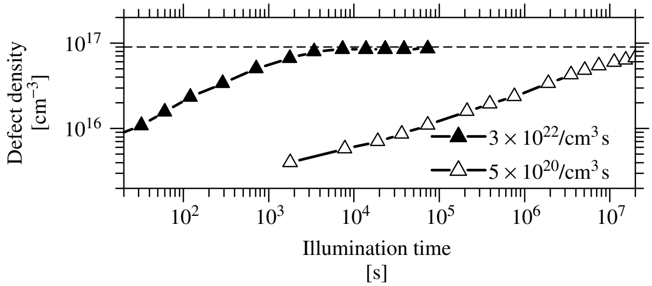

Figure 12.8 Plot of the defect (dangling bond) density during extended illumination of an a-Si:H film as measured by Park, Liu, and Wagner [34]. Data are given for high- and low-intensity illumination; the legend indicates the photocarrier generation rate of each intensity

hydrogen lost from the structure; this effect has been attributed to the evolution of hydrogen from clustered-phase sites, which presumably does not create dangling bonds.

The most intense defect research in a-Si:H has not been focused on the direct hydrogen-defect relation, but rather on the light-soaking effects. We illustrated how light soaking degrades the solar conversion efficiency in Figure 12.5, and in Figure 12.8 we illustrate how it increases the defect density. For the high intensity illumination, the defect density reaches a steady state at about $10^{17}/cm^3$. For purposes of engineering and commercial applications, it is very important that a-Si:H reaches such a "stabilized" condition after extended light soaking.

Although the defect density is not the only property of a-Si:H modified following light soaking [35], most workers believe that the principal cause of the Staebler–Wronski effect is this increase in dangling bond density after light soaking. The close connection between hydrogen and defects in a-Si:H has led to several efforts to understand the defect creation in terms of metastable configurations of hydrogen atoms [35, 36]. The idea is that illumination provides the energy required to shift hydrogen atoms away from their dilute-phase sites, thus creating dangling bonds. The technological importance of establishing the atomic mechanism underlying the Staebler–Wronski effect lies in the possibility that this effect can be mitigated in a-Si:H by changing its preparation conditions.

An essential feature of the light-soaking effects on a-Si:H cells and films is that most of the effects are "metastable" and can be removed nearly completely by annealing of a light-soaked sample at a temperature above 150°C. More generally, the stabilized condition of a-Si:H cells and films is quite temperature-dependent. For example, Figure 12.6 showed that the module efficiency is substantially affected by the seasons and is highest following the hottest days. The measurement may be understood by considering that the stabilized condition is due to competition between two rates: the creation of metastable defects by light and a thermally activated process that anneals them away.

12.2.3 Electronic Density-of-states

The most important concept used in understanding the optical and electronic properties of semiconductors is the electronic density-of-states, $g(E)$. The idea is a simple approximation: if a single electron is added to a solid, it may be viewed as occupying a well-defined