14. 02. 2022

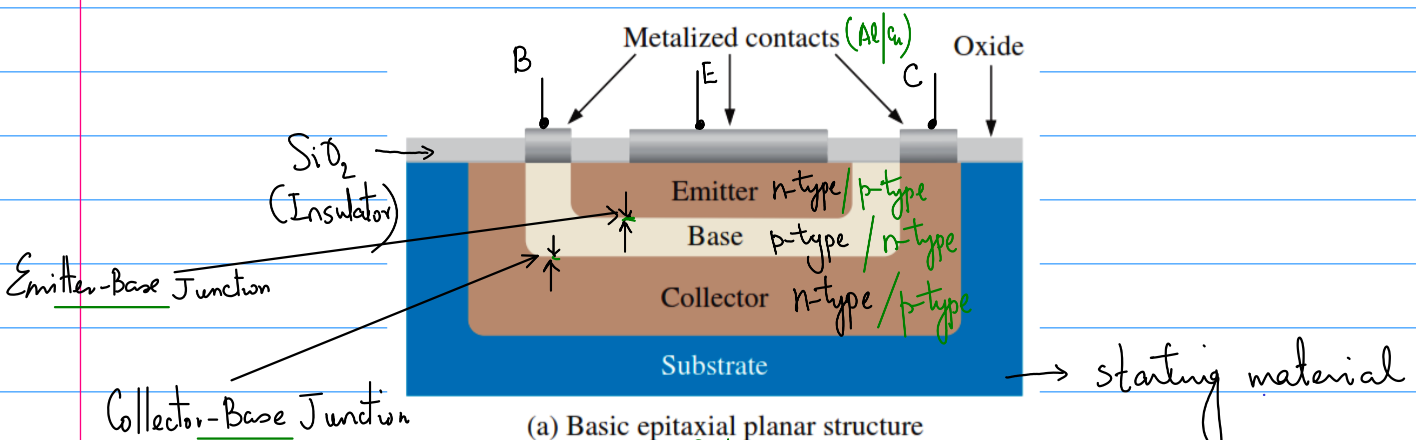
Bipolar Junction Transistors (BJTs)

– 1951, William Schockley

Bipolar : Both electrons & holes are participating in device operation.

Junction : p-n / n-p (Barrier potential associated with junction).

Transistor : Transfer of resistor (ie, transfer of current levels)



(a) Basic epitaxial planar structure
growth

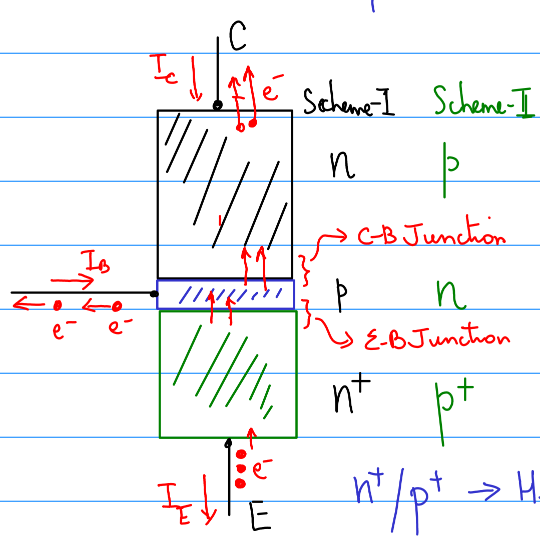
Fabrication of a BJTs.

