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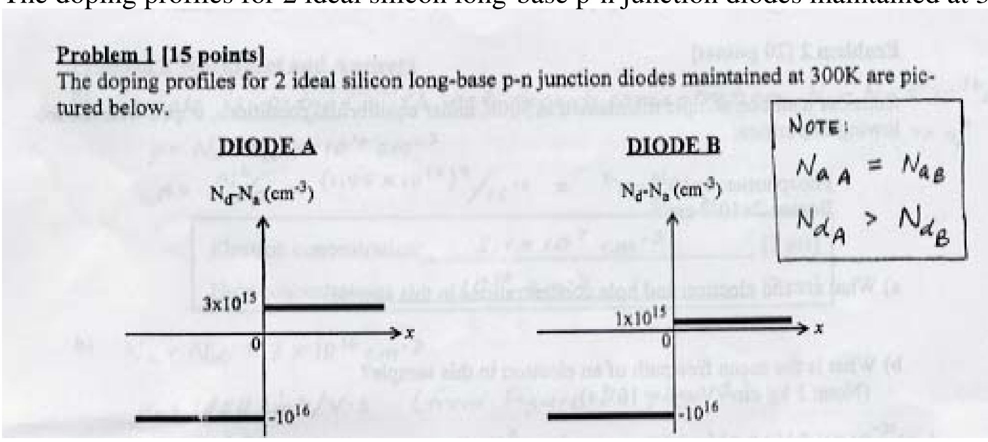
EE 130 Fall 1997
Midterm 1 Solutions
Professor King

Problem #1

The doping profiles for 2 ideal silicon long-base p-n junction diodes maintained at 300k are pictured below.



The minority carrier lifetimes in the quasi-neutral regions (tau_n, tau_p) are the same for these 2 diodes.

Answer the following questions (circle the correct choice):

a) The magnitude of the built-in potential in Diode A is LARGER THAN the magnitude of the built-in potential in Diode B.

b) The saturation current of Diode A is SMALLER THAN the saturation current of Diode B.

c) The reverse breakdown voltage of Diode A is SMALLER THAN the reverse breakdown voltage of Diode B.

d) The minority carrier diffusion length on the n-type side is SMALLER in Diode A as compared with Diode B.

e) For a given forward bias (Va > 0), the excess hole density at the edge of the depletion region on the n-type side, p_n(x_n), will be SMALLER in Diode A as compared wtih Diode B

Problem #2

Consider a silicon sample maintained at 300K under equilibrium conditions, doped with the following impurities:

Phosphorus: 1*10^16 cm^-3
Boron: 2*10^16 cm^-3

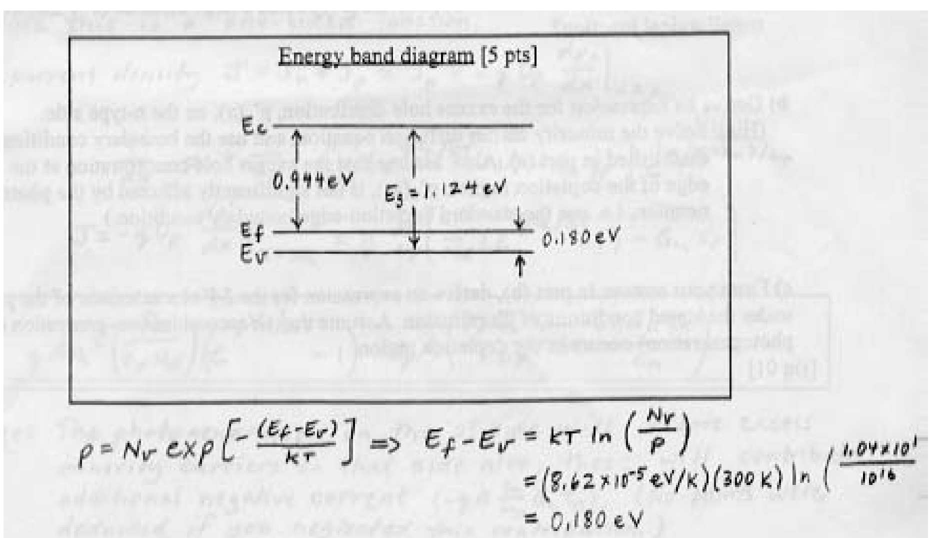
a) p = Na-Nd = 10^16 cm^-3
n= ni^2/p = (1.45 * 10^10)^2/10^16 =

