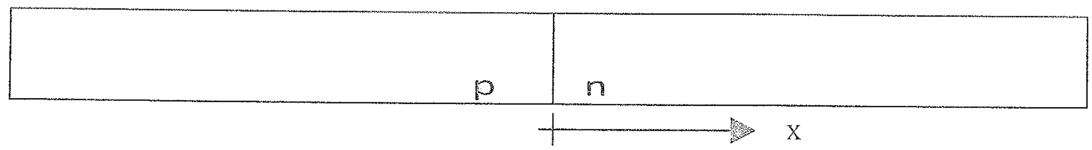
MN-2
August 2012 QE

MN-2. A pn junction in silicon has a p-type side with uniform doping $N_A = 10^{17}$ cm^{-3}. The n-type side has uniform doping $N_{D1} = 5 \times 10^{15}$ cm^{-3} from the metallurgical junction (shown) to a distance 1 μm into the n-type side. The n-type doping increases abruptly at $x = 1$ μm up to $N_{D2} = 2 \times 10^{16}$ cm^{-3}, and remains at that level to the end of the n-type region.



(a) (15 points)
Assuming the p- and n-sides are semi-infinite, draw an appropriate $(N_D - N_A)$ versus x diagram for this junction.

(b) (20 points)
Sketch ***TWO*** charge density ρ versus x plots for the diode invoking *the depletion approximation*, one assuming the depletion region in the n-type (x_n) side is $x_n < 1$ μm, and one assuming $x_n > 1$ μm.

(c) (15 points)
Assuming $|x_p| = 0.1$ μm, estimate x_n.

Write in Exam Book Only

(d) (20 points)
Set up equations to calculate the maximum electric field in the diode, $\mathcal{E}_{max}$, at equilibrium assuming the depletion region *does not* extend into the heavily doped region on the n-side of the junction. The dielectric constant of Si is 11.9.

(e) (30 points)
Suppose $\mathcal{E}_{max} = 1.8 \times 10^5$ V/cm. Set up the equations needed to sketch the electric field-distance ($\mathcal{E}$-x) relationship. Sketch the $\mathcal{E}$-x qualitatively, making no assumptions about x_p or x_n. Label all parameters including x_n and x_p.

Write in Exam Book Only