Alexandria University
Faculty of Engineering
Electrical Engineering Department

ECE 336: Semiconductor Devices
Sheet 5

Chapter 14:

1. An ideal rectifying contact is formed by depositing gold ($\Phi_M = 5.10$ eV) on an $N_D = 10^{15}/\text{cm}^3$ doped silicon substrate maintained at room temperature. Calculate:
    a. Φ_B
    b. V_{bi}
    c. W under equilibrium conditions.
    d. $|\varepsilon|_{max}$ in the semiconductor under equilibrium conditions.

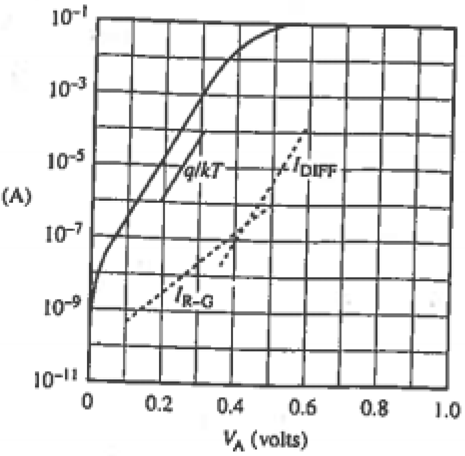
2. Construct a plot of equilibrium depletion width versus N_D doping concentration in silicon MS diodes maintained at T = 300. Vary N_D over the range $10^{14}/\text{cm}^3 < N_D < 10^{17}/\text{cm}^3$ and the curves corresponding to $\Phi_B = 0.5\text{eV}, 0.6\text{eV}$ and 0.7eV.

3. In the quasineutral portion of the semiconductor and the ohmic back contact of Schottky diodes introduce a resistance R_S in series with the current flowing across the rectifying MS junction. Graphically illustrate the effect of the series resistance on the diode I-V characteristic. Taking $I_s = 10^{-8}$A, construct a semilog plot of the forward bias I-V characteristics when $R_S = 0, 0.1\Omega, 1\Omega$ and 10Ω. Limit your plotted output to $0 < V_A < 0.6$V and $10^{-9} < I < 10^{-1}$A.

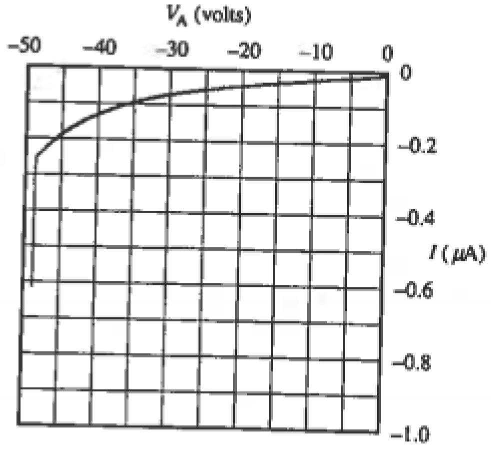
4. The minority carrier injection ratio is often cited as a quantity of interest in characterizing MS diodes. By definition, it is the number of minority carriers injected into the semiconductor per majority carrier injected from the semiconductor into the metal when the device is forward biased. Mathematically, the ratio is just I_{DIFF}/I_{TE}. I_{DIFF} and I_{TE} are respectively the diffusion and thermionic emission currents flowing in the MS diode. Estimate the minority carrier injection ratio in the MS diode when $A^* = 140\text{amps/cm}^2\text{K}^2$, $\Phi_B = 0.72$eV, $N_{D = 10}{}^{16}/\text{cm}^3$, $\tau_p = 10^{-6}$sec and T = 300K, I_{DIFF} in the given diode may be equated to the I_{DIFF} flowing in the p^+-n step junction diode with equivalent device parameters.

5. In this problem we wish to examine the magnitude and effect of Schottky barrier lowering. Paraameters will be employed similar to those of the MS diode yielding

the figure 14.6 characteristics.



(a)



(b)

a. Given a silicon MS diode with $N_D = 10^{16}/cm^3$ operating at room temperature. Compute and plot $\Delta\Phi_B$ versus V_A for $-50<V_A<0$.
b. Compute and plot $I_s(V_A)/I_s(V_A = 0)$ versus V_A for $-50<V_A<0.4$
c. Comment on the results.

6. The doping profile inside the semiconductor component of an MS diode is linearly graded; i.e., $N_D(x) = ax$.
   a. Derive solution for ρ, ε, V and W inside the semiconductor.
   b. Indicate how V_{bi} is to be determined and computed.
   c. Establish an expression for the junction depletion region capacitance.