Example 3.2 Consider a chrome-silicon metal-semiconductor junction with $N_d = 10^{17}$ cm^{-3}. Calculate the depletion layer width, the electric field in the silicon at the metal-semiconductor interface, the potential across the semiconductor and the capacitance per unit area for an applied voltage of -5 V.

Solution The depletion layer width equals:

$$x_d = \sqrt{\frac{2e_s(f_i - V_a)}{qN_d}}$$

$$= \sqrt{\frac{2\times 11.9\times 8.85\times 10^{-14}\times(0.3+5)}{1.6\times 10^{-19}\times 10^{17}}} = 0.26\,\mu\text{m}$$

where the built-in potential was already calculated in Example 3.1. The electric field in the semiconductor at the interface is:

$$E(x=0) = \frac{qN_d x_d}{e_s}$$

$$= \frac{1.6\times 10^{-19}\times 10^{17}\times 2.6\times 10^{-5}}{11.9\times 8.85\times 10^{-14}} = 4.0\times 10^5 \text{ V/cm}$$

The potential equals:

$$f(x=x_d) = \frac{qN_d x_d^2}{2e_s} = f_i - V_a = 5.3\text{ V}$$

And the capacitance per unit area is obtained from:

$$C_j = \frac{e_s}{x_d} = \frac{11.9\times 8.85\times 10^{-14}}{2.6\times 10^{-5}} = 40\text{ nF/cm}^2$$