

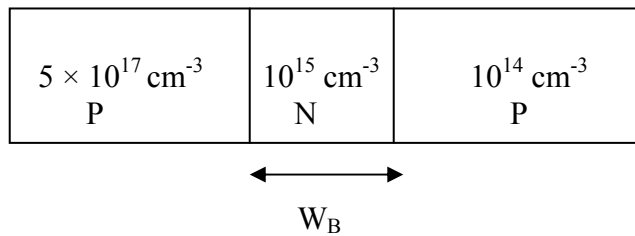
**ECSE-2210 Microelectronics Technology**  
**Class Activity 19 – Solution**

- The base region in a BJT is narrow. What is the precise definition of “narrow”?  
 The carriers emitted by the emitter need to reach the collector before they can recombine in the base. Therefore the width of the base has to be smaller than the diffusion length of the carriers. So, narrow base means the width of the base is small compared to the minority carrier diffusion length in base.
- Why is it necessary for the base region of a BJT to be narrow?  
 If the base is not narrow, then the structure is similar to back-to-back connected diodes. The E-B junction will not have any effect on the C-B junction. No transistor action will happen.
- Complete the table below by indicating the polarity (+ or -) of the input and output voltages associated with each of the four biasing modes for the npn transistor.

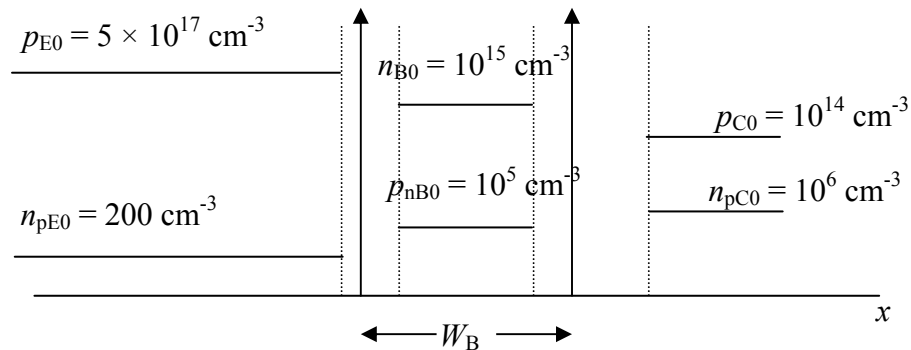
**npn BJT**

Mode	$V_{BE}$	$V_{BC}$
Active	+	-
Inverted	-	+
Saturation	+	+
Cutoff	-	-

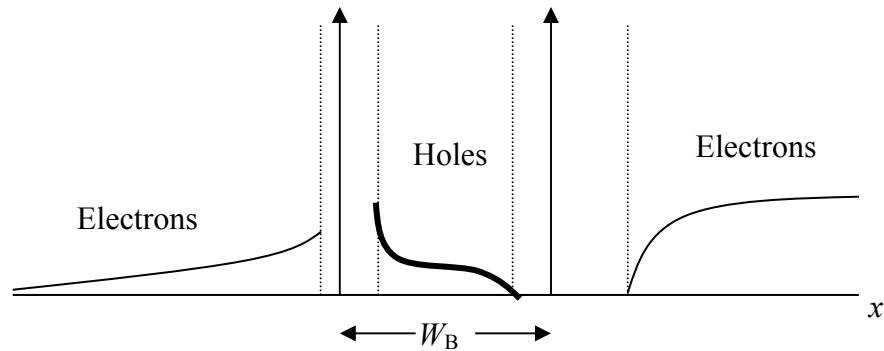
- Consider a Si pnp BJT with  $N_{AE} = 5 \times 10^{17} \text{ cm}^{-3}$ ,  $N_{DB} = 10^{15} \text{ cm}^{-3}$ , and  $N_{AC} = 10^{14} \text{ cm}^{-3}$ .



- Calculate the equilibrium majority and minority carrier concentrations in the emitter, base and collector of the transistor. Plot them in the figure below.

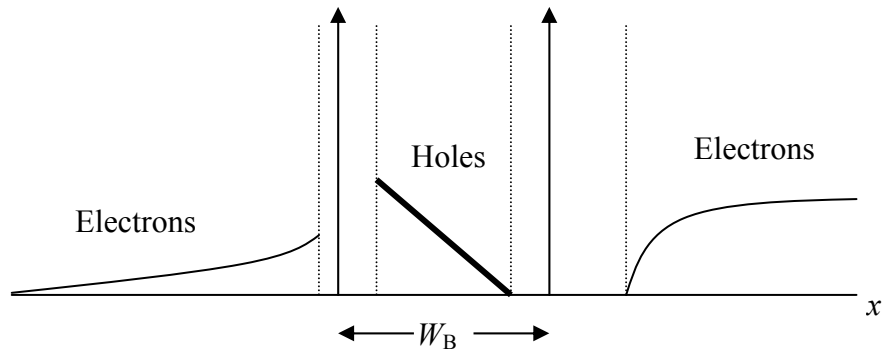


- b. Roughly sketch (qualitative) the carrier distribution (both holes and electrons) in the base, emitter and collector of this transistor under forward active biasing mode when  $W/L_p \gg 1$ .



When  $W/L_p \gg 1$ , corresponds to a back to back diode where, there is no transistor action. This is just two p-n junctions where the emitter base is forward biased and the collector base is reverse bias. But the carriers injected by the emitter, recombine in the base itself and there is no transistor action.

- c. Repeat part b when  $W/L_p \ll 1$ .



When  $W/L_p \ll 1$ ; the width of the base is smaller than the minority carrier diffusion length. Now, the carriers injected by the emitter reach the collector because the width of the base is small and the carriers are not allowed to recombine. Instead they are swept away by the reverse bias of the collector base junction leading to the required transistor action.

5. What are the typical values for  $\gamma$ ,  $\alpha_T$ ,  $\alpha_{dc}$  and  $\beta_{dc}$ ? What do these symbols stand for?  
 Typical values are 0.99, 0.99, 0.98 and 50 respectively.

$\gamma$  - Emitter Injection Efficiency

$\alpha_T$  - Base Transport Factor

$\alpha_{dc}$  - dc current gain in the common base mode

$\beta_{dc}$  - dc current gain in common emitter mode