Chapter 5
雙極接面電晶體

5.1 基本雙極接面電晶體

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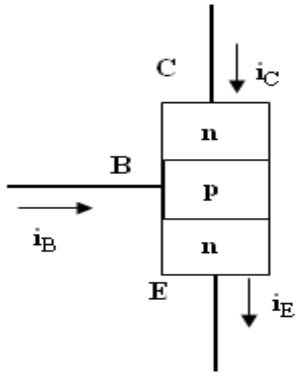
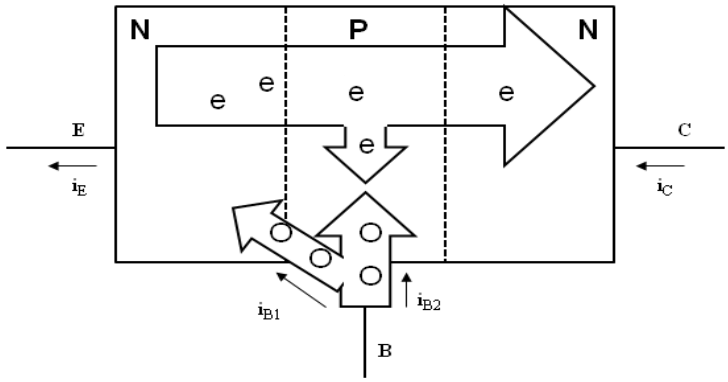


1. 改變V_{BE}的大小，可控制i_E的電流大小
2. 改變 BE 間的接面面積，亦可改變i_E的電流大小
3. 不同材質(I_S、V_T)，亦可改變i_E的電流大小

◆ 濃度: Emitter(射極)→$10^{19}cm^{-3}$

Base(基極)→$10^{17}cm^{-3}$

Collector(集極) →$10^{15}cm^{-3}$



◆ O:電洞

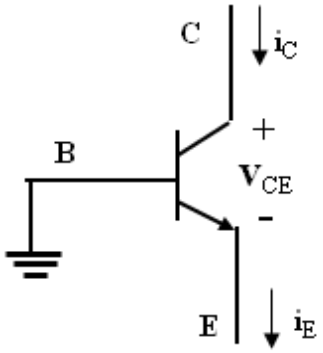
e:電子

◆ $i_{B1} \propto e^{\frac{V_{BE}}{V_T}}$

$i_{B2} \propto e^{\frac{V_{BE}}{V_T}}$

$$i_E = I_S\left(e^{\frac{V_{BE}}{nV_T}} - 1\right) \cong I_S\left(e^{\frac{V_{BE}}{V_T}} - 1\right)$$

◆ 第一種共基極電流增益(Common-Base Current Gain)

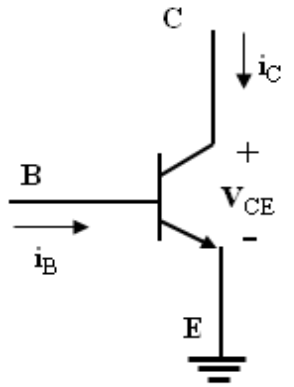


$$i_E = I_S e^{\frac{V_{BE}}{V_T}}$$

$$i_C = \alpha F i_E = \alpha F I_S e^{\frac{V_{BE}}{V_T}}$$

$$\frac{I_{out}}{I_{in}} = \frac{i_C}{i_E} = \frac{\alpha F I_S e^{\frac{V_{BE}}{V_T}}}{I_S e^{\frac{V_{BE}}{V_T}}} = \alpha F$$

◆ 第二種共射極電流增益(Common-Emitter Current Gain)



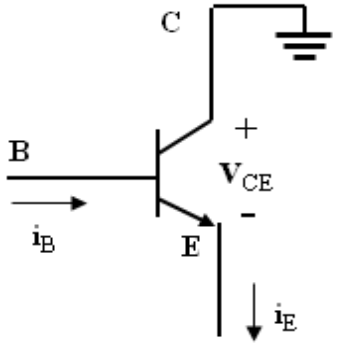
$$i_B \propto e^{\frac{V_{BE}}{V_T}}$$

$$i_C = \alpha F i_E = \alpha F I_S e^{\frac{V_{BE}}{V_T}}$$

$$\frac{I_{out}}{I_{in}} = \frac{i_C}{i_B} = \frac{\alpha F I_S e^{\frac{V_{BE}}{V_T}}}{i_B} = \beta F$$

$$i_B = \frac{\alpha F I_S e^{\frac{V_{BE}}{V_T}}}{\beta F} = \frac{i_C}{\beta F}$$

