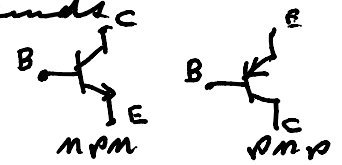
EE 303
01/26/10

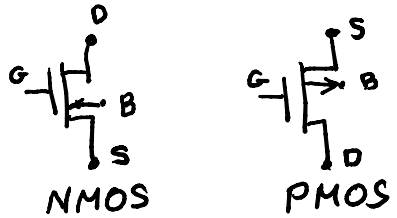
Transistor = transfer resistor

Two basic kinds of bipolar



B = base
E = emitter
C = collector

MOS

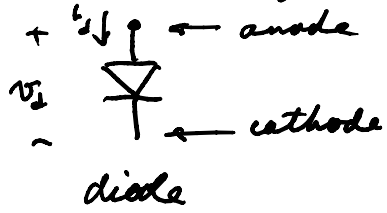


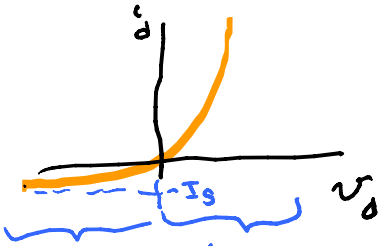
G = gate
S = source
D = drain
B = bulk

β = beta = current gain of a bipolar transistor

KP = current for voltage gain of MOS $\Rightarrow$ $KP \frac{W}{L}$

arrows come from current in diodes

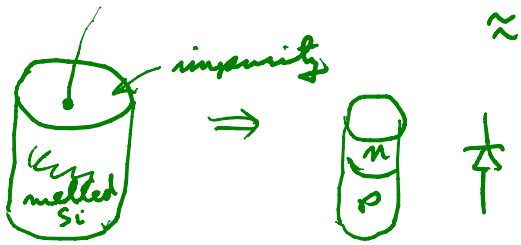




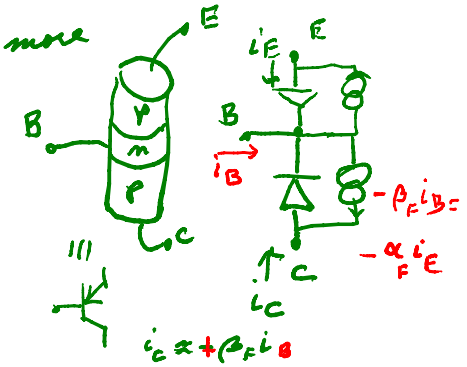
Law of diode

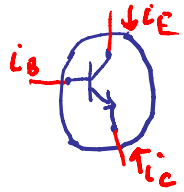
$i_d = I_S(e^{v_d/V_T} - 1)$, V_T = Thermal voltage $= \frac{kT}{|q|}$, T = temperature, k = Boltzmann's constant, |q| = electron charge

≈ 0.026 V @ room temp.



do more





KCL $\Rightarrow 0 = i_B + i_E + i_C$

$i_E = -i_B - i_C$

$i_C = -\alpha i_E \Rightarrow i_E = -i_B + \alpha i_E$

$(1-\alpha) i_E = -i_B$

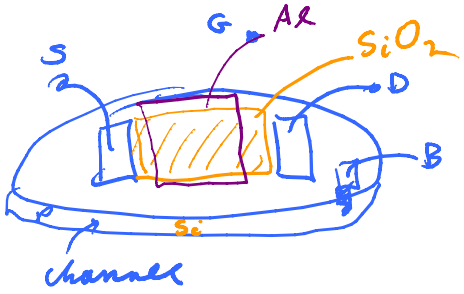
$= (1-\alpha)\left[-\frac{i_C}{\alpha}\right] = i_B$

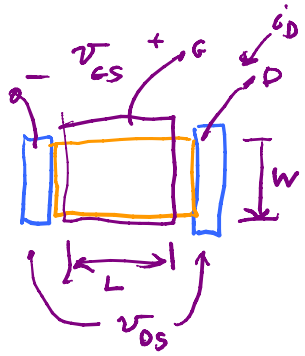
$i_C = \frac{\alpha}{1-\alpha} i_B = \beta i_B$

$\beta = \frac{\alpha}{1-\alpha}$

Bipolar transistor is a current controlled current source

MOS





$V_{th} \cong VTO$ = turn on voltage = threshold voltage

$VTO = V_{th}$ if $v_{BS} = 0$

$i_D = \frac{KP}{2}\frac{W}{L}(v_{GS} - V_{th})^2$ if $v_{GS} > V_{th}$ & $v_{GS} - V_{th} \leq v_{DS}$

$= \frac{KP}{2}\frac{W}{L}\{2(v_{GS} - V_{th})v_{DS} - v_{DS}^2\}$ if $v_{GS} > V_{th}$ & $v_{GS} - V_{th} \geq v_{DS}$

looks like a resistor $\frac{i_D}{+\ v_{DS}\ -}$ which with v_{GS}

an MOS transistor is like a voltage controlled current source.

all of the above is for DC; note these transistors are quite nonlinear.