Thickness :

C : Thickest layer

B : Thinnest layer

E : Moderate thickness



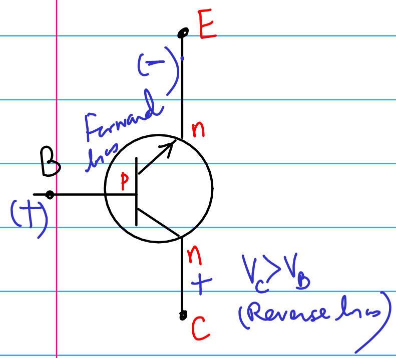
n^+/p^+ → Heavily doping

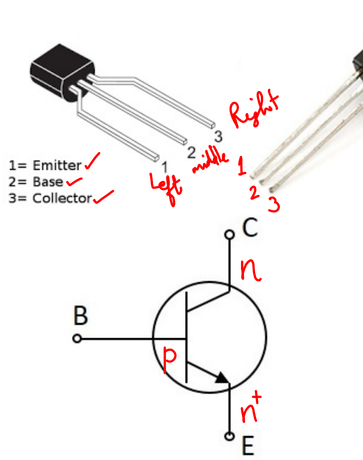
Doping levels :

C : Moderately doped ($\sim 10^{14-15}\ cm^{-3}$) dopant

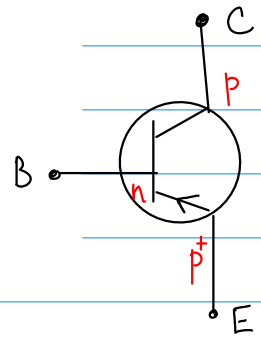
B : Lightly doped ($10^{12-13}\ cm^{-3}$)

E : Heavily doped ($10^{16-18}\ cm^{-3}$)





n-p-n Transistor



p-n-p Transistor

Basic BJT operation :

(i) Emitter-Base Junction : Forward-Bias

(ii) Collector-Base Junction : Reverse-Bias

$I_B \uparrow$ 2 times

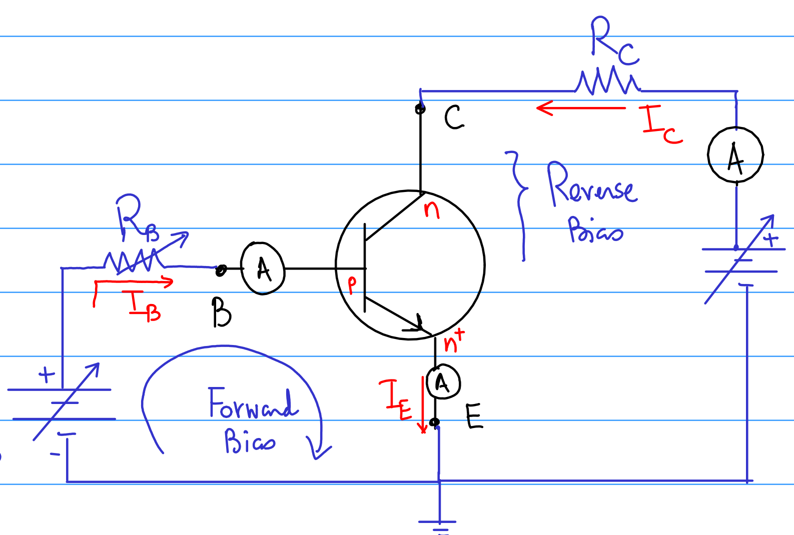
$I_{B_1} = 10\,\mu A$

$I_{B_2} = 20\,\mu A$

$I_C = \beta_{DC} I_B$

$I_{C_1} = 100 \cdot 10\,\mu A = 1\,mA$

$I_{C_2} = 100 \cdot 20\,\mu A = 2\,mA$



$V_C > V_B$

We are trying to observe the current levels in the collector, Base & Emitter terminal.