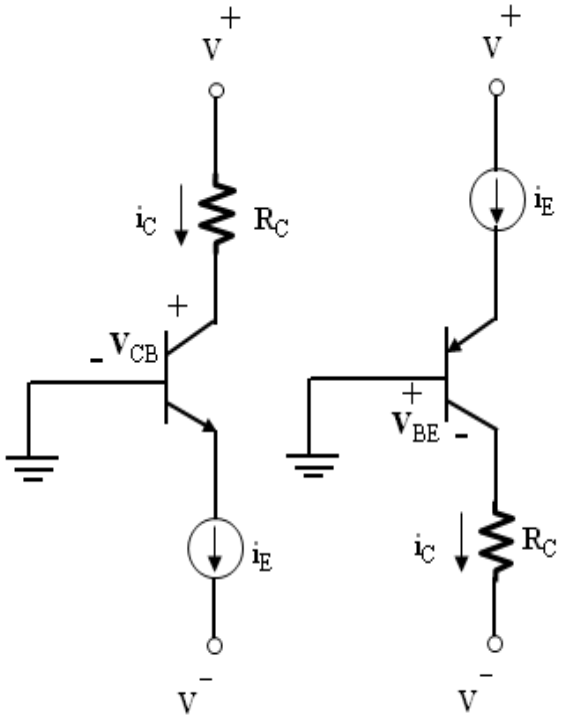
◆ 第三種共集極電流增益(Common-Collector Current Gain)

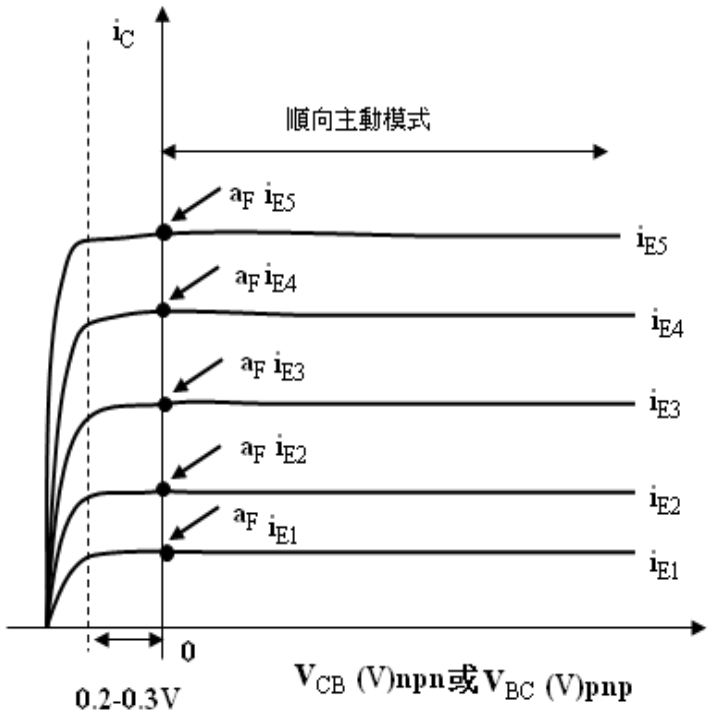


$$\frac{I_{out}}{I_{in}} = \frac{i_E}{i_B} = \frac{I_S e^{\frac{V_{BE}}{V_T}}}{\frac{\alpha F I_S e^{\frac{V_{BE}}{V_T}}}{\beta F}} = \frac{\beta F}{\alpha F}$$

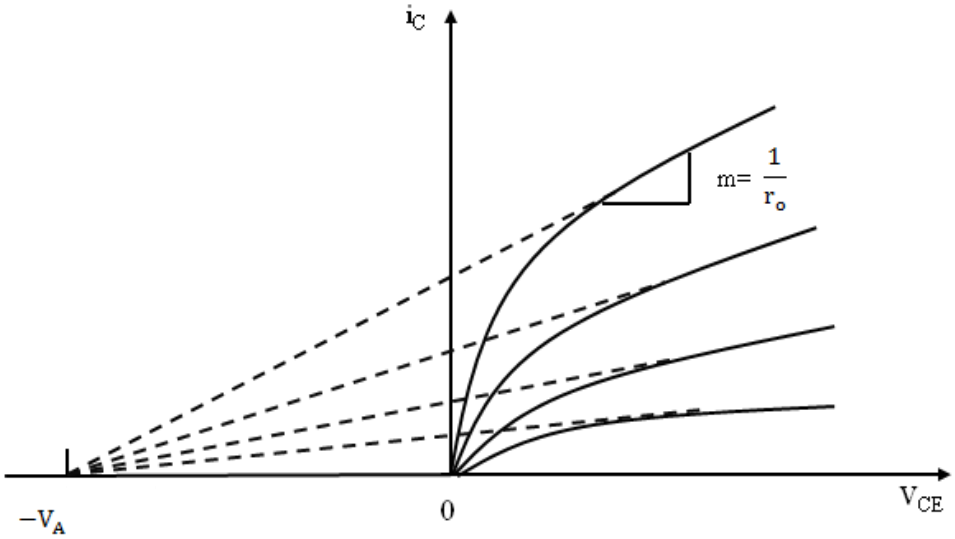
$$i_E = \frac{\beta F}{\alpha F} i_B$$

◆ 以共基極電路組態(Common-Base Circuit)為例
I-V 特性曲線(電流-電壓特性曲線)





◆ 厄利效應(Early Effect)



由i_C、V_{BE}關係得知，此為從 Collector 端視入的輸出電阻(擴散電阻)

$$\frac{1}{r_o} = \frac{\partial i_C}{\partial V_{BE}} | V_{BE} = C$$

$$\frac{1}{r_o} \cong \frac{I_C}{V_A}$$

$$r_o = \frac{V_A}{I_C}$$