P-N junction: Current / conductance-voltage relation, carrier distribution, diffusion capacitance

Problem - 1

Reverse saturation current, ideality factor, and room-temperature thermal voltage of a long p^+-n junction diode are 1.12pA, 1, and 0.025V, respectively. If at room-temperature, diffusion capacitance at a forward current of 0.1mA is found to be 10pF, find out hole life-time (τ_p) within the n-region.

Problem - 2

If the reverse saturation current, ideality factor, and room-temperature thermal voltage of a p-n junction are 1.12 pA, 1, and 0.0259 V, respectively, find out the room-temperature a.c. resistance of the diode at a forward current of 0.1mA.

Problem - 3

Find out the forward biased p-n junction diode current (in mA) at which its room temperature ($T = 300K$) a.c resistance is 250 Ω. Assume that the reverse saturation current is of the order of pA. Given ideality factor $\eta = 1$, Boltzmann's constant $k = 1.38 \times 10^{-23}$ J/K, electron charge $q = 1.6 \times 10^{-19}$ C.

Problem - 4

Plot diode conductance versus forward diode current assuming reverse saturation current, I_0=0.5nA and thermal voltage V_T=0.0259V.

Problem - 5

In a p-n junction diode, the diffusion length of holes in the n-side is 30 μm. If $x = 0$ is at the edge of the depletion region on the n-side and $x = W_n$ is at the n-contact, show the nature of hole concentration profile $p(x)$ from $x = 0$ to $x = W_n$ when the diode is forward biased if (a) $W_n = 2$ μm and (b) $W_n = 400$ μm.

Problem - 6

Two p-n junction diodes D1 and D2 are identical in all respects except that D1 is made of a wider bandgap material than D2. The reverse saturation current will be maximum for

(A) D1 operating at 100°C (B) D2 operating at 100°C (C) D1 operating at 30°C (D) D2 operating at 30°C

Problem - 7

Two p^+n diodes D3 and D4 having short n-regions are identical in all respects except that the width of the n-region in D3 is double that in D4. If the current in D3 is 1 mA at a forward bias of 0.6 V, what will be the current in D4 at the same bias?

Problem - 8

The point in the space charge layer at which $E_F = E_I$ is referred to as the intrinsic point. At this point, $n = p = n_i$. Show that the intrinsic point lies on the side of the space charge layer with the lower doping concentration.

Problem - 9

The hole injection efficiency of a junction is defined as I_p/I where I is the total diode current. Assuming that the junction follows the long diode equations, show that $I_p/I = 1/(1+ L_p\sigma_n/L_n\sigma_p)$, where L_n is the diffusion length of electrons in the p-region, L_p is the diffusion length of holes in the n-region, σ_n is the conductivity in the n-region and σ_p is the conductivity of the p-region.

Problem - 10

For a p^+n diode, $\mu_p = 450\ cm^2/V\text{-}s$ and $\tau_p = 1\ \mu s$ in the n-region. Calculate the widths of the n-region for which (a) $W_n \leqslant 0.1 L_p$ (i.e. a short-base diode) and (b) $W_n > 4 L_p$ (i.e. a long-base diode).

Problem - 11

Show that $I_p(x = x_n) = (Q_p/\tau_p)$ for a diode with a long n-region and $I_p(x = x_n) > (Q_p/\tau_p)$ for a diode with a short n-region, where (Q_p/q) is the total excess hole concentration in the neutral n-region. What are the physical interpretations of the above two conditions?