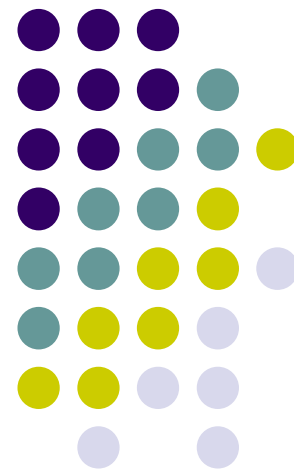


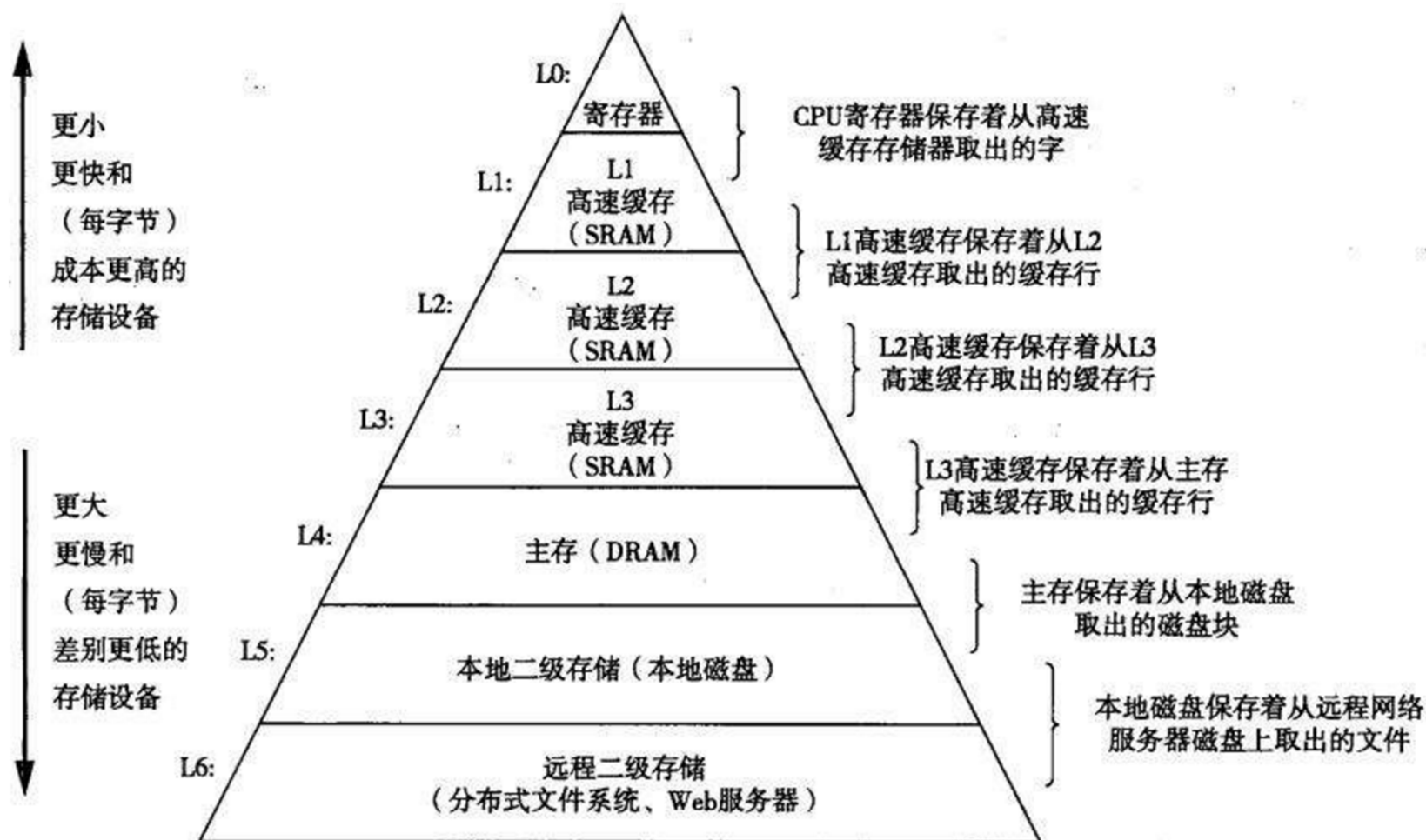
超大规模集成电路基础

Fundamental of VLSI

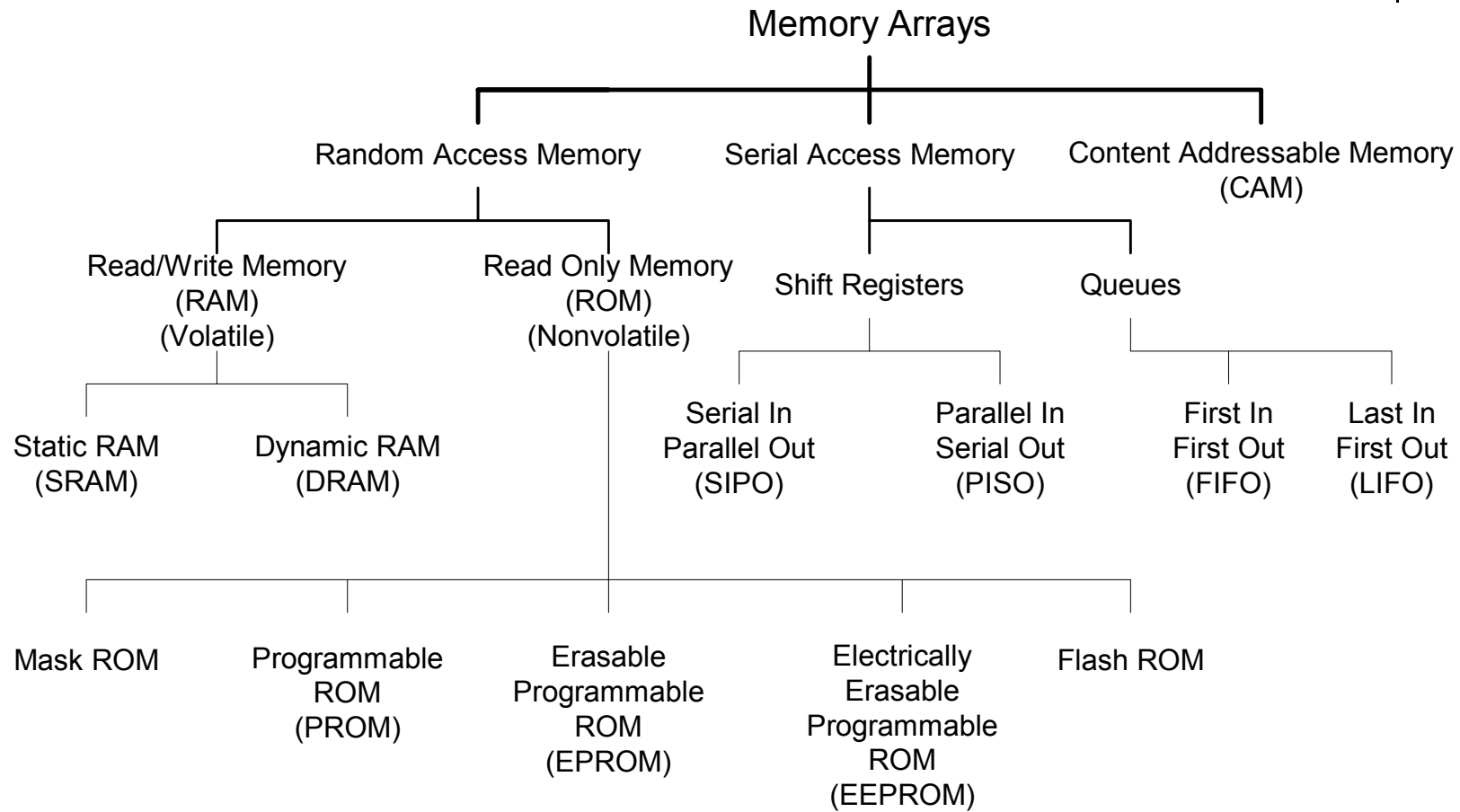
第九章 存储电路



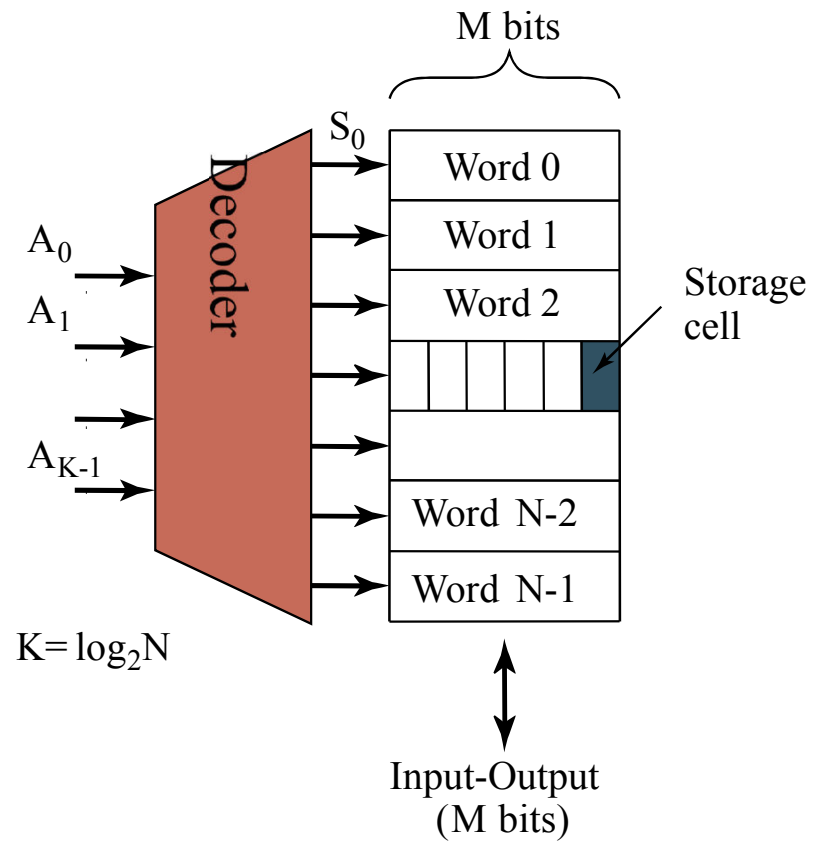