- Any change in the Base-Emitter terminals, the change is directly appearing in the collector terminal.

$$I_E = I_B + I_C$$

$\boxed{I_E \,;\, I_C \sim mA}$; $\boxed{I_B \sim \mu A}$

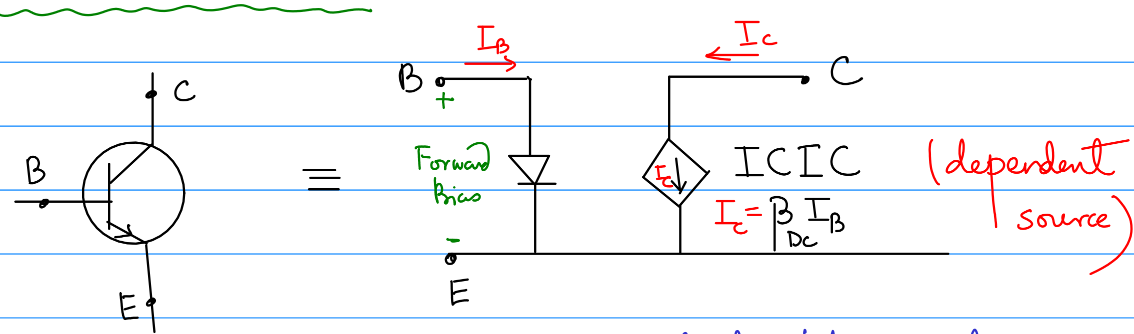
We define a parameter, $\beta_{DC} = \dfrac{I_C}{I_B} = \dfrac{\sim mA}{\sim \mu A} \simeq 100$ (typical)

β_{DC} = typically varies b/w 50–300

– "Current gain"

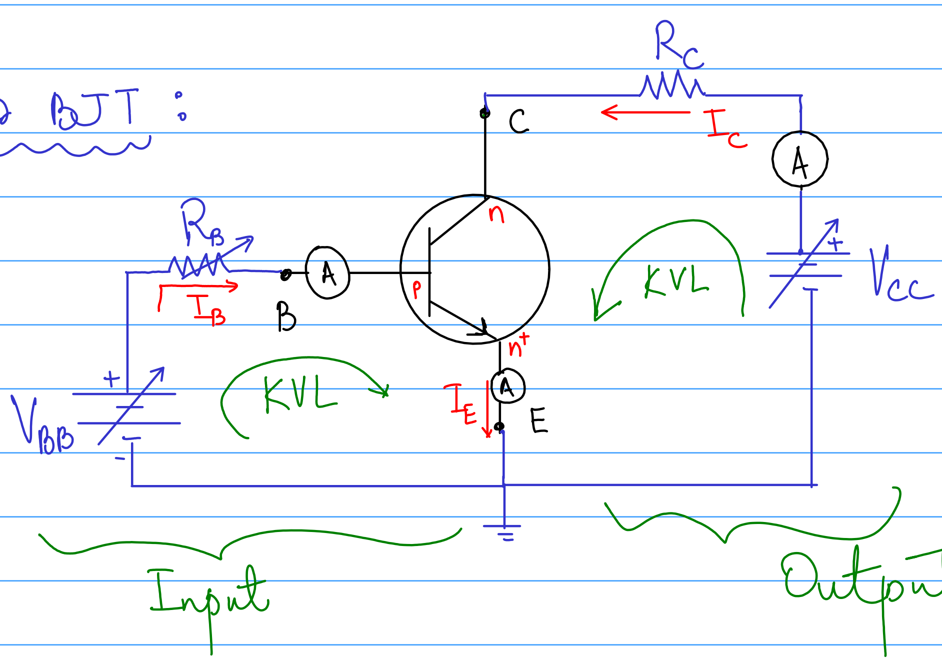
$\beta_{DC} = \dfrac{I_C}{I_B} \Rightarrow I_C = \beta_{DC} \cdot I_B$

Transistor DC Model:



Equivalent ckt model.

Biased BJT:



$V_{CC} = I_C R_C + V_{CE}$

$\underset{\sim}{I_C} = \dfrac{V_{CC} - V_{CE}}{R_C}$

$V_{BB} = I_B \cdot R_B + V_{BE} \Rightarrow \underset{\sim}{I_B} = \dfrac{V_{BB} - V_{BE}}{R_B}$