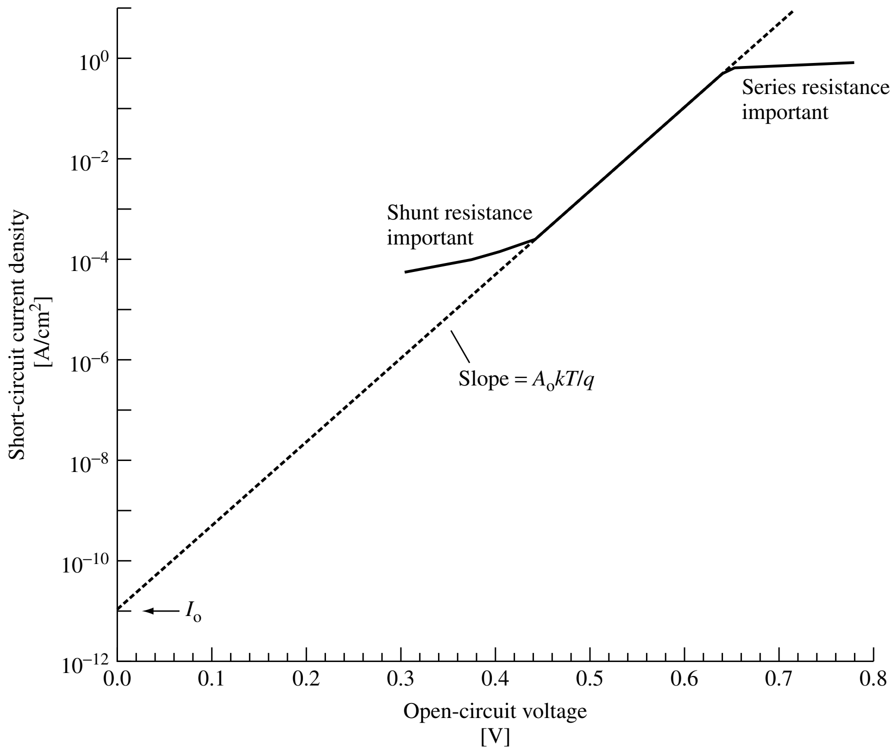

Figure 3.24 Short-circuit current versus open-circuit voltage plot illustrating parameter extraction

An increase in the intrinsic carrier concentration increases the dark saturation (recombination) current and results in a decrease in the open-circuit voltage, as can be seen from equation (3.140). The dark saturation current contains other temperature-dependent terms (D, τ, and S), but the temperature dependence of the intrinsic carrier concentration dominates. The intrinsic carrier concentration is given by equation (3.18), which when combined with equations (3.13) and (3.14) yields

$$n_{\mathrm{i}} = 2(m_n^* m_p^*)^{3/4} \left(\frac{2\pi kT}{h^2}\right)^{3/2} \mathrm{e}^{-E_{\mathrm{G}}/2kT}. \tag{3.157}$$

The effective masses are generally taken to be weak functions of temperature. The band gap decreases with temperature and its temperature dependence is well modeled by

$$E_{\mathrm{G}}(T) = E_{\mathrm{G}}(0) - \frac{aT^2}{T+\beta}. \tag{3.158}$$

where α and β are constants specific to each semiconductor. It is clear that as the temperature increases, n_{i} increases, and thus recombination increases, and cell performance is impaired. Band gap narrowing, referred to earlier, is a reduction in band gap due to high doping and also serves to increase n_{i} and impair solar cell performance.