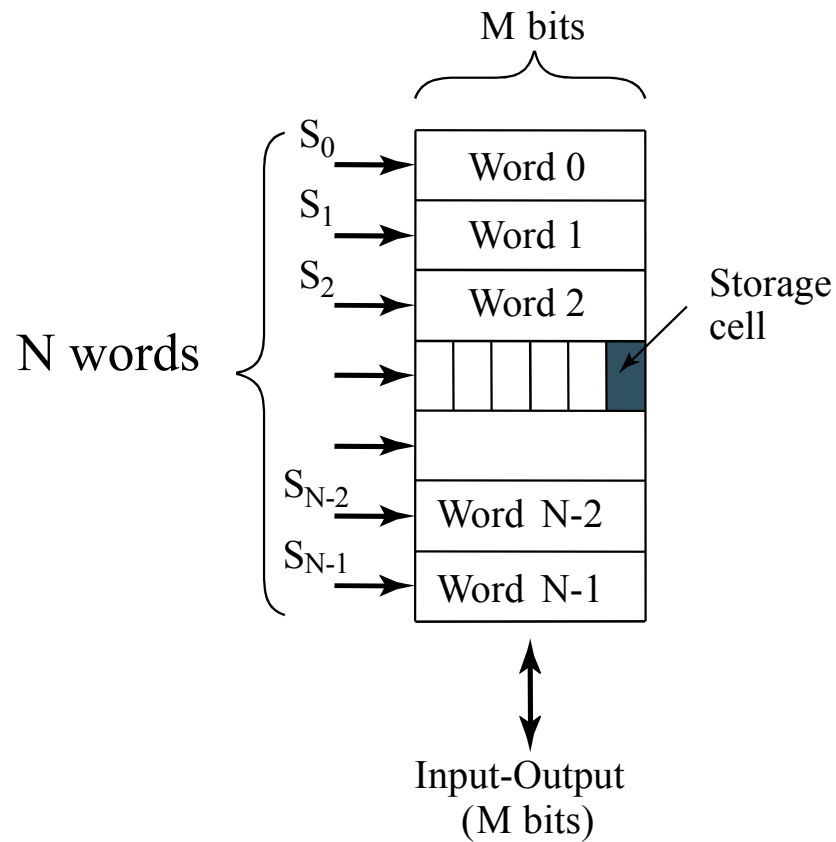
计算机存储



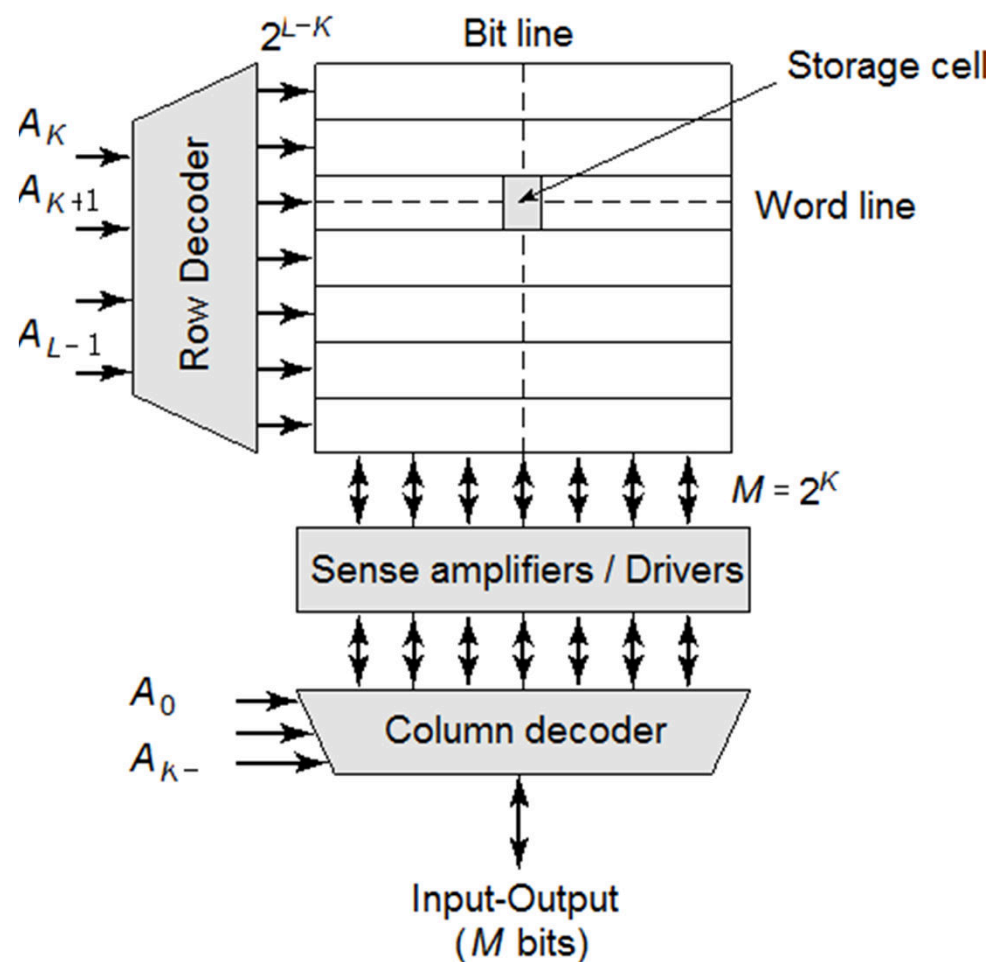
存储单元分类



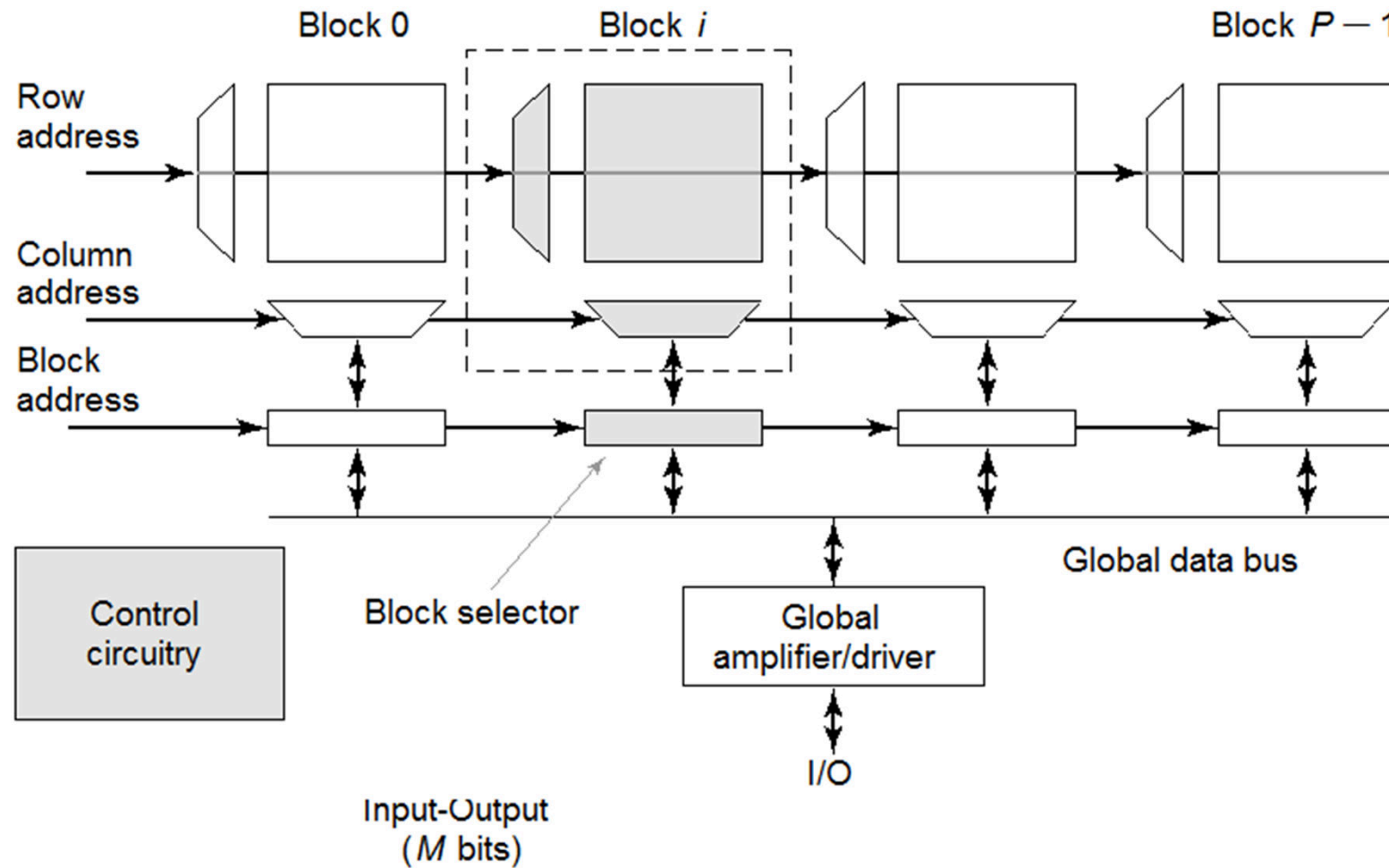
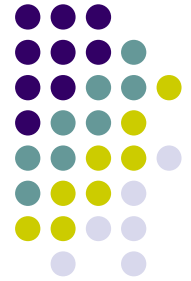
存储结构



