as a “low-pass” optical filter. This effect is illustrated in Figure 12.2, which shows that a 0.5-μm layer of a-Si:H absorbs photons with energies larger than 1.9 eV and passes photons with smaller energies. The “wasted” lower energy photons can be efficiently harvested by amorphous silicon-germanium, which has a much larger optical absorption coefficient below 1.9 eV than does a-Si:H, hence a lower threshold energy. Overall, the advantages of the multijunction design are sufficiently compelling that they usually overcome the additional complexity and cost of the deposition facility. Both tandem and triple-junction devices are being manufactured today. We discuss multijunction solar cells in detail in Section 12.5.

12.1.3 Staebler–Wronski Effect

One of the most intriguing and actively researched facets of amorphous silicon solar cells is the significant decline in their efficiency during their first few hundred hours of illumination. Figure 12.5 illustrates this effect for a single-junction cell and for a triple-junction module made at United Solar Systems Corp. [14, 15]. The single-junction cell loses about 30% of its initial efficiency after about 1000 h; the triple-junction module loses about 15% of its initial efficiency.

All amorphous silicon–based solar cells exhibit this type of initial behavior under illumination; the behavior is mostly due to the “Staebler–Wronski” effect [16], which is the light-induced change in hydrogenated amorphous silicon (a-Si:H) and related materials used in the cell. Although we have not illustrated it here, the Staebler–Wronski effect can be annealed away within a few minutes at temperatures of about 160°C (and the initial performance of the solar cell largely restored).

The Staebler–Wronski effect contributes to noticeable seasonal variations in the conversion efficiency of a-Si:H-based modules in the field. In Figure 12.6 we illustrate

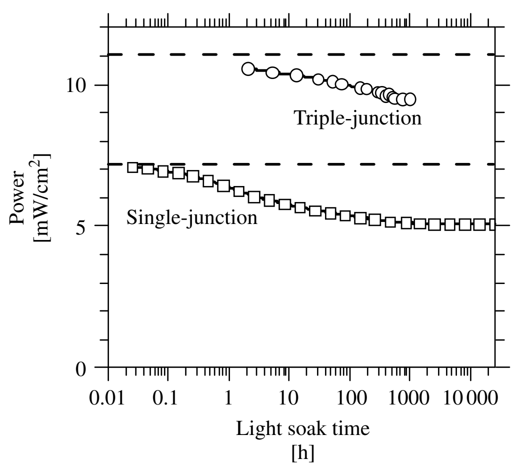

Figure 12.5 The conversion efficiency in a-Si:H-based solar cells declines noticeably upon the first exposure to sunlight. The figure illustrates this decline under a solar simulator (100 mW/cm^2) for a single-junction cell (260-nm i-layer thickness) and for a triple-junction module made at United Solar Systems Corp. [14, 15]; the dashed lines indicate the initial power measured for each device