ECE113A Fall 2003 **2nd Midterm Exam** Name:_____

11-10-2003 ID no.:_____

Sec.A: Peter Burke 10:00 to 10:50 am

PROBLEM ONE: (50 points)

1) For a Si p-n diode at 300 K, with no applied voltage, with $N_A = 10^{19}$ cm^{-3}, and $N_D = 10^{16}$ cm^{-3}
   a. Calculate V_{bi} in units of V (15 points). No partial credit.

0.88 – 0.91 V full credit.

Else none.

PROBLEM ONE: (*continued*)

b. Calculate x_p in units of μm (10 points). No partial credit.

$3.3 - 3.5 \times 10^{-4}$ μm Full credit.

Else 0.

Express answer in wrong units, no credit.

Express correct answer in cm but wrong answer in μm, no credit.

If you give more than one answer in μm and your answers are inconsistent, no credit. After all, there is only one correct answer.

c. Calculate x_n in units of μm (10 points). No partial credit.

0.33 - 0.35 μm Full credit.

Else 0.

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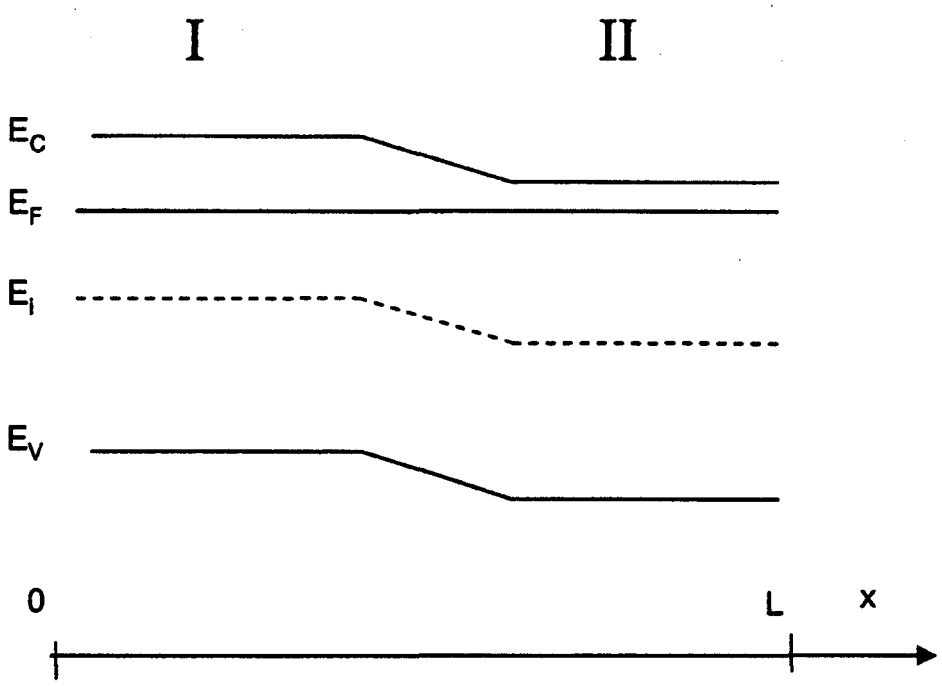
PROBLEM TWO: (50 points)



2) For the band diagram shown above,

a. Is region I p-type or n-type? (5 points)

All or nothing

b. Is region II p-type or n-type? (5 points)

All or nothing

c. Which region (I or II) has higher majority carrier density? (5 points)

All or nothing.

d) Points off if you get right answer but also say something that is irrelevant but true.
5 pts. if you say probability higher or F(E) higher or g(E) x F(E) higher but don't say $n = \int dE\, F(E) g(E)$ higher.
No credit if you density of states different.
Points off if you have correct answer and incorrect statements.

d. Why for c? (10 points)

10 pts. for E_F closer to E_C so n higher
or $n = N_C e^{(E_F - E_C)/kT}$ or $n = n_i e^{(E_F - E_i)/kT}$ so n higher.

Wrong answer c ⇒ no credit'd.
Wrong answer b ⇒ no credit'd.
Wrong answer a ⇒ no credit'd.

5 pts. for eqn. only, but don't say n higher.

PROBLEM TWO: (*continued*)

e. Which region (I or II) has higher minority carrier density? (5 points)

All or nothing.

f. Why for e? (10 points)

1) $n_P = n_i^2$
2) $p = n_i e^{(E_i - E_F)/kT}$
3) $p = N_V e^{(E_V - E_F)/kT}$

10 pts. if you say P higher because either

5 pts. if you only quote the equations (1 a 2 or 3).

Wrong answer a => no credit F
Wrong answer b => no credit F.
Wrong answer c => no credit F.

g. Sketch the electrostatic potential (V) inside the semiconductor as a function of x. (10 points)

10 pts V constant LHS, RHS, and V line, positive slope between.
5 pts " " " " " "smooth curve" " "

h. Sketch the electric field (ε) inside the semiconductor as a function of x. (10 points)

10 pts. $\mathcal{E}=0$ LHS, RHS $\mathcal{E}$ negative, constant between.
3 pts. " " " " positive, " " .
5 pts. " " " " negative, smooth curve " .
0 pts Triangle of any sort.
3 pts Correct shape, don't specify if $\mathcal{E}$ positive or negative.

i. Do equilibrium conditions prevail and why? (5 points)

Must say E_F constant and yes to get 5 pts.

Else 0.