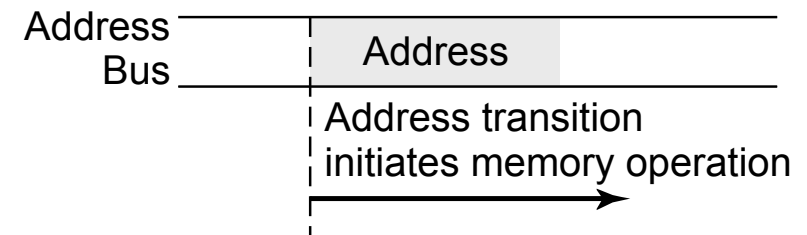
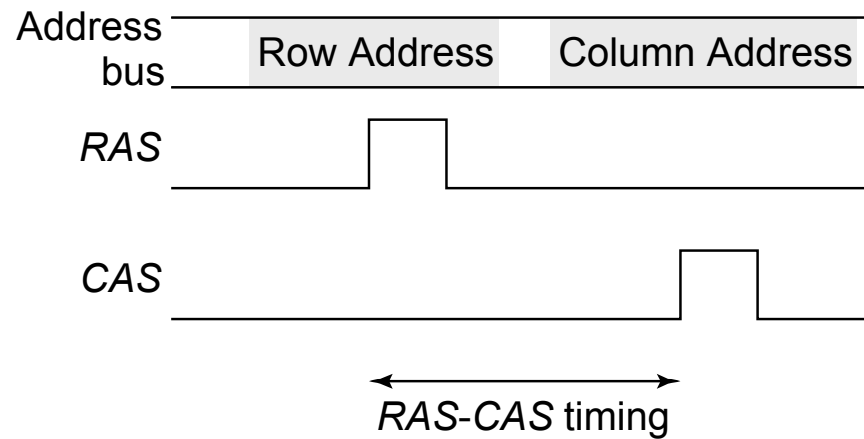
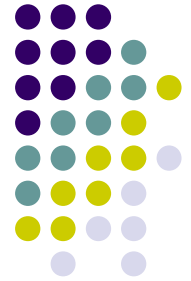
矩阵结构的存储器



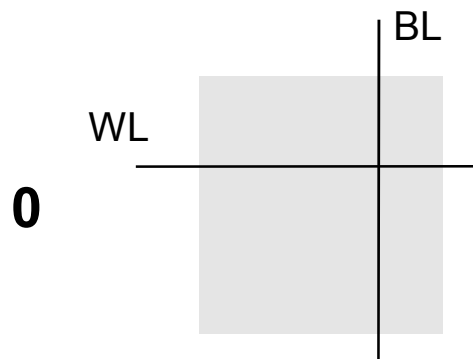
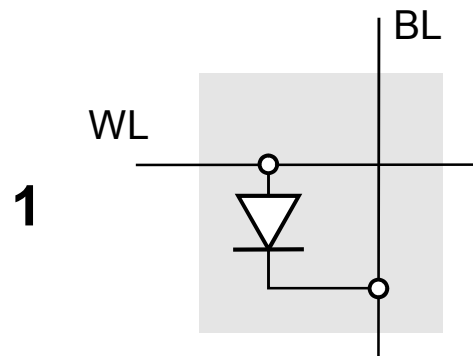
层级结构存储器



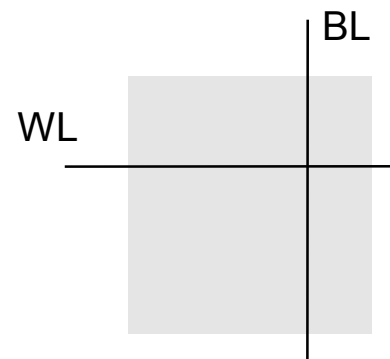
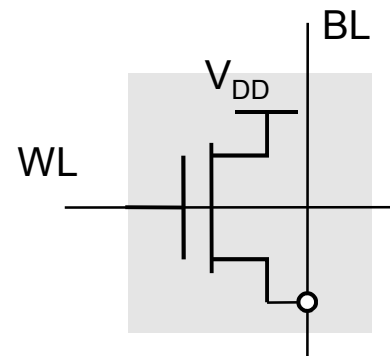
存储器时序



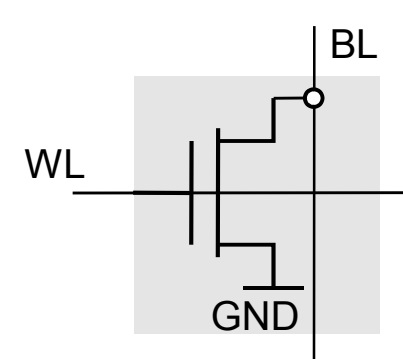
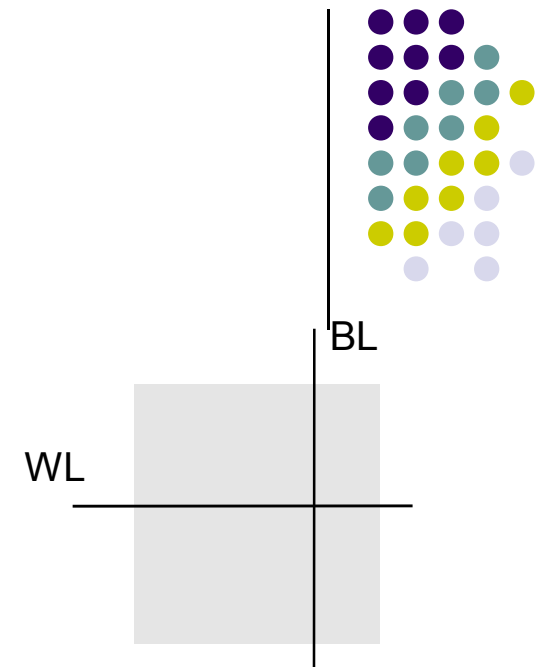
ROM 单元



