Test 2 - EE 5340/4329 (print last name)____________________________ (print first name)___________________________

Thursday, November 2, 2000

80 minutes allowed (student #) ________ - _____ - ___________(e-mail)______________________________________

Instructions: Do your own work. Open book (including class handouts), calculator allowed, no notes. Each part is worth [x] points**. Explicitly state definitions and assumptions that you use. Where possible, calculate parameters rather than read them from a graph**. Do all work on this paper. Show all calculations, making numerical substitutions and giving numerical results where possible. Write answers in space given. Unless stated otherwise, T = 300K and V_t = 25.852 mV.

Notes: (1) Unless given other wise, assume the material is silicon at 300K. (2) Use the analytical mobility relationships given in Casey's text on pages 74-74 and 162-163. (3) When minority carrier lifetimes are required, use the relationship that τ_{min} = [45E-6 sec]÷[1+7.7E-18*N+4.5E-36*N^2], where N = the total impurity concentration.

1. A planar p-n junction has 7E15/cm^3 phosphorous doping on one side and 3E18/cm^3 boron on the other side. The p-side is 0.5E-4 cm thick and the n-side is 5E-4 cm thick. **a.**First, solve for the zero-voltage depletion thickness.

a. [5] W = _____________________. **b.**Next, find the dimension of the charge-neutral region on the n-side for zero-voltage.

b. [5]$x_{n,CNR}$ = ______________________. **c.**Next, find the dimension of the charge-neutral region on the p-side for zero-voltage.

c. [4]$x_{p,CNR}$ = ______________________. **d.**Next, find the minority carrier diffusion length on the n-side.

d. [5] L_p = ____________________. **e.**Next, find the minority carrier diffusion length on the p-side.

e.[5] L_n = ____________________. **f.**Next, find the saturation current density for hole diffusion.

f.[5] $J_{s,p}$ = ____________________. **g.**Next, find the saturation current density for electron diffusion.

g.[5] $J_{s,n}$ = ____________________. **h.**Next, find the minority carrier concentration at the n-edge of the depletion region when V_a = 750 mV.

h.[5] $p_n(0)$= ____________________. **i.**Next, find the minority carrier concentration at the p-edge of the depletion region when V_a = 750 mV.

i.[5] $n_p(0)$= ____________________. **j.**Next, find the diode current density when V_a = 600 mV.

j.[5] J = _____________________. **k.**Next, find the reverse breakdown voltage for this diode.

k.[5] BV = _____________________.

2. An ideal n-Si (N_d = 3E16) to gold Schottky-barrier diode is to be analyzed. **a.**First, calculate the barrier for flow of electrons from the metal into the silicon.

a.[5] ϕ_{Bn} = _________________. **b.**Next, calculate the barrier for flow of electrons from the silicon into the metal.

b.[5] V_{bi} = _____________________. **c.**Next, calculate the electron concentration at the metal-silicon interface.

c.[5] n_s = _____________________. **d.**Next, calculate the zero-volt depletion width.

d.[5] W = ____________________.

3. A planar npn bipolar junction transistor is to be fabricated with the following parameters:

emitter charge neutral width = 0.5E-4 cm, $N \equiv N_d - N_a$ = 1E18 cm^3,

base charge neutral width = 0.5E-4 cm, N = -1E16 cm^3, and

collector charge neutral width = 2E-4 cm, N = 1E15 cm^3

(Unless otherwise directed, assume the same width values for all biases.) **f.**First, calculate the emitter efficiency.

a.[5] γ = __________________. **b.**Next, calculate the base transport factor.

b.[5] α_T = __________________. **c.**Next, calculate the base transit time.

c.[5] τ_{tr} = __________________. **d.**Next, calculate the base-emitter voltage for the onset of high level injection of minority carriers into the base.

d.[5] VKF = __________________.