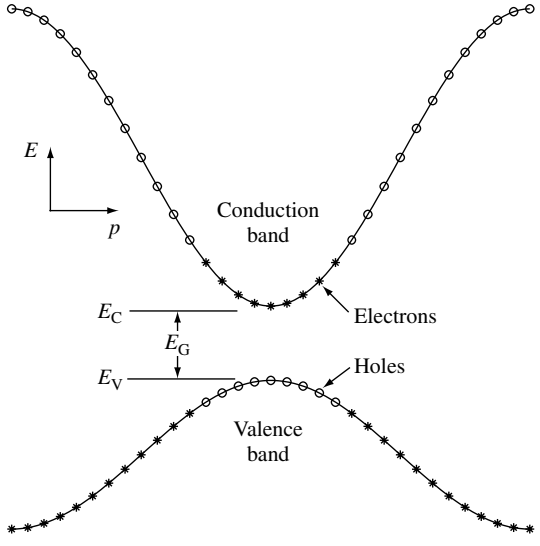

Figure 3.3 A simplified energy band diagram at $T > 0$ K for a direct band gap (E_G) semiconductor. Electrons near the maxima in valence band have been thermally excited to the empty states near the conduction-band minima, leaving behind holes. The excited electrons and remaining holes are the negative and positive mobile charges that give semiconductors their unique transport properties

near the bottom of the conduction band is a constant, as is the hole effective mass (m_p^*) near the top of the valence band. This is a very practical assumption that greatly simplifies the analysis of semiconductors.

When the minimum of the conduction band occurs at the same value of the crystal momentum as the maximum of the valence band, as it does in Figure 3.3, the semiconductor is a *direct band gap* semiconductor. When they do not align, the semiconductor is said to be an *indirect band gap* semiconductor. This is especially important when the absorption of light by a semiconductor is considered later in this chapter.

Even amorphous materials exhibit a similar band structure. Over short distances, the atoms are arranged in a periodic manner and an electron wave function can be defined. The wave functions from these small regions overlap in such a way that a *mobility gap* can be defined with electrons above the mobility gap defining the conduction band and holes below the gap defining the valence band. Unlike crystalline materials, however, there are a large number of localized energy states within the mobility gap (band tails and dangling bonds) that complicate the analysis of devices fabricated from these materials. Amorphous silicon (a-Si) solar cells are discussed in Chapter 12.

3.2.3 Conduction-band and Valence-band Densities of State

Now that the dynamics of the electron motion in a semiconductor has been approximated by a negatively charged particle with mass m_n^* in the conduction band and by a positively charged particle with mass m_p^* in the valence band, it is possible to calculate the density