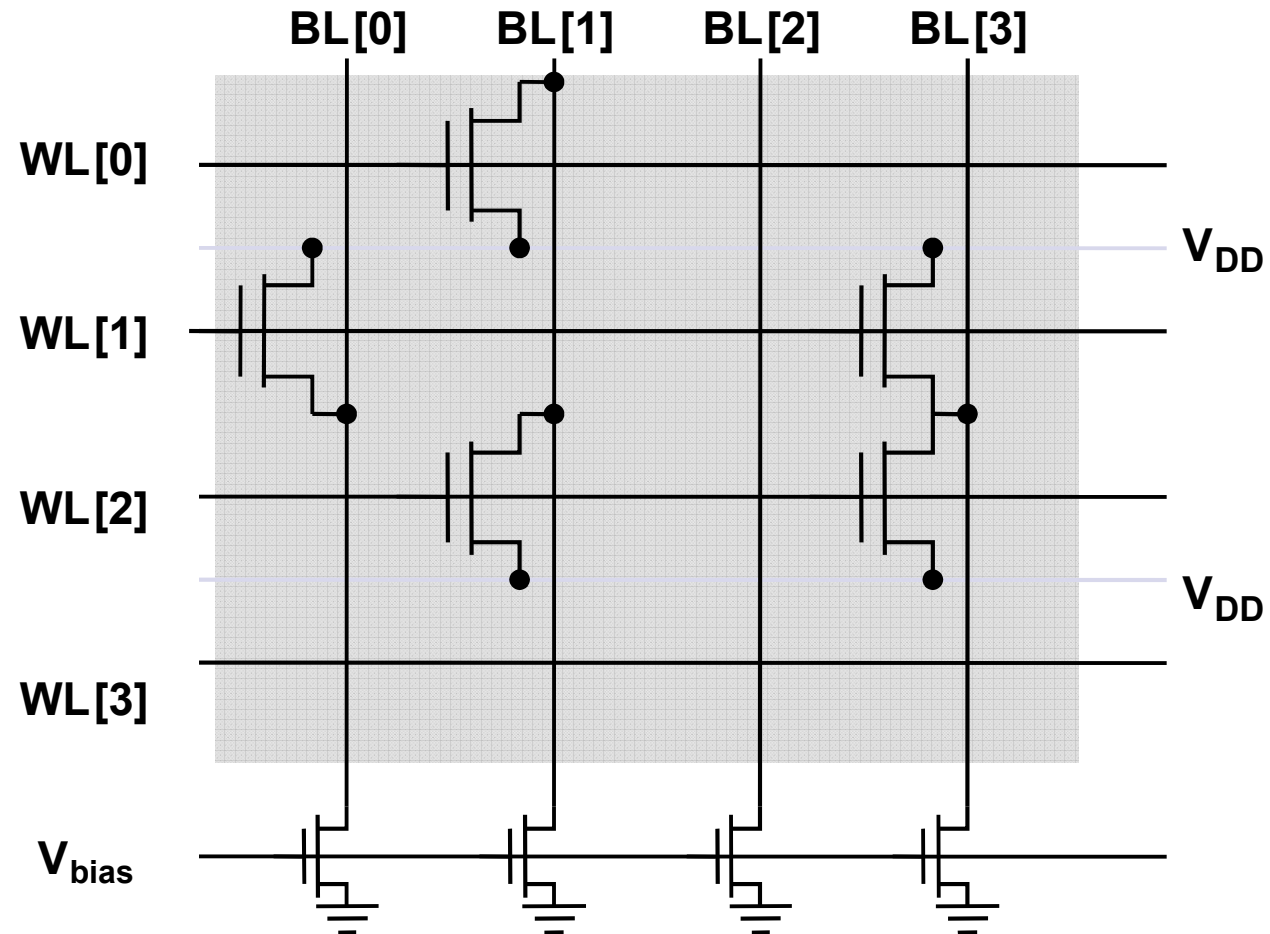
Diode ROM



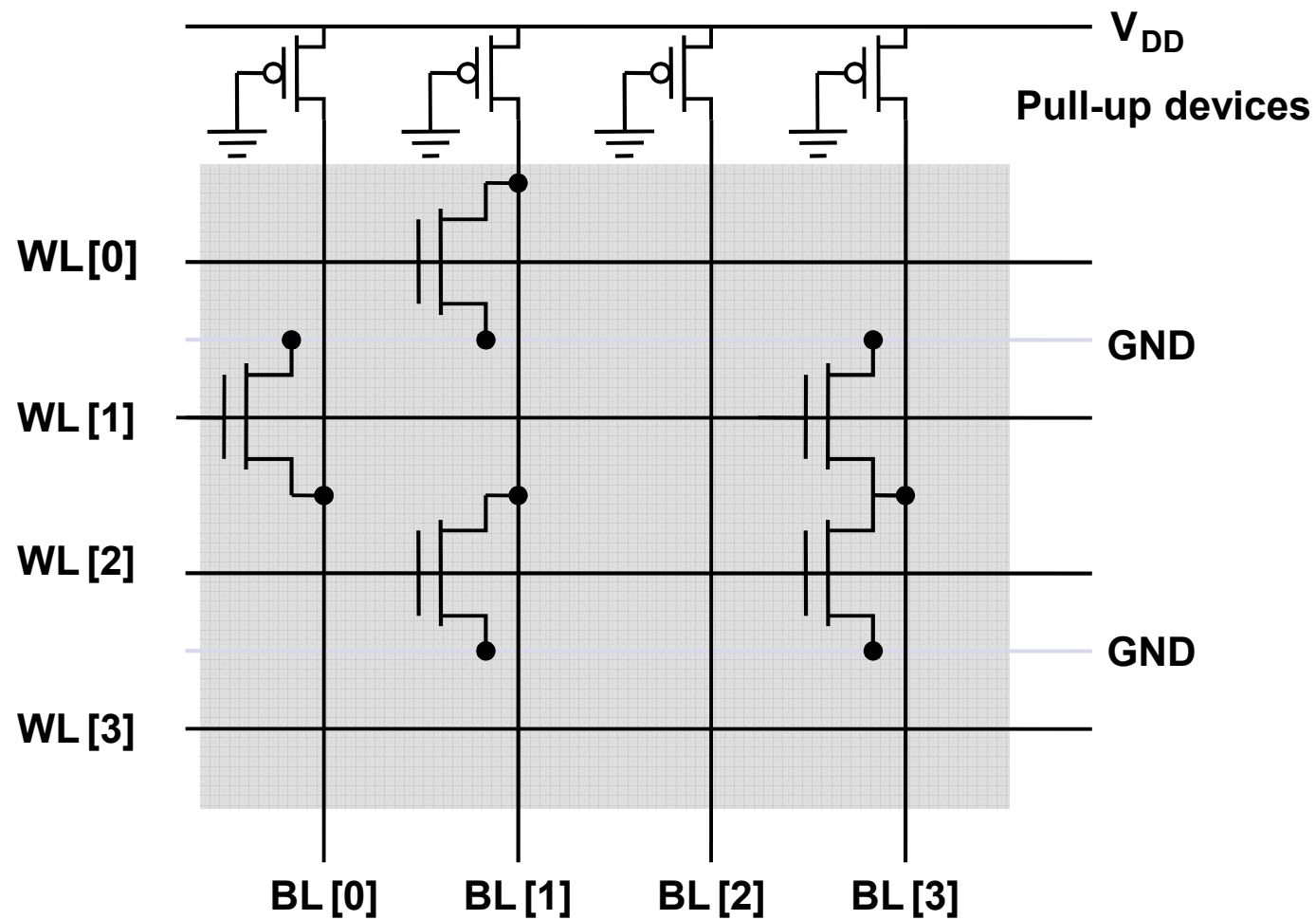
MOS ROM 1



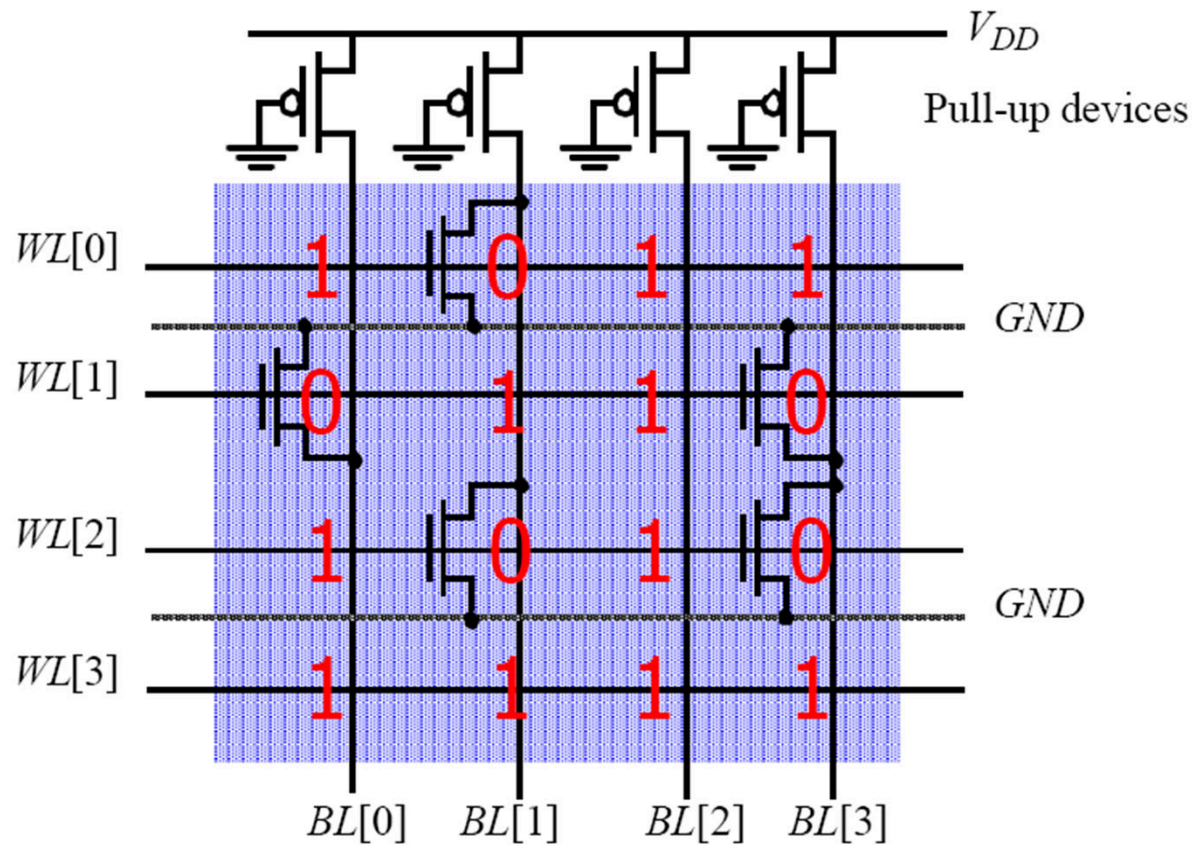
MOS ROM 2



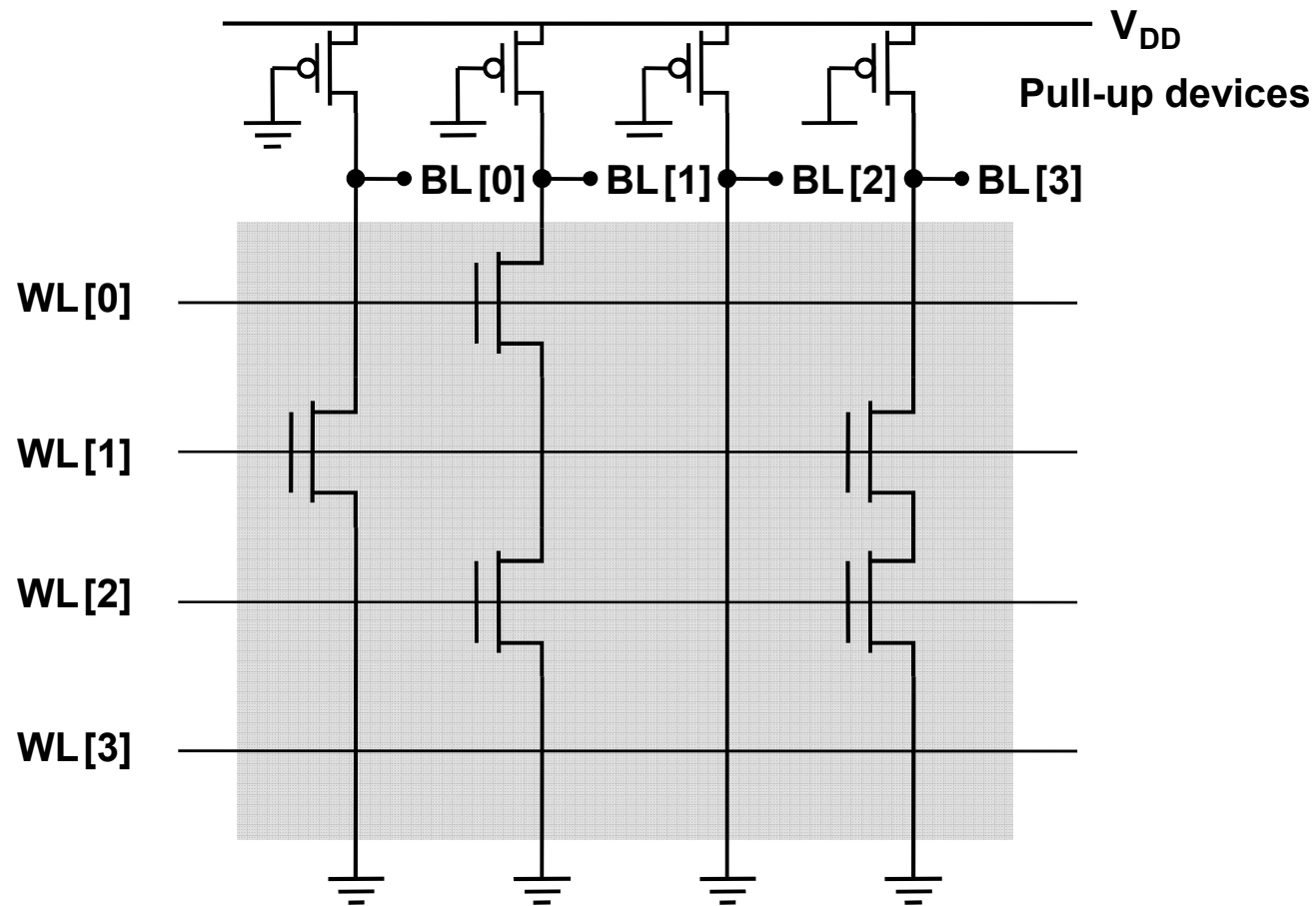
MOS NOR ROM



MOS NOR ROM



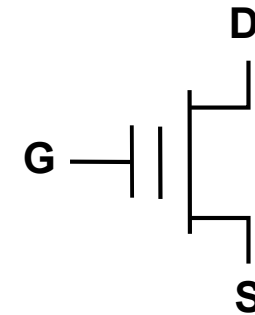
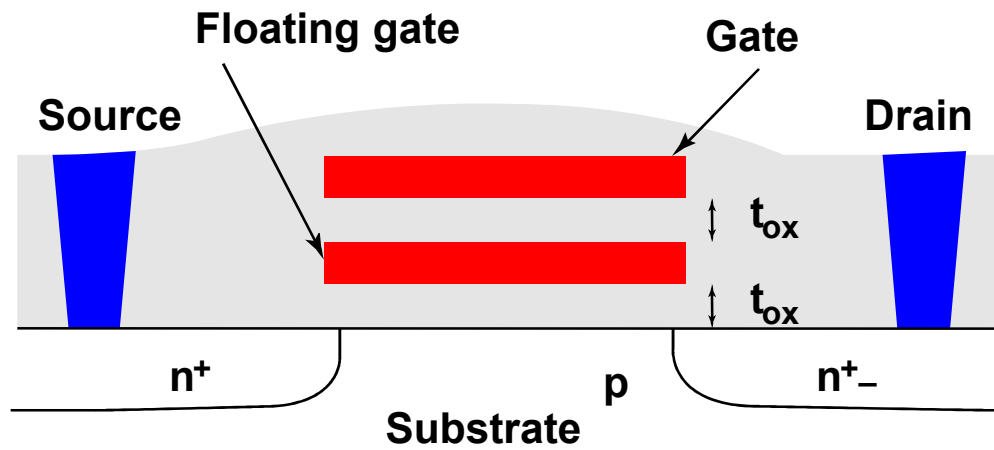
