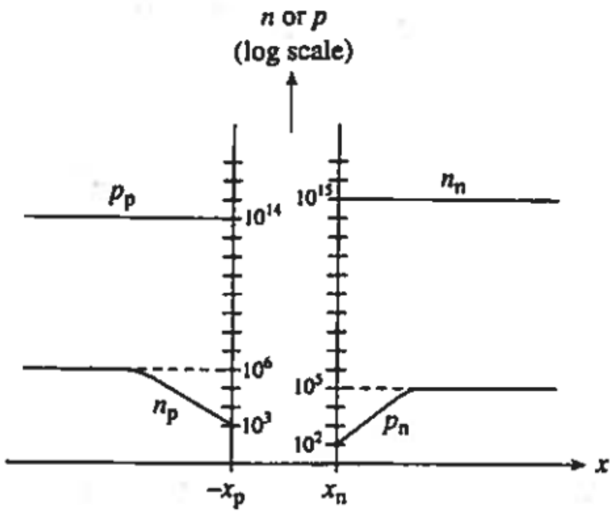
Notice: The assignments are open-book and everyone is free to discuss homework with each other. But the homework you submit must be your own.
Please finish the homework before the deadline, then convert it into a PDF document, and finally submit it through the ISPACE system. The home work should be written in English.

Assignments-2-PN Junction

1. Use the depletion region assumption to analyze and discuss the **linearly graded junction**. For a pn junction with dopants linearly distributed in the depletion region $N_D - N_A = \alpha x$ and applied bias V_A. Determine the formulas for
   (1) Electric field;
   (2) Electric potential;
   (3) Built-in potential;
   (4) Depletion region width.
2. A Si pn abrupt junction maintained at RT is doped such that $E_F = E_V - 2kT$ for the p-Si side and $E_F = E_C - E_G/4$ for the n-Si side.
   (1) Draw the equilibrium energy band diagram for this pn junction;
   (2) Determine the built-in potential V_{bi} and mark it in the energy band diagram.
3. A Si pn abrupt junction at RT under thermal equilibrium condition has doping of $N_A=10^{16}$ cm^{-3} and $N_D=10^{15}$ cm^{-3}. Determine
   (1) V_{bi};
   (2) x_p, x_n and W_{dep};
   (3) E_{max}.
   (4) Draw the figures for charge density, electric field and electric potential as a function of coordinate.
4. For a Si **p^+n long diode** at RT, both sides are uniformly doped. Given that $N_D=10^{16}$ cm^{-3}, $\tau_p=10^{-8}$ s, $D_p=10$ cm^2/s, and $V_A=23kT/q$. Determine:
   (1) minority distribution in n-Si, i.e. $\Delta p_n(x)\sim x$;
   (2) the x-coordinate at which majority induced current equals to the minority induced current, i.e. $J_n=J_p$.
5. For a Si pn abrupt junction at RT, the distribution of carrier concentrations is shown in the figure below.
   (1) Is this junction forward or reverse biased? Explain your reason.
   (2) Does low-level injection prevail in the quasi-neutral regions? Explain your reason.
   (3) Determine N_A and N_D.
   (4) Determine the applied bias V_A.



6. For a Si **pn long diode** at RT. $N_D=10^{18}$ cm^{-3}, $N_A=10^{16}$ cm^{-3}, $\tau_p=\tau_n=10^{-8}$ s, $D_n=31$ cm^2/s, $D_p=12$ cm^2/s, $A_E=10^{-4}$ cm^2. Determine the G_D, C_D and C_J at following bias conditions:
   (1) $V_A=0.1$ V;
   (2) $V_A=0.5$ V;
   (3) $V_A=0.7$ V;
   (4) $V_A=0$ V;
   (5) $V_A=-5$ V.
7. For a Si **n^+p junction** at RT. $N_A=10^{17}$ cm^{-3}, $D_n=19$ cm^2/s and $A_E=10^{-5}$ cm^2. The width between the boundary of SCR in p-Si and Ohmic contact metal electrode of p-Si is 3 μm. **All the carriers recombine at the Ohmic contact metal electrode of p-Si**. Assuming that the current flowing in this junction is 0.5 mA, determine the total number of stored charges in the quasi-neutral region of p-Si.
8. The hole concentration in n-Si of a Si **p^+n abrupt junction** at a given instant of time is as shown below.
   (1) Is this junction forward or reverse biased? Explain your reason.
   (2) If $p_{n0}=10^4$ cm^{-3} and T=300 K, determine V_A at this specific time.
   (3) Is there a forward or reverse current flowing in the junction? Explain your reason.