

ECE 3030 Spring 2025 HOMEWORK ASSIGNMENT NO. 6

Due: Wednesday, March 5th 11:59 pm upload to Carmen 3030 SpeedGrader

1. (20 pts) An abrupt Si p-n junction has $N_a = 10^{17} \text{ cm}^{-3}$ on the p side and $N_d = 10^{16} \text{ cm}^{-3}$ on the n side. At 300 K, (a) calculate the contact potential of the Si device, (b) calculate the contact potential for similarly doped Ge and GaAs junctions. (c) Compare these contact potentials: what trend do you notice? (d) Would you expect a large or a small contact potential for GaN? Why?
2. (20 pts) An abrupt Si p-n junction has $N_a = 10^{18} \text{ cm}^{-3}$ on one side and $N_d = 5 \times 10^{15} \text{ cm}^{-3}$ on the other.
(a) Calculate the Fermi level positions at 300 K in the p and n regions.
(b) Draw an equilibrium band diagram for the junction and determine the contact potential V_0 from the diagram.
(c) Compare the results of part (b) with V_0 as calculated from S&B eq.(5-8).
3. (20 pts) The junction in problem 2 has a circular cross section with diameter of 4 μm . Calculate x_{n0} , x_{p0} , Q_+ , and \mathcal{E}_0 for this junction at equilibrium (300 K). Sketch $\mathcal{E}(x)$ and charge density to scale, as in S&B Fig. 5-12.
4. (20 pts) An abrupt Si p-n junction has the following properties at 300 K:

<u>p-side</u>	<u>n-side</u>	$A = 10^{-4} \text{ cm}^2$
$N_a = 10^{15} \text{ cm}^{-3}$	$N_d = 10^{17} \text{ cm}^{-3}$	
$\tau_n = 10 \mu\text{s}$	$\tau_p = 0.01 \mu\text{s}$	
$\mu_n = 1300 \text{ cm}^2/\text{V-s}$	$\mu_p = 250 \text{ cm}^2/\text{V-s}$	
$\mu_p = 450 \text{ cm}^2/\text{V-s}$	$\mu_n = 700 \text{ cm}^2/\text{V-s}$	

(a) Calculate the reverse saturation current I_0 , and find the current I with a forward bias of 0.6 V.
(b) Find the electron injection efficiency I_n/I , at $x_p = 0$.
5. (20 pts) Assume that an abrupt Si p-n junction with area 10^{-4} cm^2 has $N_a = 10^{17} \text{ cm}^{-3}$ on the p side and $N_d = 10^{17} \text{ cm}^{-3}$ on the n side. The diode has a forward bias of 0.7 V. From S&B Fig. 3-23, $\mu_n = 700$ and $\mu_p = 250 \text{ cm}^2/\text{Vs}$. Assuming $\tau_n = \tau_p = 1 \mu\text{s}$, plot I_p and I_n versus distance on a diagram such as S&B Fig. 5-17, including both sides of the junction. Neglect recombination within W . Provide computer plot.

Suppose $N_d = 10^{18} \text{ cm}^{-3}$ and $N_a = 10^{17} \text{ cm}^{-3}$ while D and τ values remain unchanged. Show how the plot changes.(10 pt. Bonus)
6. Extra Credit (10 pts): For Prob. 5, plot $\delta n(x_p)$ and $\delta p(x_n)$. Provide computer plot.