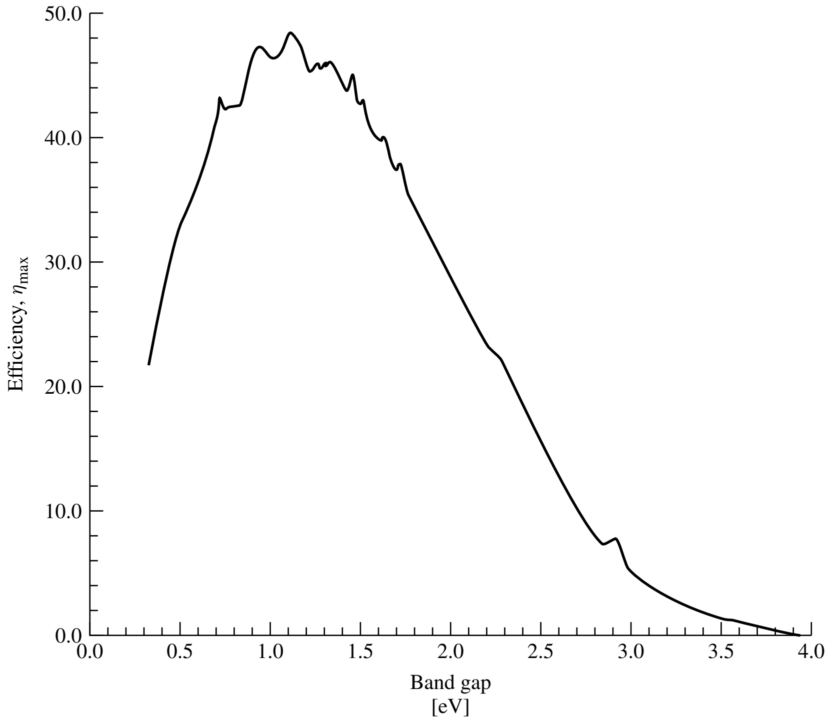

Figure 3.19 Theoretical maximum efficiency as a function of semiconductor band gap for an AM1.5 global spectrum

This is plotted in Figure 3.19 for an AM1.5 global spectrum and shows a maximum efficiency of 48% at about $E_G = 1.1$ eV, close to the band gap of silicon. Of course, this is only a simple estimate and assumes that $V_{OC} = 1/qE_G$ and $FF = 1$, which are obvious exaggerations. Perfect light trapping was also assumed so that $I_{SC} = I_{inc}$, but that is a more realistic prospect. Under nonconcentrated solar illumination, the actual maximum theoretical efficiency for a silicon solar cell is approximately 30%. However, this simple approach does serve to demonstrate the important role the semiconductor band gap plays in determining solar cell performance and shows that band gaps between 1.0 and 1.6 eV have nearly equivalent maximum theoretical efficiencies.

3.5.2 Spectral Response

The spectral response, $SR(\lambda)$, of a solar cell permits an examination of how photons of different wavelengths (energy) contribute to the short-circuit current. Just as the collection efficiency can be measured as either an external or an internal collection efficiency, so can the spectral response. The spectral response is defined as the *short-circuit current*, $I_{SC}(\lambda)$, resulting from a single wavelength of light normalized by the maximum possible current. The external spectral response is defined as

$$SR_{ext} = \frac{I_{SC}(\lambda)}{qAf(\lambda)} \tag{3.146}$$