orientation. A dramatic consequence of the fabrication process was the consumption of the CdS layer, leading to a nearly uniform $CdTe_{1-x}S_x$ alloy throughout the film thickness, which reduced the absorber-layer band gap to ∼1.4 eV. In the highest-efficiency cells made by spray deposition, CdS diffusion and subsequent alloy formation consumed most of the CdS film, resulting in an enhanced blue-spectral response and correspondingly high short-circuit densities. The method was extensively investigated by the group at Golden Photon [115, 116].

14.2.3.3 Screen-print deposition

Screen-print deposition is perhaps the simplest of the CdTe techniques, combining Cd, Te, $CdCl_2$, and a suitable binder into a paste that is applied to the substrate through a screen. Following a drying step to remove binder solvents, the layer is baked at temperatures up to 700°C to recrystallize the film and activate the junction. Films fabricated by this method typically have a thickness ranging from 10 to 20 μm with lateral grain dimension of ∼5 μm and random orientation. Screen-printed CdTe can be traced back to the 1970s with the pioneering work of Matsushita [117] and subsequently by groups at the University of Seoul [118] and the University of Ghent [119].

14.3 CdTe THIN-FILM SOLAR CELLS

All high-efficiency CdTe solar cells to date have essentially the same *superstrate* structure as that successfully demonstrated by Bonnet and Rabenhorst in 1972 [26]. This structure is depicted in Figure 14.7. The alternative *substrate* configuration, with the TCO/CdS/CdTe deposited onto an opaque substrate, has been much less successful, primarily because of poor CdS/CdTe junction quality and poor ohmic CdTe contact, resulting from chemical instability of the back contacts and from copper diffusion out of the back contact toward the CdTe surface during film growth.

The primary photodiode junction occurs between the *p*-type CdTe absorber and the *n*-CdS window layer. There are, however, a number of complicating factors, such as the need for a high-resistance oxide layer when the CdS is thin, the need for a thermal treatment with $CdCl_2$ and oxygen to improve the CdTe quality, the interdiffusion of CdS and CdTe, and the barrier associated with the back contact. The following sections will address these complications.

14.3.1 Window Layers

The first step in the fabrication of a superstrate CdTe cell is to coat the glass with a transparent conducting oxide (TCO), such as SnO_2, indium–tin oxide, In_2O_3:Sn, referred to as ITO, or cadmium stannate, Cd_2SnO_4, which serves as the front contact. To obtain high current density in the completed cell, the CdS layer needs to be very thin, which, owing to its polycrystallinity, raises the possibility of local shunting or excessive forward current. It has been found that the deposition of a second, highly resistive, transparent oxide layer, referred to as the HRT layer, between the TCO and CdS significantly ameliorates this problem and improves junction quality and uniformity in a manner analogous to