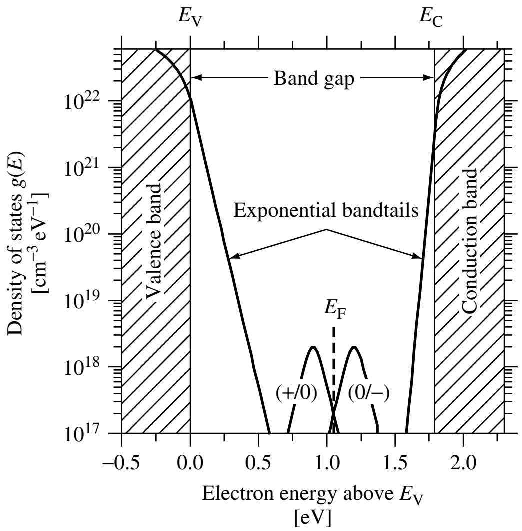

Figure 12.9 Density of electronic states $g(E)$ in hydrogenated amorphous silicon. The shaded areas indicate delocalized states in the bands; these bands themselves have tails of localized states with an exponential distribution. Midway between the bands are levels belonging to gross defects such as dangling Si bonds indicated by the two peaked bands around E_F

state (or molecular "orbital") at a particular energy level E. In a range of energies ΔE, the number of such states per unit volume of the solid is $g(E)\Delta E$.

In Figure 12.9 we have illustrated the density-of-states for hydrogenated amorphous silicon as it has emerged primarily from measurements of electron photoemission [37, 38], optical absorption [39], and electron and hole drift mobilities [40]. In the dark at low temperatures, the states with energies below the Fermi energy E_F are filled by electrons; above the Fermi energy the states are empty. There are two strong bands of states illustrated: an occupied valence band ($E < E_V$), originating with the Si–Si and Si–H bonding orbitals and an unoccupied conduction band ($E > E_C$), originating with "antibonding" orbitals.

12.2.4 Bandtails, Bandedges, and Band Gaps

Between the conduction and valence bands lies an "energy gap" where the density-of-states is very low. Any functional semiconductor, crystalline or noncrystalline, must have such an energy gap. For perfect crystals, the valence and conduction bandedge energies E_V and E_C are well defined, as is the *band gap* $E_G = E_C - E_V$. Interestingly, in disordered semiconductors there are exponential distributions of bandtail states near these bandedges. For the valence bandtail, we write $g(E) = g_V \exp[-(E - E_V)/\Delta E_V]$. The width ΔE_V of this exponential distribution is important in interpreting optical absorption experiments, in which it is usually identified with the exponential "Urbach" tail of the spectrum apparent in Figure 12.2. For a-Si:H, a typical value $\Delta E_V = 50 \times 10^{-3}$ eV. ΔE_V is also used to account for the very slow drift of holes in an electric field (i.e. the hole *drift mobility*) [40, 41]. The conduction bandtail width ΔE_C is much narrower; for