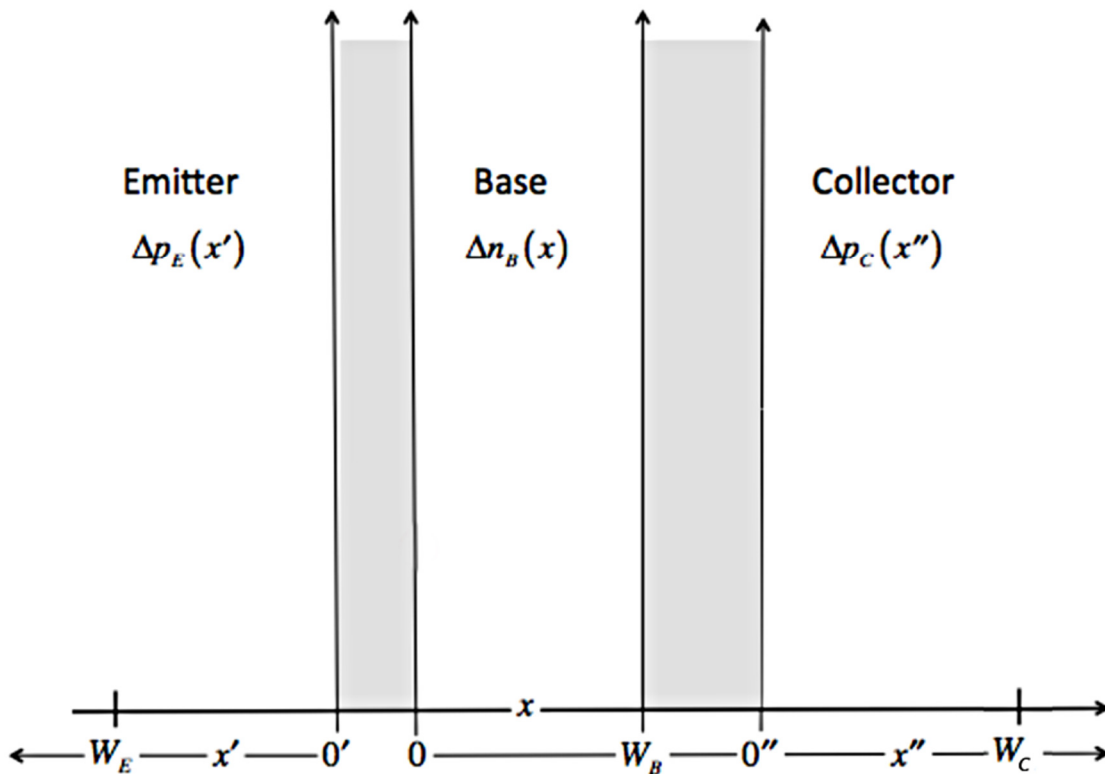


ECE 305 – Spring 2018

Homework 12 – Due Tuesday, April 24, 2018 at 12:00 PM in class (or in EE 326B)

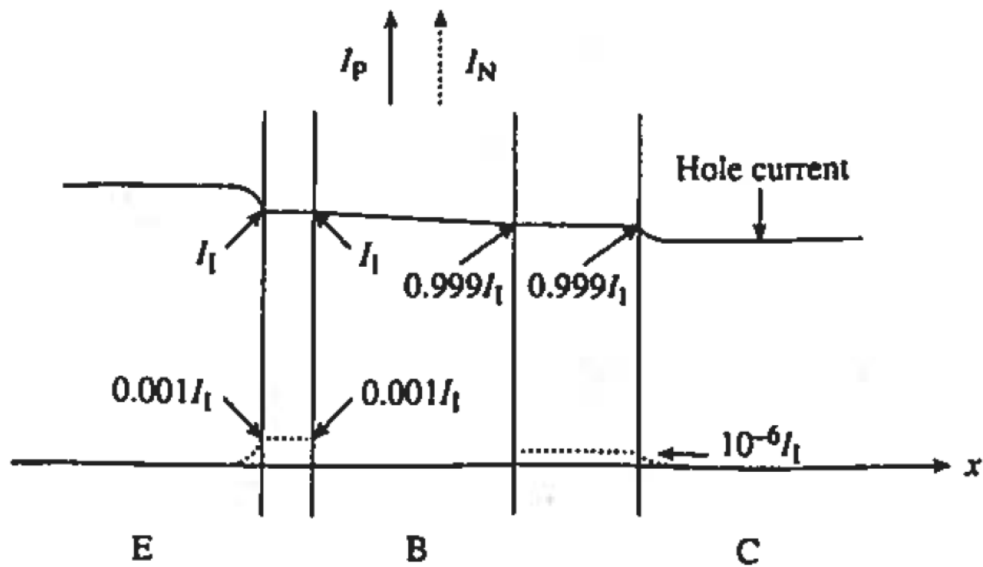
- Consider the crystalline silicon-based *npn* bipolar junction transistor (BJT) depicted below. The shaded regions represent the depletion regions, while white regions may be treated as having zero electric field (in the depletion approximation). Assume the system is in equilibrium, with doping concentrations  $N_{D,E}=5 \cdot 10^{17}/\text{cm}^3$ ,  $N_{A,B}= 10^{15}/\text{cm}^3$ ,  $N_{D,C}= 10^{14}/\text{cm}^3$ , and each region is 'short' (i.e., minority carrier diffusion lengths greatly exceed the physical thickness of each region).



- Calculate the excess minority carrier concentration in all white regions: i.e., from  $x'=W_E$  to  $x'=0'$ ; from  $x=0$  to  $x=W_B$ ; and from  $x''=0''$  to  $x''=W_C$ .
- Sketch the excess minority carrier concentration in all white regions: i.e., from  $x'=W_E$  to  $x'=0'$ ; from  $x=0$  to  $x=W_B$ ; and from  $x''=0''$  to  $x''=W_C$ .
- What would be qualitatively different about these sketches if  $V_{BE}=0.35$  V and  $V_{BC}=0.25$  V? What regime of operation would this correspond to? **Hint:** compare to Exercise 11.3.

*Continued on next page...*

2. The electron and hole currents inside a pnp BJT biased in the active mode are plotted below. All the currents are referenced to  $I_1$ , defined here as the hole current injected into the base.



Determine the following quantities:

- The emitter efficiency  $\gamma$ .
- The base transport factor  $\alpha_T$ .
- The common emitter DC current gain  $\beta_{dc}$ .
- The base current  $I_B$ .
- For this transistor, is the recombination-generation current arising from the depletion regions negligible, as is assumed in the ideal transistor analysis? Justify your answer.