Electron concentration: 2.1 * 10^4 cm^-3
Hole Concentration: 10^16 cm^-3

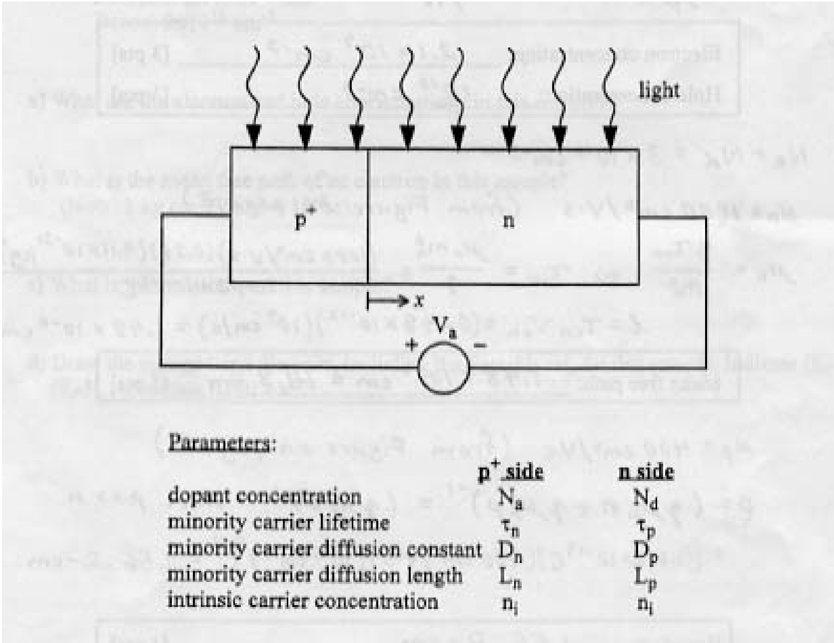
b) Na + Nd = 3 * 10^16 cm^-3
mu_n = 1000 cm^2/V . S (From figure on page 2)
mu_n = q*tau_cn/m_n* => tau_cn = mu_n(m_n*)/q = 0.148 ps
l = (tau_cn)v_th = 1.48 * 10^-6 cm

Mean free path: 1.48 * 10^-6 cm = 14.8 nm

c) mu_p = 400 cm^2/V . s
rho = (q(mu_n)n + q(mu_p)p)^-1 ~= (q(mu_p)p)^-1 = 1.56 Omega - cm

d) 

Problem #3



a) far away from junction p_n(x -> infinity): G_L(tau_p)

b) since p_n (infinity) is finite and equal to G_L(tau_p), A2 = 0, and A3 = G_L(tau_p)
p_n(x_n) = A1 + G_L(tau_p) = (ni^2/Nd)(e^(qVa/kt) - 1)

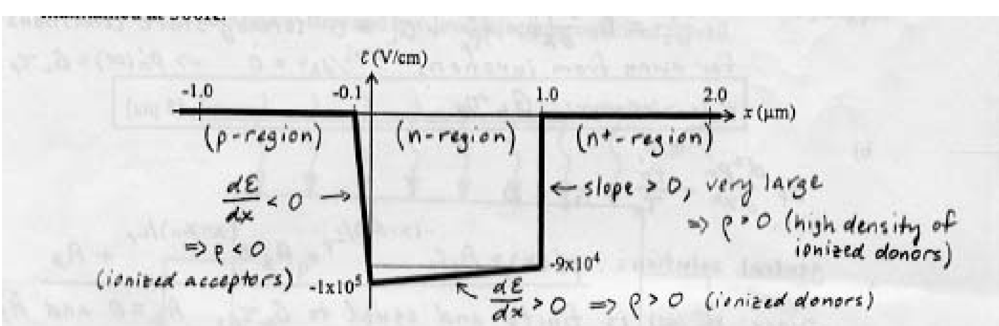
p_n(x) = [(ni^2/Nd)(e^(qVa/kt) - 1) - G_L(tau_p)]e^-(x-x_n)/Lp + G_L(tau_p)

c) Since this is a one-sided junction,
current density J = Jn + Jp ~= Jp = -qDp(dp/dx)

I = -qAni^2(Dp/LpNd)(e^qVa/kT - 1) - qA(DpG_L(tau_p)/Lp + DnG_L(tau_n)/Ln)

Note: The photogeneration on the p+ side will create excess minority carriers on that side also; these will contribute additional negative current (-qA(dn/ln)G_L(tau_n)).

Problem #4



No other solutions available