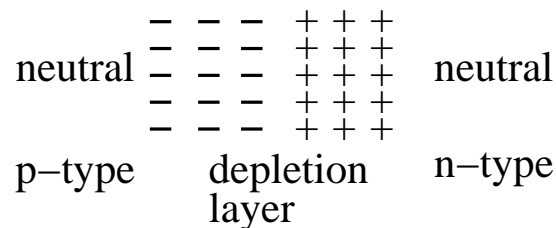


PROBLEM SET 9

Reading: Ashcroft and Mermin (AM) Chapter 29

1. A p-n junction in equilibrium has a charge distribution in the depletion region as shown:



The density of acceptors in the p side is N_A and the density of donors on the n side is N_D and the thickness of the depletion regions are d_n and d_p .

- (a) If $N_D = N_A = 10^{17} \text{ cm}^{-3}$ find the total thickness of the depletion region $d = d_p + d_n$ for a junction in silicon. Assume a Si band gap and that the dopings are high enough that the valence band edge is near μ in the p region and the conduction band edge is near μ in the n region.
 - (b) Find the thickness $d = d_p + d_n$ if a reverse bias voltage of 5.0 volts is applied.
2. A certain fictitious semiconductor has nondegenerate valence and conduction bands centered at $\vec{k} = 0$ (i.e., like InSb, but with only one hole band). At room temperature its parameters are the following: band gap = 0.5 eV, $m_e^* = m_v^* = 0.1 m$, $\epsilon = 20$, electron mean free path = hole mean free path = 10^2 \AA , recombination time = 10^{-3} secs. To form a pn junction it is doped with a concentration of 10^{22} m^{-3} acceptor impurities on one side and 10^{22} m^{-3} donor impurities on the other. Assuming that at room temperature all donors and acceptors are ionized, calculate

- (a) the diffusion coefficient (identical for electrons and holes)
- (b) the diffusion length
- (c) the minority carrier density on each side
- (d) the saturation current density
- (e) the current density at a bias of 0.05 V in (i) the forward, and (ii) the reverse direction

[Note: Parts of this question refer to material covered in Ch. 28 of AM as well as that covered in pages 601-611 of Ch. 29.]