MOS NAND ROM



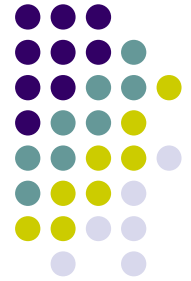
非易失性存储器



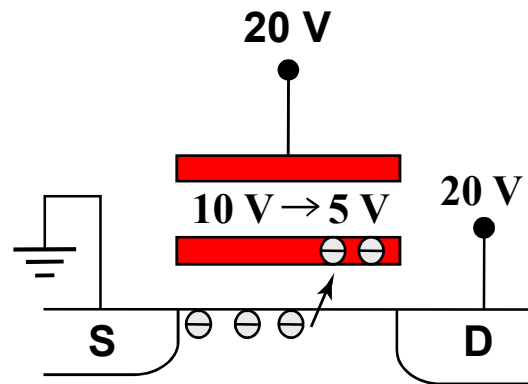
- 浮栅技术



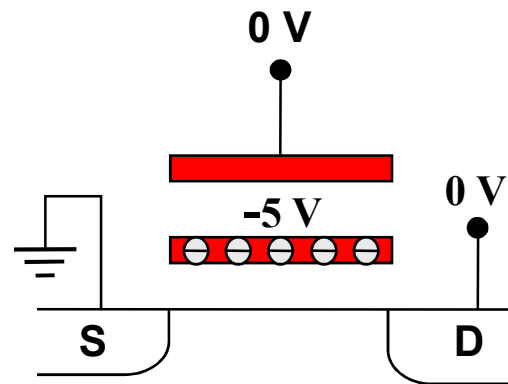
浮栅雪崩注入晶体管



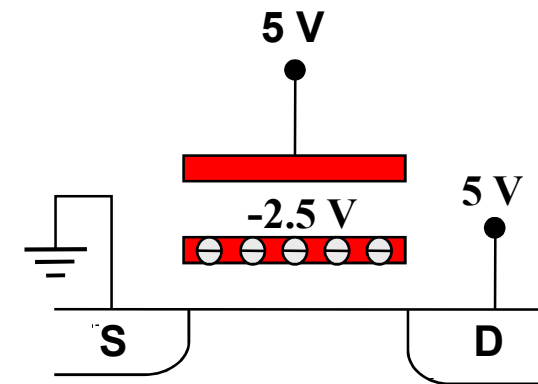
- 编程



雪崩注入
编程



浮栅储存电荷
编程结束

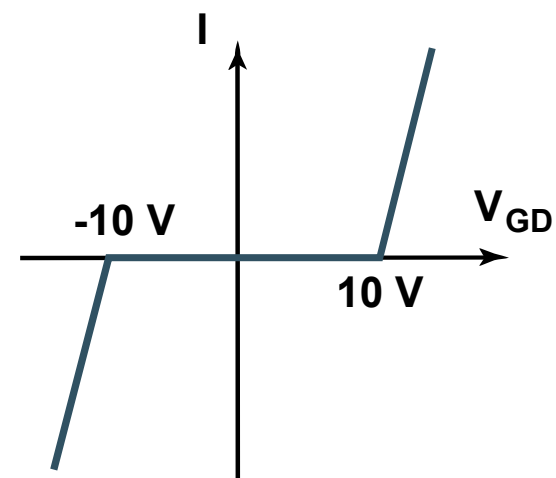
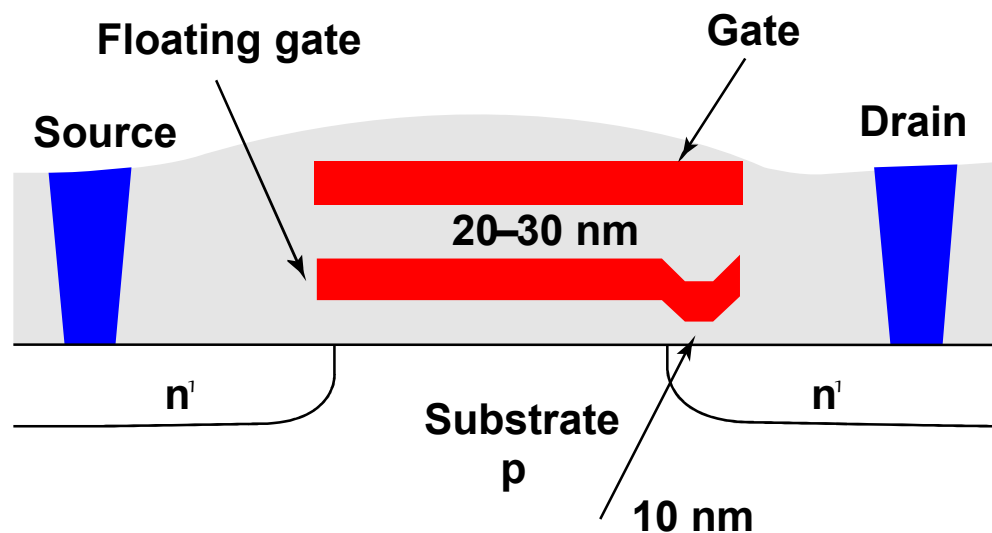


