

## Homework #11

### Reading and Watching and Doing

- [Watch YouTube videos for week 14.](#)
- Kasap 6.1-6.5

### Problems

#### 1. ***pn* Junction (Kasap 6.1 – tip: review Kasap Chapter 5.5)**

Consider an abrupt Si  $pn^+$  junction at room temperature that has  $10^{15}$  acceptors  $\text{cm}^{-3}$  on the  $p$ -side and  $10^{19}$  donors on the  $n$ -side. The minority carrier recombination times are  $\tau_e \approx 500$  ns for electrons in the  $p$ -side and  $\tau_h = 2.5$  ns for holes in the  $n$ -side. The cross-sectional area is  $1 \text{ mm}^2$ . Assuming a long diode, calculate the current,  $I$ , through the diode at room temperature when the forward voltage,  $V$ , across it is  $0.6 \text{ V}$ . What are  $V/I$  and the incremental resistance ( $r_d$ ) of the diode and why are they different? [Hints: use the Einstein relationship between mobility and diffusion coefficient. Use Fig. 5.19 to determine the mobility values based on doping. Use the appropriate mobility for the minority carrier in each region.]

#### 2. **Si *pn* junction (Kasap 6.2)**

Consider a long  $pn$  junction diode at room temperature with an acceptor doping,  $N_a$ , of  $10^{18} \text{ cm}^{-3}$  on the  $p$ -side and donor concentration of  $N_d$  on the  $n$ -side. The diode is forward biased and has a voltage of  $0.6 \text{ V}$  across it. The diode cross-sectional area is  $1 \text{ mm}^2$ . The minority carrier recombination time,  $\tau$ , depends on the dopant concentration,  $N_{\text{dopant}} (\text{cm}^{-3})$ , through the following approximate relation

$$\tau \approx \frac{5 \times 10^{-7}}{(1 + 2 \times 10^{-17} N_{\text{dopant}})}$$

The dependence of the drift mobility on the dopant concentration is given by Equation 5.94 and Table 5.4

- Suppose that  $N_d = 10^{15} \text{ cm}^{-3}$ . Then the depletion layer extends essentially into the  $n$ -side and we have to consider minority carrier recombination time,  $\tau_h$ , in this region. Calculate the diffusion and recombination contributions to the total diode current. What is your conclusion?
- Suppose that  $N_d = N_a = 10^{18} \text{ cm}^{-3}$ . Then  $W$  extends equally to both sides and, further,  $\tau_e = \tau_h$ . Calculate the diffusion and recombination contributions to the diode current. What is your conclusion?

For both (a) and (b), first determine the diffusion component of the diode current, and then determine the recombination component.

#### 3. **Complete and Submit the [Final Exam Team Charter](#).**