P1 Ten volts are applied across a 2 cm long semiconductor bar. (a) If the average electron drift velocity is $10^4$ cm/s, what is the electron mobility? (b) If the electron mobility is $840$ cm$^2$/V s, what is the average electron drift velocity?

P2 Assume that the effective density of states functions in silicon are

$$N_e = 2.8 \times 10^{19} \left( \frac{T}{300} \right)^{3/2} \quad N_v = 1.04 \times 10^{19} \left( \frac{T}{300} \right)^{3/2},$$

the mobilities are

$$\mu_n = 1350 \left( \frac{T}{300} \right)^{-3/2} \quad \mu_p = 480 \left( \frac{T}{300} \right)^{-3/2},$$

and the bandgap energy $E_g = 1.12$ eV and independent of temperature. Calculate the intrinsic conductivity (a) at $T = 300$ K; (b) at $T = 450$ K.

P3 (a) Consider a silicon sample doped with $10^{16}$ cm$^{-3}$ arsenic. What is its resistivity? (b) Consider the same silicon sample doped additionally with $2 \times 10^{17}$ cm$^{-3}$ boron. What is its resistivity?

To determine the mobility as a function of impurity concentration $N$ you can either use Fig. 5.3 or calculate it using the following empirical relationships for silicon:

$$\mu_n = 65 + \frac{1265}{1 + \left( \frac{N}{8.5 \times 10^{16}} \right)^{0.72}} \quad \mu_p = 48 + \frac{447}{1 + \left( \frac{N}{6.3 \times 10^{16}} \right)^{0.76}}$$

P4 At which concentration of electrons $n$ the GaAs conductivity at room temperature is minimal? Take the intrinsic carrier concentration from Table 4.2, and mobilities from Table 5.1.

P5 Consider silicon $n$-doped at $N_d = 1 \times 10^{16}$ cm$^{-3}$. An empirical expression relating electron drift velocity to electric field is given by

$$v_d = \frac{\mu_{n0}E}{\sqrt{1 + \left( \frac{\mu_{n0}E}{v_{sat}} \right)^2}}$$

where $\mu_{n0} = 1350$ cm$^2$/V s. In an experiment, the deviation from the Ohm’s law $v_d = \mu_{n0}E$ is found to reach 10% at electric field $E = 6.5$ kV/cm. Find the saturation drift velocity $v_{sat}$. At what electric field does the drift velocity reach 90% of its saturation value?