7.7 OTHER INDUSTRIAL APPROACHES

Other commercially available technologies will be described in this section. They all look for a decrease in the $ W^{-1} figure of merit, following different approaches:

- using ribbons, presented in Chapter 6, as substrates;
- implementing techniques that do not need high-temperature processes: HIT, based on a-Si/*x*-Si heterojunction emitter;
- substituting screen-printing metallization by a more efficient technique: LGBG, based on the buried contact concept;

These only cover a small fraction of the PV market today, but they all have big expansion plans for the next few years.

7.7.1 Silicon Ribbons

Ribbon technologies offer a cost advantage over crystalline silicon, thanks to the elimination of the slicing process. They cover at the moment around 5% of the PV market, Edge-defined-Film-fed Growth (EFG) being the most mature of them, while string ribbon (STR) and dendritic web (WEB) are also into industrial production.

A specific solar cell process is needed for ribbon substrates, to account for the high density of defects (dislocations, grain boundaries, impurities, etc). Al paste is usually printed to create a deep BSF and to benefit from gettering, and silicon nitride is deposited by PECVD for bulk defect passivation and anti-reflection coating.

For EFG solar cells, the uneven surface of the sheets precludes the use of screen-printing metallization, and back and front contact formation is done by pad-printing and direct writing (extrusion) of silver pastes and inks. Efficiencies exceeding 14% on an average have been produced in the manufacturing line, achieving more than 14.7% in some cases [116]. Further reduction of production costs is expected by the growth of large-diameter EFG cylinders, which reduce thermoelastic stresses and can result in thinner and more uniform wafers. Thin curved wafers will require new technology for solar cell processing.

In the case of STR, 14.7% efficiencies have been reported for a process including screen-printed contacts fired with RTP [117], and 50 and 100 W modules are commercially available [118]. Regarding dendritic web, an $n^+ np^+$ structure (phosphorus front diffusion and rear Al alloyed emitter) is implemented on a high-resistivity antimony-doped substrate. Because of the low substrate thickness (100 μm), it can benefit from the location of the *p-n* junction at the back, performing an effective front surface field, enabling a high diffusion length and immunity to light-induced degradation. Using only production-worthy, high-throughput processes, dendritic web cells have been fabricated with efficiencies of up to 14.2% [119].

7.7.2 Heterojunction with Intrinsic Thin Layer

A new structure called HIT has been developed recently, which makes use of the cheaper amorphous silicon (a-Si) technology, depositing a-Si layers on crystalline silicon by