

Leakage and subthreshold current

- A variety of leakage currents draw current away from the main logic path.
- The subthreshold current is one particularly important type of leakage current.

Types of leakage current

- Weak inversion current (a.k.a. subthreshold current).
- Reverse-biased pn junctions.
- Drain-induced barrier lowering.
- Gate-induced drain leakage;
- Punchthrough currents.
- Gate oxide tunneling.
- Hot carriers.

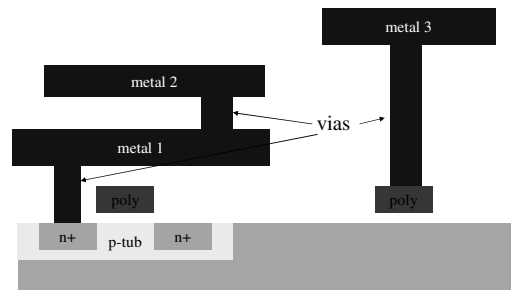
Threshold voltage

Components of threshold voltage V_t :

$$V_{t0} = V_{fb} + \phi_s + \frac{Q_b}{C_{ox}} + V_{II}$$

- V_{fb} = flatband voltage; depends on difference in work function between gate and substrate and on fixed surface charge.
- ϕ_s = surface potential (about $2\phi_F$).
- Voltage on parallel plate capacitor.
- Additional ion implantation.

Wires and vias



Metal interconnect

- Many layers of metal interconnect are possible.
 - 12 layers of metal are common.
- Lower layers have smaller features, higher layers have larger features.
- Can't directly go from a layer to any other layer.

Poly/metal wire capacitance

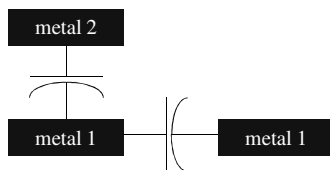
- Two components:

- parallel plate;
- fringe.



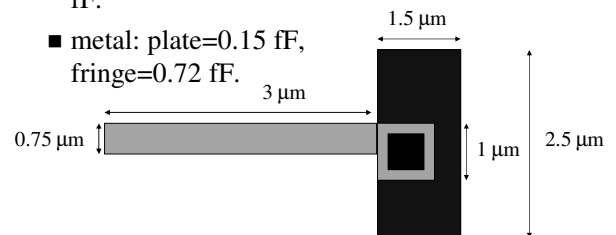
Metal coupling capacitances

- Can couple to adjacent wires on same layer, wires on above/below layers:



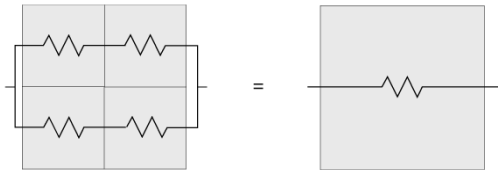
Example: parasitic capacitance measurement

- n-diffusion: bottomwall=2 fF, sidewall=2 fF.
- metal: plate=0.15 fF, fringe=0.72 fF.



Wire resistance

- Resistance of any size square is constant:



Skin effect

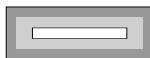
- At low frequencies, most of copper conductor's cross section carries current.
- As frequency increases, current moves to skin of conductor.
 - Back EMF induces counter-current in body of conductor.
- Skin effect most important at gigahertz frequencies.

Skin effect, cont'd

- Isolated conductor:
- Conductor and ground:



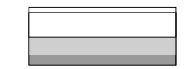
Low frequency



High frequency



Low frequency



High frequency