Course:	**Semiconductor Device Fundamentals**
Level:	**Undergraduate**
Module:	**B**
Test:	**B2**
Type:	**Closed Book, Closed Notes**
Note:	**Available Info/Equation Sheets**

Problem Weighting--- **T2-1...22 (a.b-6, c,d-5)**
T2-2...24 (a-8, b-16)
T2-3...24 (a-8, b,c,d,e-4 each)
T2-4...20 (5 each variable)
T2-5...10 (1 each)

MATLAB *EXTRA-CREDIT* TAKE-HOME PROBLEM

DUE: To be handed in before or at the time of the sit-down test.

The test problem answer is understood to be your own work, completed without the direct or indirect assistance of another person.

MAXIMUM EXTRA CREDIT: 2.5% added to semester test score.

PROBLEM:

Employing MATLAB, complete Problem 14.11 in the SDF[†] text. Make a plot of the $1/C^2$ vs. V_A data, with the least squares fit to the data added to the plot.

In submitting your problem solution, include a listing of the basic computational relationships, the numerical results for V_{bi}, N_D, and Φ_B, the comparison of results with Exercise 14.4 in the SDF text, the required plot, your MATLAB program, and possibly a few words of explanation.

[†] R. F. Pierret, *Semiconductor Device Fundamentals*, Addison-Wesley, Reading MA, © 1996.

T2 – 1

[Outcome–(iii)]

Score_____/22

Given an equilibrium p^+n Si ideal step junction diode at room temperature

A. What is the numerical value of V_{bi} if E_F in the p^+ Si is at E_V and E_F in the n-material is $E_G/4$ below E_c? Assume E_i is mid-gap. (6 pts)

B. What is the approximate numerical value of W, the total depletion width? (6 pts)

C. What is the numerical value of absolute value of the maximum electric field (5pts)

D. If W is made to be 10^{-6} m, and A is 10^{-8} m^2, and V_A=0, what is the numerical value of C_J in units of farads? (5 pts)

T2 – 2

[Outcome–(iii)] Score_____/24

Given an ideal p-n Si diode such that the thickness of quasi neutral regions on both sides of the junction, D, is such that D<< Lp or Ln. Also $N_A = N_D$ and $D_p = D_n$. Under forward bias minority carriers that travel farther than D on either side of the junction have a lifetime of 0.

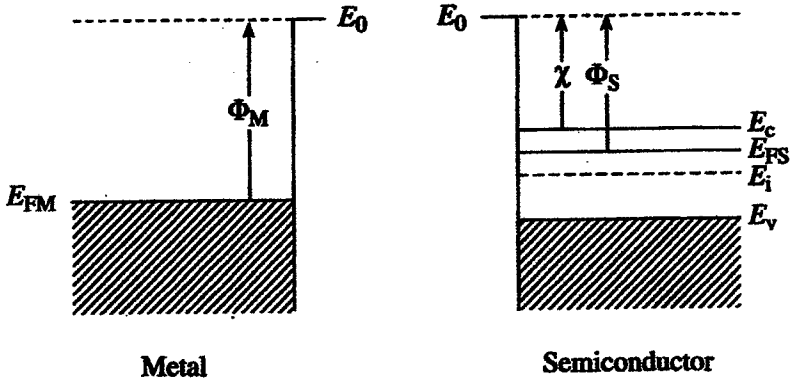
A. Yes or No. Is there any significant recombination of excess minority carriers in the quasi neutral region? Explain your answer. (8 points)

B. What is the numerical value of Jn/Jp? (16 points)

T2 – 3
[Outcome–(iv)]

Score_____/24

Consider the energy band diagrams for a metal and a semiconductor picture below.
$\Phi_M = 2.0$ev, $\chi = 1.25$ev, $\Phi_S = 1.5$ev, and $E_c - E_v = 1.0$ev.



Metal Semiconductor

(a) Draw the equilibrium energy band diagram for an ideal Metal-Semiconductor (MS) structure formed from the pictured components. **(8 points)**

(b) Is the ideal MS structure rectifying or ohmic? Explain. **(4 points)**

(c) The metal-semiconductor barrier height of the MS structure, $\Phi_B = ?$ **(4 points)**

(d) The build-in voltage of the MS structure, $V_{bi} = ?$ **(4 points)**

(e) What is "Schottky Barrier Lowering"? **(4 points)**

T2 – 4

[Outcome–(iv)] Score_____/20

The doping profile inside the semiconductor component of an MS diode is linearly graded; i.e $N_D(x) = ax$. Obtain solutions for $\rho(x)$, $\mathcal{E}(x)$, $V(x)$, and the deletion width W inside the semiconductor. **(20 points, 5 each)**

T2 – 5

[Outcome–(iv)]

Score_____/10

(10 pts) 1. Circle true or false concerning the following statements.

Indirect band gap semiconductors are not good optical emitters therefore indirect band gap materials are rarely used for making light emitting diodes.	true	false
AM0 represents the solar spectral irradiation that would be incident on the earth's surface on a clear day when the sun is at the zenith position	true	false
The wider the bandgap the larger the short circuit current is for a solar cell.	true	false
The wider the bandgap of the semiconductor used to make an LED, the shorter the wavelength of light emitted from the LED.	true	false
Photodetectors can be made from indirect bandgap material.	true	false
A pn photodetector has a higher frequency response than a pin photodetector partly because of its reduced capacitance	true	false
The narrower the bandgap, the larger the open circuit voltage for a solar cell.	true	false
In a solar cell, photons with energy greater than the bandgap generate 2 hole-electron pairs per absorbed photon in the solar cell	true	false
The purpose of texturing the surface of a solar cell is to increase the surface area of the cell.	true	false
The product of the short-circuit current, the open-circuit voltage and fill factor is the maximum power produced by a solar cell.	true	false