5V电压不能产生沟道

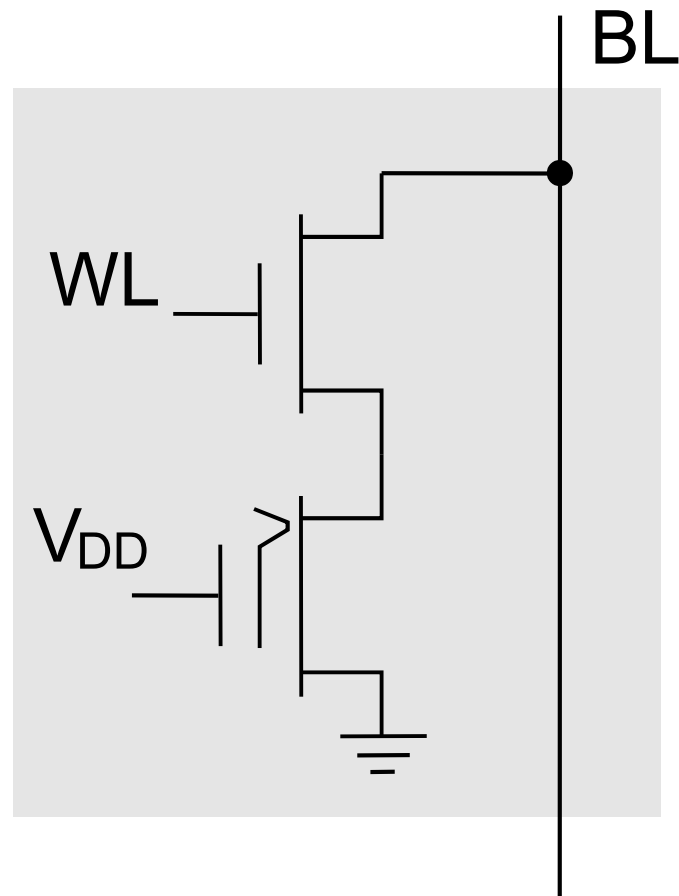
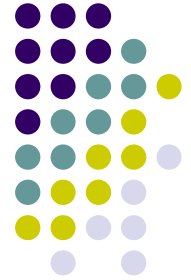
- 擦除：紫外线照射

- 周期长
- 阈值不稳定

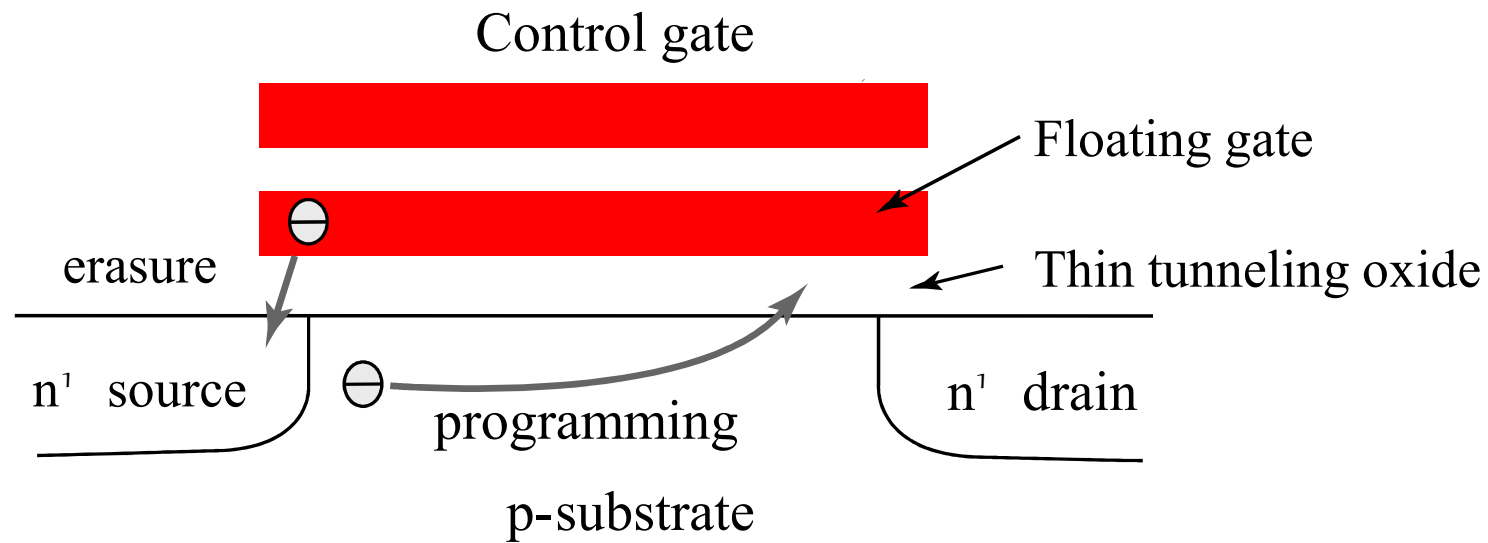
浮栅隧穿注入晶体管



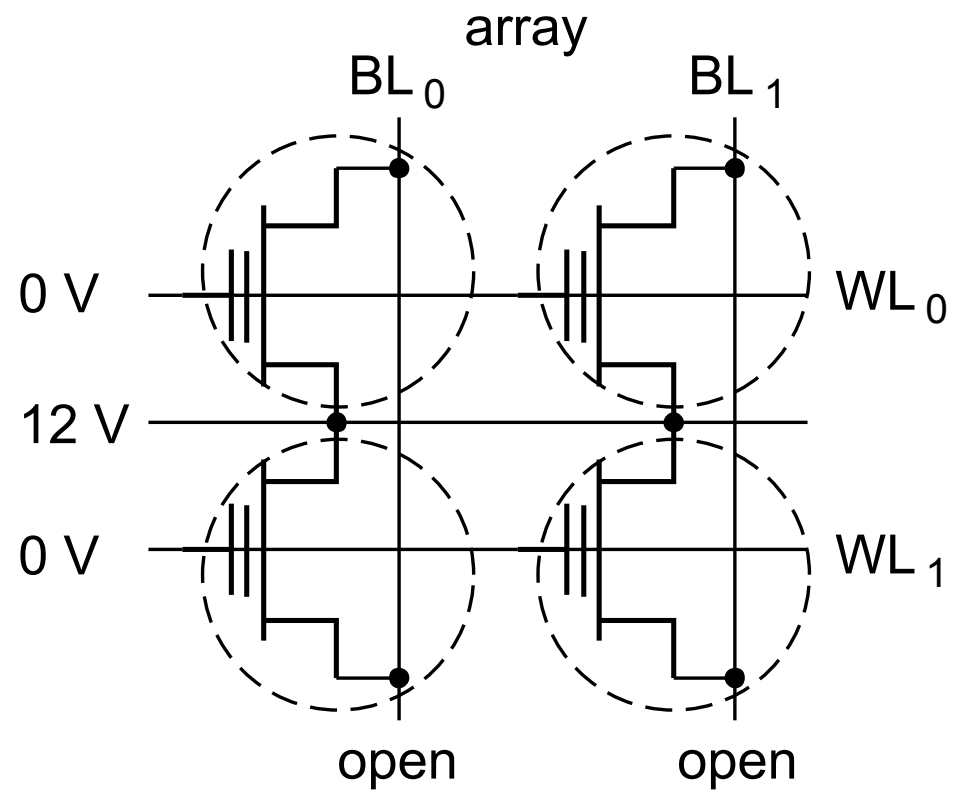
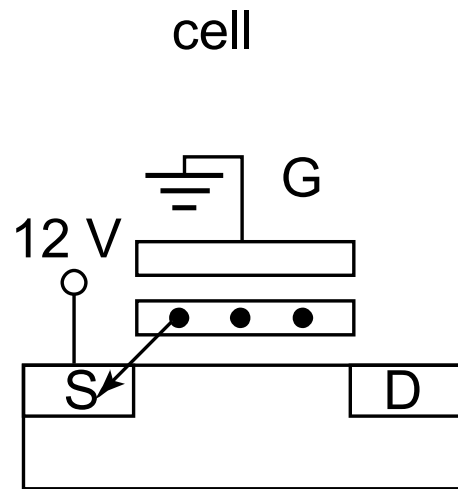
EEPROM



