p-n junction: Energy-band diagram, built-in potential, depletion width, field, junction capacitance-voltage relation

Problem - 1

In an abrupt p-n junction under equilibrium, derive the expressions for (a) position-dependent electric field and (b) position-dependent potential in terms of the doping concentration in n- and p-side, temperature and other known constants.

Problem - 2

In an abrupt p-n junction under equilibrium, derive the expressions for (a) peak electric field, (b) contact (built-in) potential and (c) depletion width in terms of the doping concentration in n- and p-side, temperature and other known constants.

Problem - 3

Draw the energy band diagrams and carrier concentration plots of an abrupt p-n junction diode when the diode is (a) in thermal equilibrium, (b) forward biased by V_f and (c) reverse biased by V_r. In each figure, show the position of the Fermi level or quasi Fermi levels along with their energy difference, whichever is applicable. Also show the difference in the energies of the conduction band edges of the p-region and n-region in all the cases (built-in potential is V_{bi}).

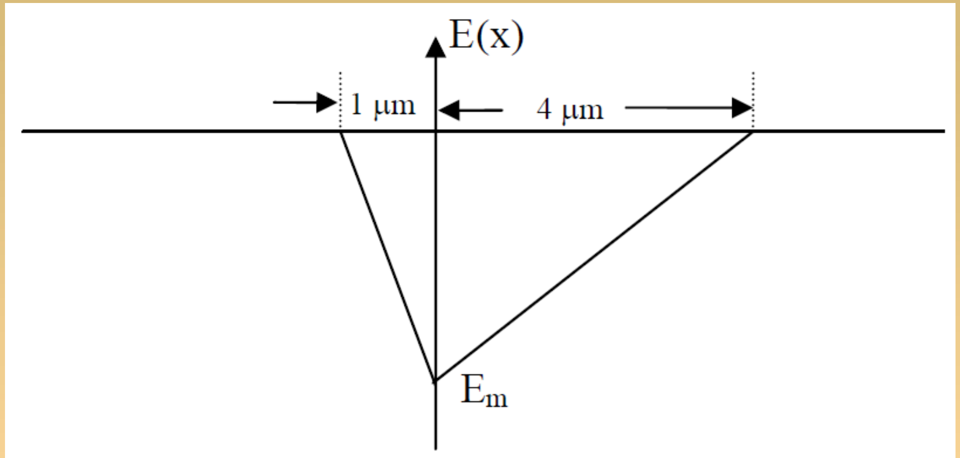
Problem - 4

Acceptor and donor concentration of an abrupt pn-junction are $N_a = 4x10^{18}/cm^3$ and $N_d = 4x10^{17}/cm^3$. Sketch (in scale) the electric field distribution from $-X_{p0}$ to $+X_{n0}$ considering the metallurgical junction at the origin. X_{p0} and X_{n0} are the penetration depth of the space charge region in p and n regions, respectively.

Problem - 5

A p-n junction under a forward bias of 0.4V has a depletion width of W = 0.1μm. Calculate the peak electric field E_{peak} in V/cm. Given the built in potential V_0 = 0.8V.

Problem - 6



The figure shows the electric field profile for a reverse biased p-n junction.

(a) If the doping concentration on the p-side is $10^{17}/cm^3$, what is the doping concentration on the n-side?

(b) If the built-in potential of the p-n junction is 0.75 V and the applied reverse bias is 5.25 V, what is magnitude of the maximum electric field (E_m)?

Problem - 7

If the depletion layer width in a reverse biased abrupt p-n junction is 1 μm when the voltage across the depletion layer is 1 V, what will be the depletion layer width when the reverse bias across the abrupt p-n junction is increased to 4 V?

Problem - 8

In a p-n junction, the doping concentrations in the p and n regions are given by $N_A = 10^{17}/cm^3$ and $N_D = 10^{16}/cm^3$ respectively. If the depletion layer width on the n-side is 1 μm, what will be the depletion layer width on the p-side?

Problem - 9

The built-in potential of a p-n junction is 0.8 V. The depletion capacitances of the junction at a forward bias of 0.7 V and a reverse bias of 0.8 V are $C_{0.7f}$ and $C_{0.8r}$ respectively. Find out the ratio $C_{0.7f}/C_{0.8f}$.

Problem - 10

The depletion layer width (W) for a reverse biased abrupt p^+-n junction is 1 µm and the depletion (or junction) capacitance (C_J) is 10 pF when the voltage across the depletion layer ($V_{bi} + V_r$) is 0.75 V. What are the values of W and C_J when ($V_{bi} + V_r$) is 3 V?

Problem - 11

A silicon abrupt p^+n junction diode has a built-in potential of 0.8 volts. At a reverse bias of 3.2 V, the depletion capacitance is 100pF. What is the value of the reverse bias at which the capacitance will become 50 pF?

Problem - 12

The built-in potential of an abrupt p-n junction is 0.75 V. If the depletion layer width (W) and junction capacitance (C_J) are 1 μm and 10 pF when the reverse bias (V_r) is 1.25 V, what are the values of (a) W and (b) C_J when V_r is 31.25 V?