

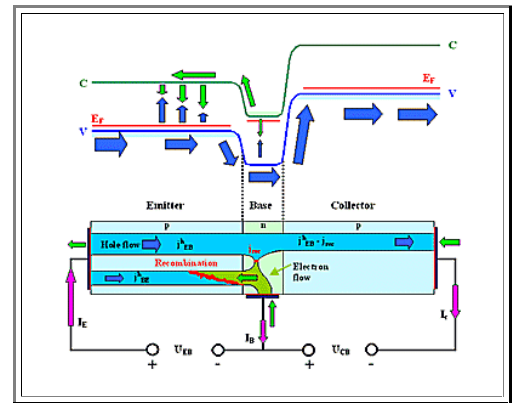
5.0.3 Summary to: Required Reading to Chapter 5

Essentials of the bipolar transistor:

- High emitter doping (N_{Don} for npn transistor here) in comparison to base doping N_{Ac} for large current amplification factor $\gamma = I_C/I_B$.
- $N_{Don}/N_{Ac} \approx \kappa =$ injection ratio.

$$\gamma \approx \frac{N_{Don}}{N_{Ac}} \cdot \left(1 - \frac{d_{base}}{L} \right)$$

- Small base width d_{base} (relative to diffusion length L) for large current amplification.
- Not as easy to make as the band-diagram suggests!

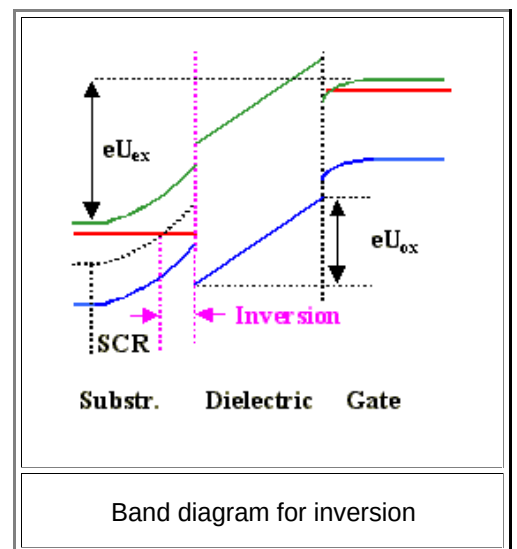
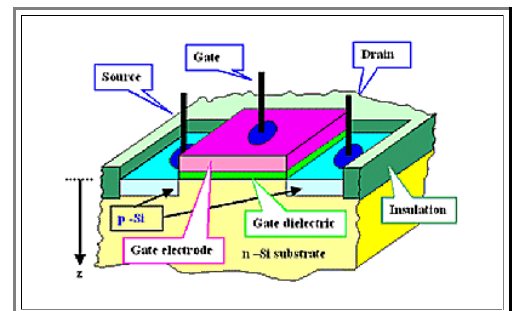


Essentials of the MOS transistor:

- Gate voltage enables Source-Drain current
- Essential process. Inversion of majority carrier type in channel below gate by:
 - Drive intrinsic majority carriers into bulk by gate voltage with same sign as majority carriers.
 - Reduced majority concentration n_{maj} below gate increases minority carrier concentration n_{min} via mass action law

$$n_{maj} \cdot n_{min} = n_i^2$$

- An inversion channel with $n_{min} > n_{maj}$ develops below the gate as soon as threshold voltage U_{Th} is reached.
- Current now can flow because the reversely biased pn-junction between either source or drain and the region below the gate has disappeared.



The decisive material is the gate dielectric (usually SiO_2). Basic requirement is:

- High capacity C_G of the gate electrode - gate dielectric - Si capacitor = high charge Q_G on electrodes = strong band bending = low threshold voltages U_G
- It follows:

- Gate dielectric thickness $d_{Di} \Rightarrow$ High breakdown field strength U_{Bd}
- Large dielectric constant ϵ_r
- No interface states.
- Good adhesion, easy to make / deposit, easy to structure, small leakage currents, ...

$$Q_G = C_G \cdot U_G$$

Example:

$$U = 5 \text{ V}, d_{Di} = 5 \text{ nm} \Rightarrow E = U/d_{Di} = 10^7 \text{ V/cm} !!$$

$$\epsilon_r(\text{SiO}_2) = 3.9$$