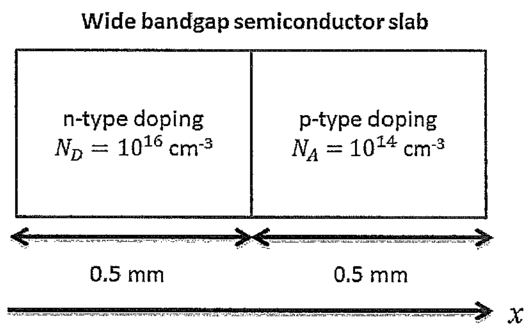
MN-2
August 2014 QE

1. Consider the 1D wide-bandgap semiconductor slab of 1 mm thickness depicted below, with n-type doping $N_D = 10^{16}$ cm^{-3} on the left half, and p-type doping of $N_A = 10^{14}$ cm^{-3} on the right half. This will form a one-sided abrupt pn homojunction. Find the depletion width of the junction under open circuit conditions, in terms of the built-in voltage V_{bi} across the junction, as well as one or both of the doping levels, and appropriate physical constants.



2. Find the expression for the excess minority carrier concentration $n(x) - n_{op}$ in the p-type doped region as a function of both position and voltage. Note that the excess carriers at the depletion edge increase exponentially with voltage, but go to zero by definition as one gets far enough away from the junction.

3. Use your answer from part 2 as well as the drift-diffusion equation in 1D to write down the current-voltage relation (include both electron and hole currents).

4. Now assume that our wide bandgap semiconductor is GaAs ($E_g = 1.42$ eV, $n_i = 1.8 \cdot 10^6$ cm^{-3}, $n_{op} = 10^{16}$ cm^{-3}), held at $T = 300$ K. First, determine the equilibrium concentration of holes p_o from the intrinsic carrier concentration. If carriers are then injected from the left side of the n-type region at a rate $R = 10^{18}$ cm^{-3}s^{-1}, while the recombination parameter $r = 10^{-11}$ cm^{3}s^{-1}, determine the recombination lifetime τ and injected carrier concentration Δn in that region under open circuit conditions in equilibrium, without considering charge transport into the p-type region.

Each Question is 25 Points

Write in Exam Book Only