The probability of fracture of the wafer during handling increases, especially in conjunction with a larger size. Adequate handling tools must be designed. Some steps appear to be critical: for instance, in chemical baths convection can exert significant torque on the wafers. This issue is fostering the study of the mechanical properties of silicon [79, 80] and even the development of new crystallization procedures.

The behavior during heat treatments is modified due to a decreased thermal mass. On the other hand, wafers can more easily become bent. Processes need to be specifically optimized for thin cells [81].

Thin cells largely depend on surface passivation and optical confinement. If attained to reasonable degrees, efficiency improvement comes as a bonus for thin cells, but otherwise the performance is degraded. New optimal structures must be developed.

7.5.2 Back Surface Passivation

The enhancement of material quality and the decrease of wafer thickness will make it necessary to passivate the back surface. Several approaches are feasible to be incorporated to the basic screen-printing process [55, 82]:

- *Aluminum back surface field*: With the benefit of gettering action, a highly doped *p*-type region at the back can easily be formed by screen-printing aluminum paste on the entire surface followed by high-temperature alloying. Several manufacturers implement aluminum BSF in their production lines. It can be integrated in the process flow (1) before metallization, possibly at the same time as phosphorus diffusion, and (2) by printing the aluminum paste after the front contact print so that the alloy forms during paste firing, though in this case lower temperatures are possible leading to worse properties.

  In either case, a back, silver-based contact is still needed for solderability. Bending of the wafers is an issue for thin cells.
- *Boron back surface field*: Like phosphorus, boron can be diffused from solid sources, so that it can easily be integrated into the basic process. Though it would be very attractive to diffuse both phosphorus and boron during the same thermal step, it appears that the obtained profiles are far from optimum and that a two-step diffusion seems necessary.
- *Silicon nitride passivation*: The surface and bulk passivation properties of silicon nitride are explained below. This replaces AR coating deposition and does not alter the basic process, though the parasitic junction must not be allowed to form in this case. This structure, as well as boron BSF, is compatible with the bifacial operation of the solar cell.

7.5.3 Improvements to the Front Emitter

Quantitative improvements in both recombination currents and spectral response will be derived from front surface passivation only when better paste formulations and finer line prints allow more resistive emitters – thinner and/or less doped – to be used [83]. In that case, tube oxidation and silicon nitride deposition appear as good candidates for industrial use.