the next ten years, staying within the realm of the existing technologies at each major step of thickness. However, the arguments above provide motivation for a major reduction in thickness – to a new generation of Si solar cells using Si films less than 10 μm thick. Such a thin-film Si (TF-Si) solar cell offers many advantages that can lower the cost of generating solar electricity. A TF-Si cell offers (1) reduced bulk recombination leading to lower dark current, higher V_{OC} and higher FF of the device. Compared to a thick cell, a thin cell of the same material quality can yield higher device performance. Likewise, for a comparable performance, TF-Si solar cell requires lower material quality than a thick cell. It also offers (2) potential for low-cost cells/modules, (3) potential for lightweight photovoltaics, (4) lower energy consumption for device fabrication, and (5) potential for flexible solar cells.

These advantages of TF-Si solar cells, in concurrence with the performance advantage, make them very attractive for the future. Practical realization of solar cells with the above advantages poses many challenges in both the design and device fabrication. These challenges include an efficient method for light-trapping to compensate for reduced thickness, and a low-cost substrate to support the thin film. Low-cost substrates generally imply materials that may not be compatible with the high temperatures required for formation and processing of Si film. This incompatibility can arise because of impurities in the substrate that can diffuse into the Si film, softening of the substrate, thermal mismatch, and less desirable electronic properties of the interface leading to high S_b.

This chapter will discuss current efforts to develop a new technology (or set of technologies) that can achieve the potential performance of very thin Si solar cells. In the last few years, a number of R&D groups around the world have embarked on the design and fabrication of TF-Si solar cells. These efforts have already led to some exciting results. However, the design and fabrication of high-efficiency TF-Si solar cells continue to present a host of challenges. We review the salient aspects of the current research on TF-Si cells, and we present a systematic approach to the analysis, design, and fabrication of such devices.

8.2 A REVIEW OF CURRENT THIN-FILM SI CELLS

Many basic concepts of thin-film Si solar cells were suggested decades ago [1, 2]. It was apparent then that thinner cells would require a means of enhancing optical absorption. As early as 1975, it was proposed that enhanced optical absorption accompanying light-trapping can help lower the cell thickness required for efficient generation of photocurrent to a few microns. The proposed approach used a prismatic configuration to deflect light into a thin film at oblique incidence, so that the light would be total internally multireflected within the thin cell. This approach is similar to launching guided waves in integrated optics. Although this approach did not flourish because of evident drawbacks, other cell configurations that would support the use of very thin Si films for solar cell applications were later suggested [3, 4]. Some simple (approximate) calculations showed that cell efficiencies approaching 10% could be obtained with polycrystalline Si films of 10-μm thickness with 1-μm grain size [3]. These calculations only considered bulk recombination arising from grain boundaries (GBs) in polycrystalline Si and planar cell structures. Although the possibility of the thin-film Si solar cell was envisioned long ago, a practical realization has begun only recently. The path to TF-Si cells has