The primary aim of exploiting a thin cell is to lower the bulk recombination losses that can lead to higher *FF* and V_{OC}. However, this must be done in a way that promotes good carrier generation and collection. Carrier collection can be a particularly difficult problem in a μc-Si cell because of carrier recombination at the GBs and the small grain size. The University of New South Wales (UNSW) has developed a multijunction cell approach to overcome this problem. The multijunction approach, reminiscent of a-Si cell designs, can circumvent the effect of poor material quality (i.e. short minority-carrier diffusion length) by providing closely spaced collecting junctions. Although the details of the cell material are not known, it is expected that the semiconductor film will consist of hydrogenated microcrystalline silicon. Such a film consists of polycrystalline Si with grain size typically <1 μm, hydrogenated grain boundaries, and material that contains a significant amount of amorphous tissue in the film. Recently, UNSW group reported 7.2% efficiency using this approach. Details of the device structure and processing methods were not disclosed. However, it is believed that a PECVD technique is used for Si deposition [52]. This type of material, deposited by plasma-assisted deposition, has been used by the Neuchatel group in Switzerland [53], which has reported an efficiency of 12%.

8.3 DESIGN CONCEPTS OF TF-SI SOLAR CELLS

Like any other emerging technology, the fabrication of TF-Si solar cells has, to date, followed empirical optical and electronic designs. The optical design aims at a high degree of light-trapping, such that the effective optical thickness of the absorber is similar to that of a much thicker wafer-based cell. It is generally known that one or more interfaces must be rough or textured to produce effective light-trapping. The electronic design of a TF-Si cell, particularly one using small-grain Si, is very difficult because such a structure has three-dimensional nonuniformity. Later in this chapter, we will illustrate some preliminary calculations using a software package that is currently being developed. However, qualitative designs can be derived using lumped material parameters such as effective minority-carrier lifetime, effective surface-recombination velocity, and absence of local shunting.

The material quality of a TF-Si cell should be such that the volume recombination is significantly lower than its thick-cell counterpart. In a thin-Si cell, the carrier recombination is expected to arise primarily from impurities, grain boundaries, and interfaces. Impurity effects can be minimized by the use of Al gettering, whereas a large ratio of grain size/Si thickness can minimize shunting effects of grain boundaries. A more difficult task is that of interface passivation, particularly if the Si film is in contact with a substrate material that may be conducting.

Unfortunately, cell design and processing are intimately connected. We will, however, attempt to consider a representative cell structure (that has nearly all the elements of any TF-Si cell) and illustrate optical and electronic design concepts. The emphasis will be on the physics and methods of designs. The cell structure we consider is illustrated in Figure 8.12. It consists of a glass substrate coated with a layer of a metal such as Al. A thin layer of *p*-type amorphous or fine-grained μc-Si film is deposited on the Al-coated substrate. The deposited film may be grain-enhanced by using one of the techniques described in the next section describing deposition techniques. In particular, it must employ a technique that allows the substrate temperature to remain below its softening point. The grain-enhanced film forms the base region of the cell. The method of