Still another approach to a triple-junction cell design is to combine a 1.8 eV a-Si top cell, a 1.6 eV a-SiGe middle cell, and a 1.1 eV μc-Si bottom cell [165]. Such a cell design would have the advantages of a thinner and more stable top cell than for a micromorph tandem cell, would have better long-wavelength collection, and would reduce consumption of (expensive) GeH_4 gas compared with an all-amorphous, a-Si/a-SiGe/a-SiGe triple-junction cell.

12.6 MODULE MANUFACTURING

Although the stabilized conversion efficiency of a-Si-based solar cells is presently lower than those of several other types of solar cells, a-Si-based PV products are highly attractive for terrestrial applications since they can be produced using low-cost manufacturing methods. The a-Si PV products are environmentally friendly. They are made mostly using silicon, which is abundant on earth. In addition, the a-Si PV products can be made lightweight, flexible, and radiation-resistant. These make them highly desirable for portable power applications as well as for space power applications. Furthermore, the fact that a-Si products have higher stabilized power output at higher temperature makes these products more desirable in warm weather environment.

During the past 10 years, there has been a rapid increase in the worldwide a-Si production. Presently in 2002, the total worldwide a-Si production capacity exceeds 85 MW/year, including about 30 MW at United Solar Systems Corp. (USA), 20 MW at Kaneka Corp. (Japan), 10 MW at BP Solar, Inc. (USA), 10 MW at Canon (Japan), 6 MW at Sanyo (Japan), 3 MW at EPV (USA), 2 MW at Sovlux (Russia), and several 1-MW plants in various companies in different parts of the world.

These production facilities can be roughly divided into two major categories: those with substrate-type a-Si PV products and those with superstrate-type a-Si PV products. To transform small-area R&D developments into any type of large-scale manufacturing, key issues including uniform deposition over large areas, process gas utilization, deposition rate, production throughput, process reproducibility, machine maintainability and serviceability, process automation, and production yield must be addressed.

For a large-scale production line, in-line processes have been used by all major manufacturers. In the following, we use the production process at United Solar as the example for the substrate-type process and that at BP Solar as the example for the superstrate-type process.

12.6.1 Continuous Roll-to-roll Manufacturing on Stainless Steel Substrates

The continuous, "roll-to-roll" a-Si PV manufacturing process was developed by Energy Conversion Devices, Inc. (ECD) and has been used by ECD's PV joint ventures and partners (United Solar, Sovlux, and Canon) [184–186]. Roll-to-roll refers to the process whereby a "roll" of flexible SS is unrolled and fed into the manufacturing process, and then the SS is again "rolled up" after a manufacturing step has been completed. The production process can be separated into two distinct parts: the front-end coating process and the back-end module assembly process.