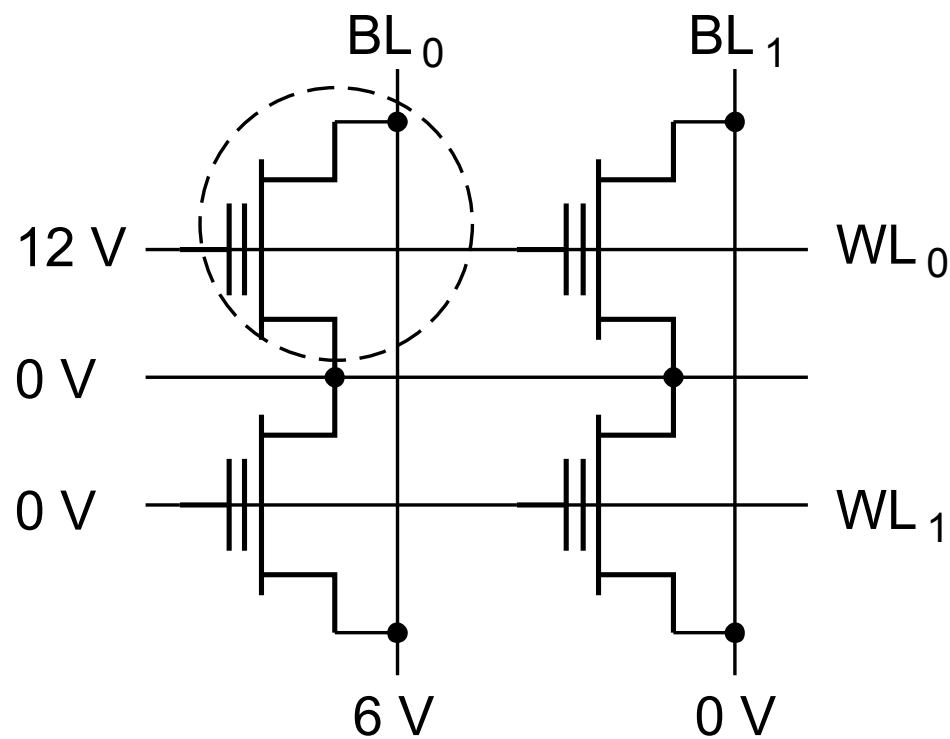
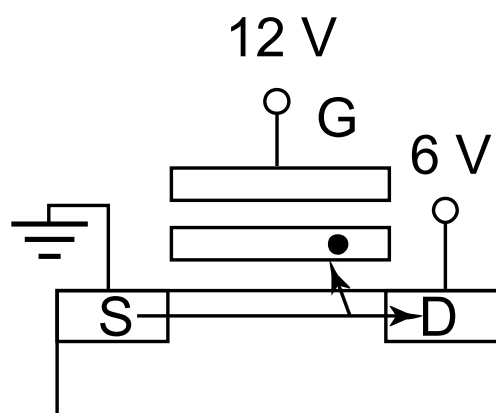
Flash ROM



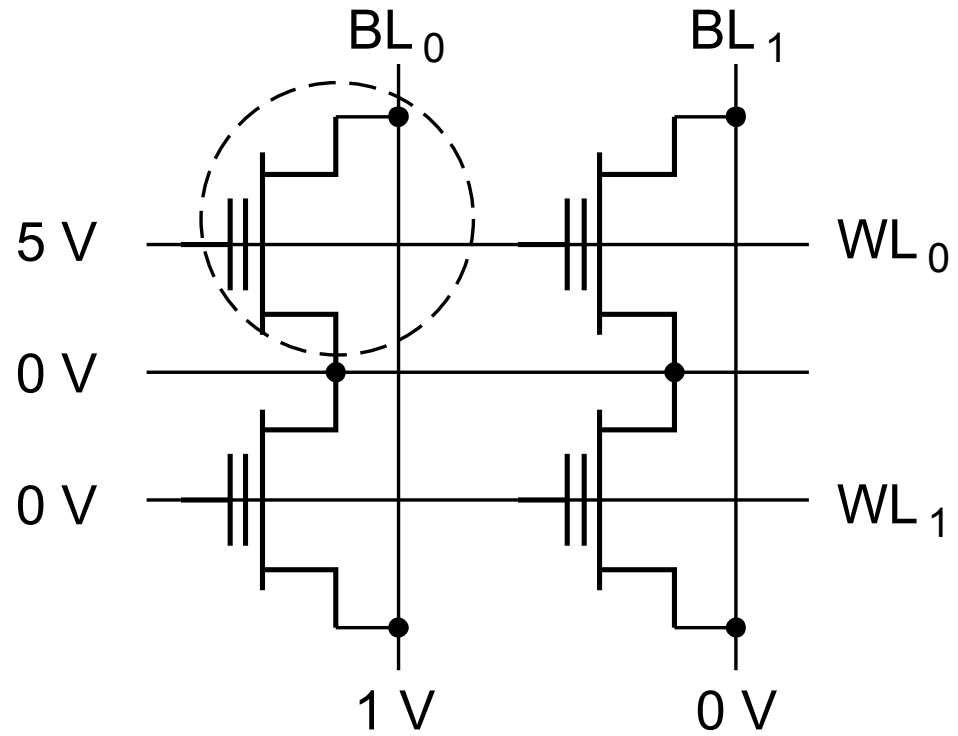
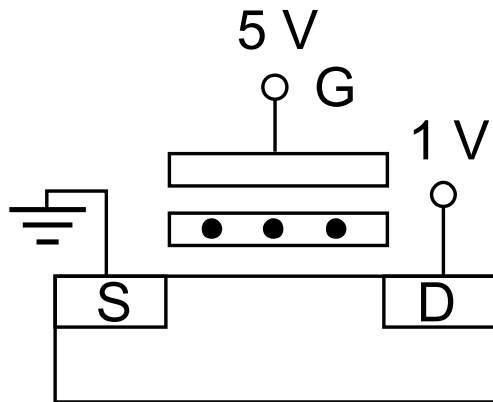
Flash ROM擦除

