Table 8.4 The parameters used in calculating the solar cell characteristics

G [s^{-1}]	α [cm^{-1}]	D [cm·s]	Junction depth	n-doping	p-doping
10^{18}	100	50	0.5 μm	10^{18}	10^{17}

absorption coefficient. $G = \alpha \times$ number of photons incident at the surface (photons/unit area-second).

Calculated J–V curves, depicting the influence of grain-boundary recombination, are shown in Figure 8.25. Figure 8.25(a) is for a 5-μm-grain-size sample, and Figure 8.25(b) is for a 0.5-μm-grain-size sample. It can be seen that, for larger grain size, the recombination at the GBs will mainly degrade V_{OC}, and not J_{SC}. From Figures 8.24 and 8.25, it can be seen that the larger the grain size, the better the performance of the device. However, the interface recombination has a strong influence on each parameter. For low interface recombination velocity, when grain size is large (~1 μm), a decrease in the grain size will primarily degrade V_{OC} and not J_{SC}. However, for small grain size (<0.5 μm), J_{SC} will also decrease rapidly with a decrease in grain size. Because interface recombination has a very strong influence on the device performance, passivation of the GBs is very important for μc-Si thin-film solar cells. Furthermore, it can also be concluded that, to get a device with satisfactory J_{SC} and V_{OC}, the grain size of a μc-Si thin solar cell should be several microns.

8.3.4 Methods of Making Thin-Si Films for Solar Cells

The deposition techniques for Si films run the gamut from single-crystal deposition using crystalline substrates to microcrystalline Si thin films on glass or steel foil. A variety of techniques are now used for the deposition of thin films for solar cells [73, 74]. These include RF and DC glow-discharge techniques such as plasma-enhanced CVD (PECVD), hot-wire CVD (HWCVD), the electron cyclotron resonance CVD (ECRCVD), and other microwave- and plasma-beam deposition methods. Of these, the PECVD system is well suited to large-area depositions. Some of the newer techniques, such as ECRCVD, remote plasma-assisted CVD, and HWCVD have produced materials with interesting properties such as lower defect density, greater minority-carrier diffusion length, and lower hydrogen concentration. Some of these techniques may hold promise for the future.

Today, commercial a-Si:H solar cells are mostly deposited in multichamber reactors. Hydrogen incorporation is an important issue in the deposition of a-Si:H cells. A Si-bearing gas, typically silane, is used as the process gas in a DC or an RF (13.56–200 MHz) plasma in a pressure range of 0.1 to 1 torr. Typically, the deposition rates are 1–5 Å/s. A material with good electronic quality requires a dense and a homogeneous network of amorphous Si with minimum void density. These conditions dictate low deposition rates. Hydrogen dilution appears to have a strong influence on the properties of a-Si. However, a high hydrogen dilution rate is accompanied by a reduction in the deposition rate. Typically, VHF plasma excitation involves a source in the vicinity of 50 MHz. Operation