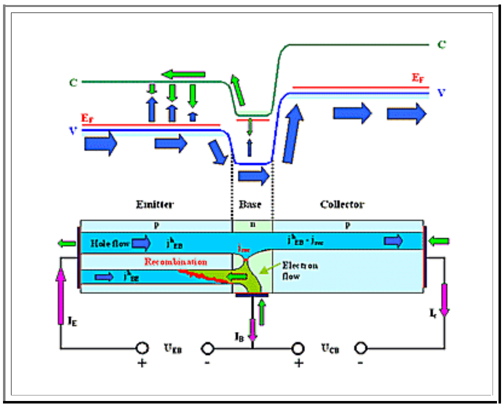
5.0.3 Summary to: Required Reading to Chapter 5

Essentials of the bipolar transistor:

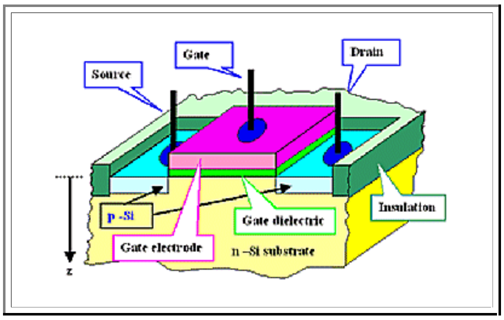
- High emitter doping (***N*$_{Don}$** for **npn** transistor here) in comparison to base doping ***N*$_{Ac}$** for large current amplification factor $\gamma = I_C/I_B$.
- ***N*$_{Don}$/*N*$_{Ac}$** $\approx \kappa$ = injection ratio.



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

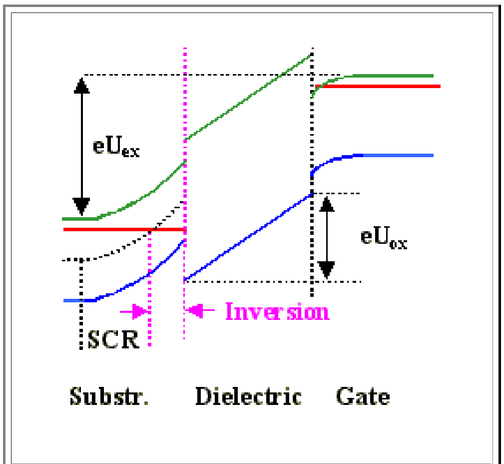
- Small base width ***d*$_{base}$** (relative to diffusion length ***L***) for large current amplification.
- Not as easy to make as the band-diagram suggests!

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

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



Band diagram for inversion

  - 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

$$Q_G = C_G \cdot U_G$$

- It follows:
  - Gate dielectric thickness d_{Di} ⇒ 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, ...

Example:
U = 5 V, d_{Di} = 5 nm ⇒ $E = U/d_{Di}$ = 10^7 V/cm !!

$\epsilon_r(SiO_2)$ = 3.9