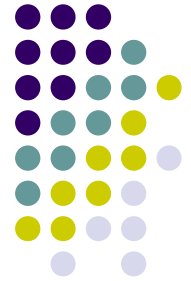


Flash ROM写



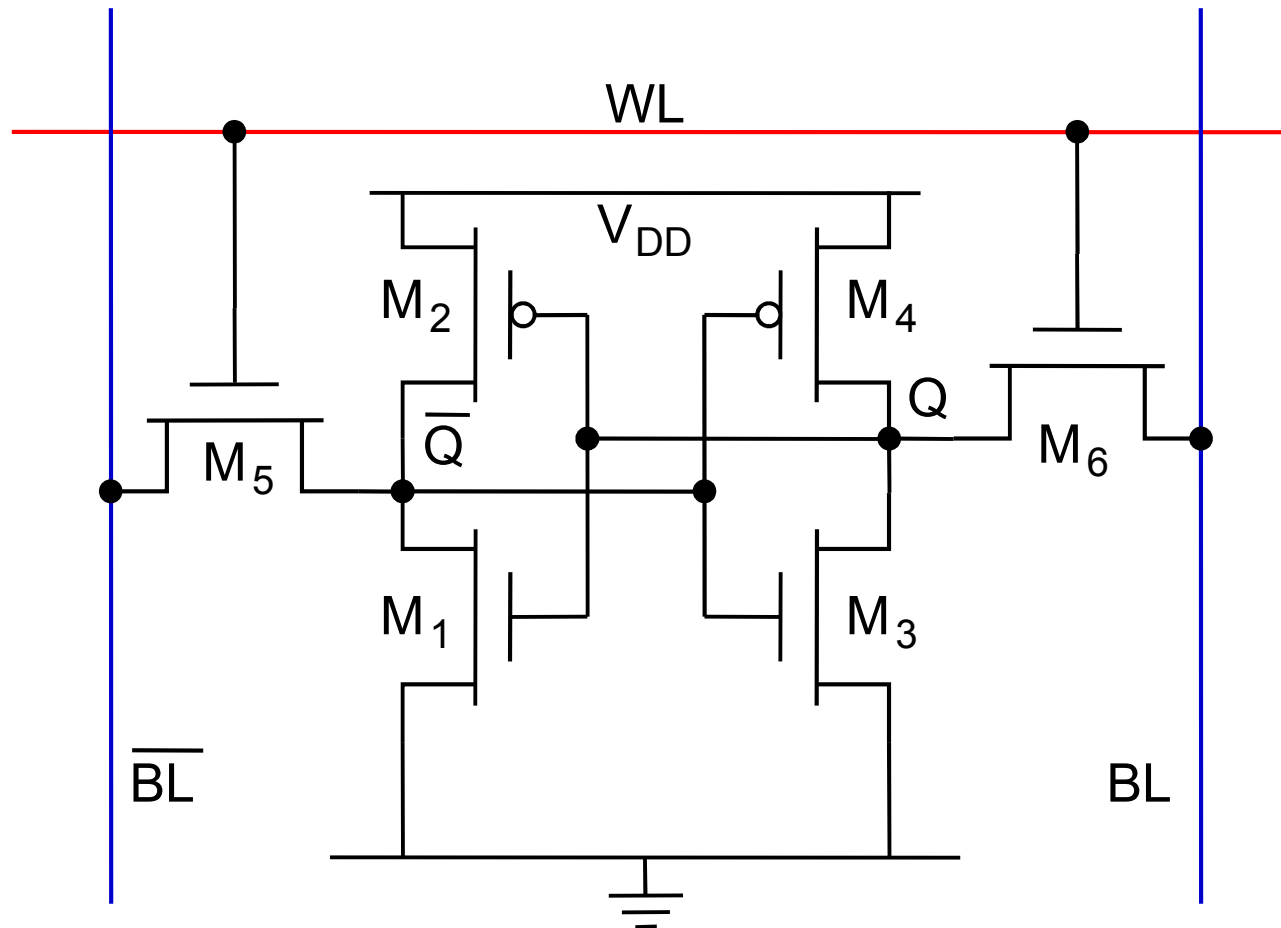
Flash ROM读



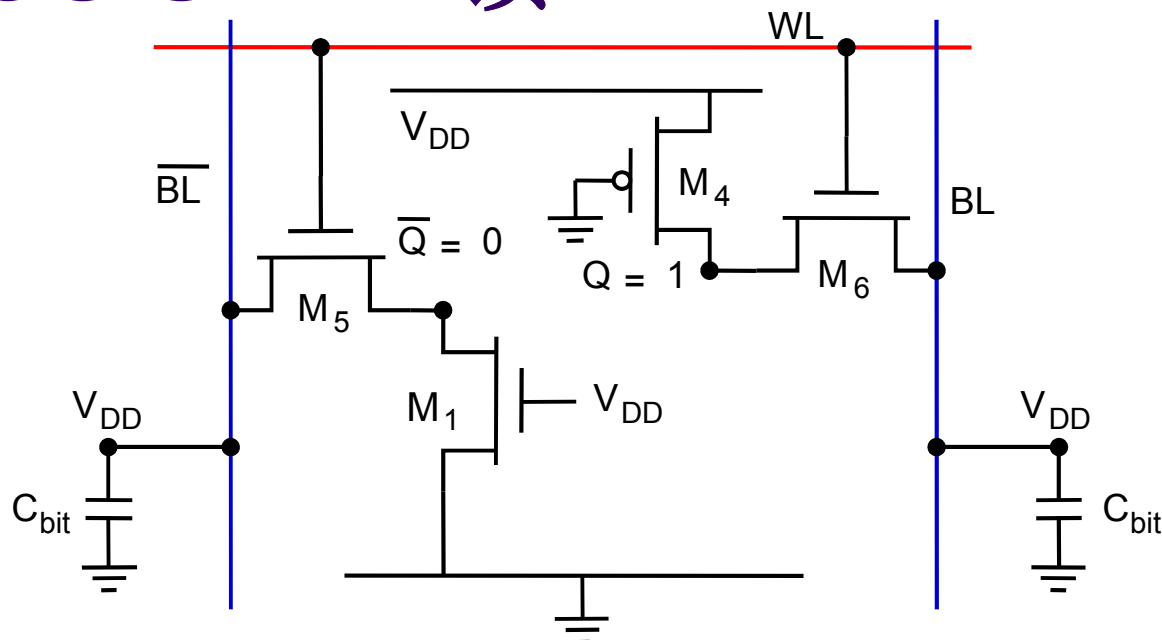


Read-Write Memories (RAM)

- Static RAM (SRAM)
 - 只要有电数据一直保持
 - 面积大
 - 速度快
 - 输出为差分形式
- Dynamic RAM (DRAM)
 - 需要周期刷新
 - 面积小
 - 速度慢
 - 单端输出



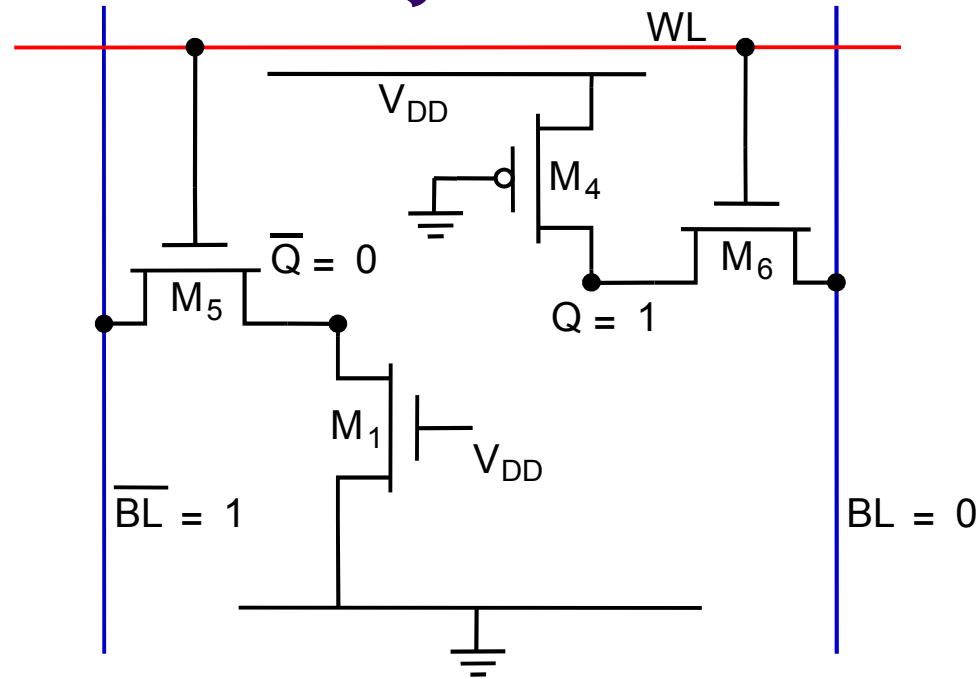
CMOS SRAM读



$$k_{n,M5} \left((V_{DD} - \Delta V - V_{Tn}) V_{DSATn} - \frac{V_{DSATn}^2}{2} \right) = k_{n,M1} \left((V_{DD} - V_{Tn}) \Delta V - \frac{\Delta V^2}{2} \right)$$

$$\Delta V = \frac{V_{DSATn} + CR(V_{DD} - V_{Tn}) - \sqrt{V_{DSATn}^2(1 + CR) + CR^2(V_{DD} - V_{Tn})^2}}{CR}$$

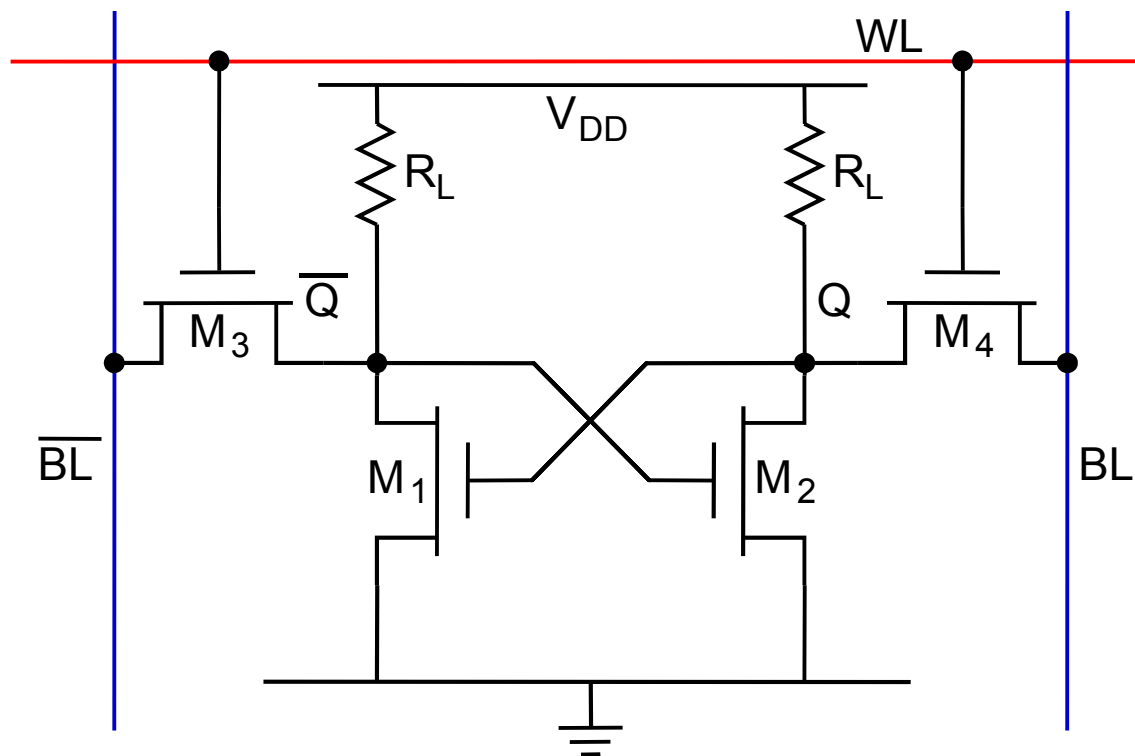
CMOS SRAM写



$$k_{n, M6} \left((V_{DD} - V_{Tn}) V_Q - \frac{V_Q^2}{2} \right) = k_{p, M4} \left((V_{DD} - |V_{Tp}|) V_{DSATp} - \frac{V_{DSATp}^2}{2} \right)$$

$$V_Q = V_{DD} - V_{Tn} - \sqrt{(V_{DD} - V_{Tn})^2 - 2 \frac{\mu_p}{\mu_n} PR \left((V_{DD} - |V_{Tp}|) V_{DSATp} - \frac{V_{DSATp}^2}{2} \right)},$$

负载电阻CMOS SRAM



CMOS DRAM

