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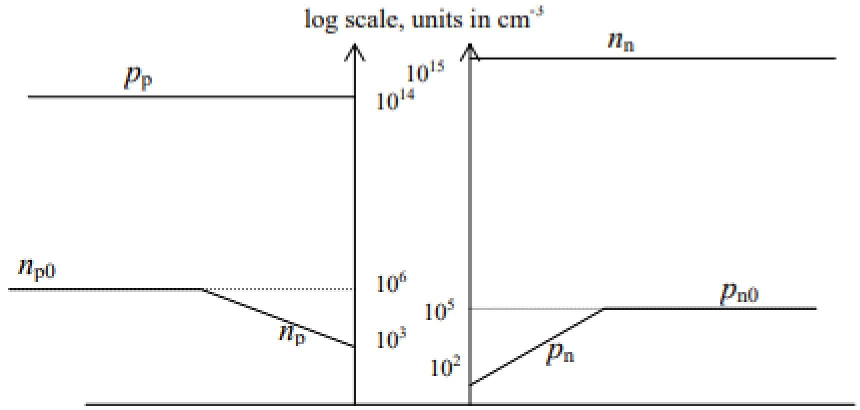
Microelectronics HW6

Reading list: Chapter 5 (pages 195 - 223. Ignore section 5.2.5).

1. (Problem 6.10 in text). The figure below is a dimensioned plot of the steady state carrier concentration inside a p-n junction diode at 300 K.



   a. a. Is the diode forward biased or reverse biased? Explain.

Reverse because the concentrations dip down near the depletion region, stopping any current flow

   b. b. Do low-level injection conditions prevail in the quasi-neutral regions? Explain.

Yes, there is still a small amount of minority carriers, Delta p_n << n_n and Delta n_p << p_p

   c. c. What are the p-side and n-side doping concentrations?

10^6 cm^-3 and 10^5 cm^-3

   d. d. Determine the applied voltage, VA.

VA=kT/q ln(np/ni^2) = .025 ln(10^17/10^20) = -0.1727V

2. An abrupt silicon p-n junction diode has the following characteristics.

   P-side: N-side:

   NA = 10^16 cm-3 ND = 4 × 10^16

   μn = 1000 cm2 /Vs μp = 350 cm2 /Vs

   τp = 10-7sec τp = 10-7sec

   Area A = 10-2 cm2

   Calculate the following (a-d) quantities:

   a. (a) Reverse saturation hole current component.

Jp=qDp/Lp (e^(VA q/kT)-1)
Dp=up * kT/q = 350*.025
Lp=sqrt(Dp*tau_p)
Jp=-1.925*10^-17

   b. (b) Reverse saturation electron current component.

Jn=qDn/Ln (e^(VA q/kT)-1)
Dn=un * kT/q = 1000*.025
Ln=sqrt(Dn*tau_n)
Jn=-3.255*10^-17

   c. (c) Minority carrier concentrations at the edge of the depletion layer, np(0) and pn(0), for a forward voltage of 0.6 V.

I've spent hours here and I'm just lost…

   d. (d) Electron and hole current for the bias condition of (c).

   e. (e) Make a rough sketch of the minority carrier concentration profile in the quasi-neutral regions for the bias condition of (c).

   f. (f) Suppose the forward voltage is increased to a value such that the injected minority carrier concentration at the n-side depletion layer edge is equal to the doping concentration (i.e., 4 × 1016 cm-3). Calculate this forward voltage. Compare this voltage to the built-in voltage. Comment on the results.

   g. (g) Suppose the critical electric field at breakdown for this diode is 106 V/cm, and then calculate the breakdown voltage of this diode.