}$$

Voltage swing is small; typically < 200 mV.

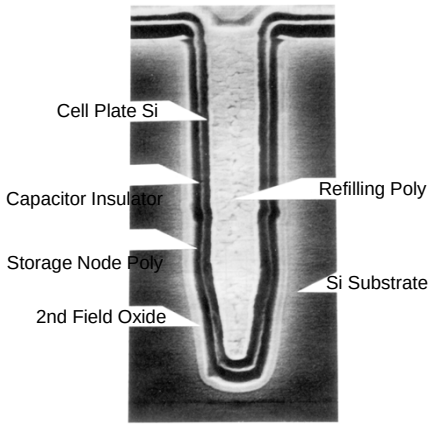
DRAM Cell Observations

- 1T DRAM requires a sense amplifier
- Read-out of the 1T DRAM cell is destructive
  - Need refresh
- Lose a V_{TH} when writing a "1" into a DRAM cell
  - Bootstrap the word lines to a higher value than V_{DD}

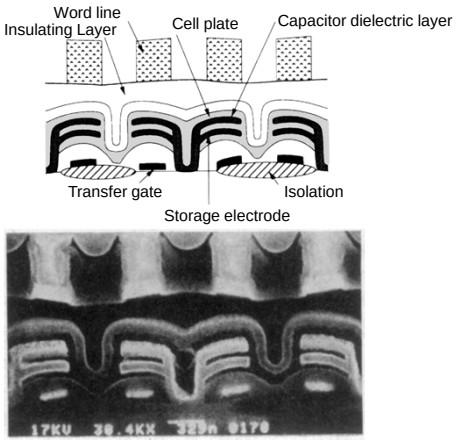
Sense Amp Operation



Modern 1T DRAM Cells



Trench Cell



Stacked-capacitor Cell

THE END

- This is just the beginning…