
Example 4.4 Consider an abrupt p-n diode with $N_a = 10^{18} \text{ cm}^{-3}$ and $N_d = 10^{16} \text{ cm}^{-3}$. Calculate the junction capacitance at zero bias. The diode area equals 10^{-4} cm^2 . Repeat the problem while treating the diode as a one-sided diode and calculate the relative error.

Solution The built in potential of the diode equals:

$$f_i = V_t \ln \frac{N_d N_a}{n_i^2} = 0.83 \text{ V}$$

The depletion layer width at zero bias equals:

$$w = \sqrt{\frac{2e_s (f_i - 0)}{qN_d}} = 0.33 \text{ } \mu\text{m}$$

And the junction capacitance at zero bias equals:

$$C_{j0} = \frac{e_s}{w} \Big|_{V_a=0} = 3.17 \text{ pF}$$

Repeating the analysis while treating the diode as a one-sided diode, one only has to consider the region with the lower doping density so that

$$w = x_n = \sqrt{\frac{2e_s (f_i - V_a)}{qN_d}} = 0.31 \text{ } \mu\text{m}$$

And the junction capacitance at zero bias equals

$$C_{j0} = \frac{e_s}{w} \Big|_{V_a=0} = 3.18 \text{ pF}$$

The relative error equals 0.5 %, which justifies the use of the one-sided approximation.
