features are implemented, such as a selective emitter (highly doped under the metal fingers and low-doped and surface-passivated in the active area) and a Back Surface Field by Al evaporation and alloying, which also produces gettering effect.

The buried contact solar cell has been licensed to many manufacturers, but for the moment only one of them has implemented it at the industrial level, commercializing it as the LGBG solar cell. The LGBG process is sketched in Figure 7.16. Three high-temperature steps are needed, and a number of wet steps must be performed. A key element is the silicon nitride layer, which serves as a masking layer for heavy phosphorus diffusion and plating, and also performs as an antireflection coating and surface passivator. Efficiencies of 17% are routinely achieved with Cz-Si [121], and improvements are being researched and implemented to further increase cell efficiency [122].

The buried contact approach relies on compensating the increase in process complexity as compared to screen-printed technology with an increase in cell efficiency. A midway is proposed with a simplified buried contact solar cell process, with only one high-temperature step, TiO_2 antireflection coating and screen-printed Al BSF [123].

7.8 CRYSTALLINE SILICON PHOTOVOLTAIC MODULES

The power of a single solar cell being small, several of them must be electrically associated to make a practical generator. The module is the building unit for generators that can be purchased in the market, that is, it is the real PV product. Performance and lifetime of PV systems depend on the protection that module construction offers to the active photovoltaic devices.

The basic module fabrication procedure used by most manufacturers was developed three decades ago and is described below briefly. Modules for special applications (building integration, marine operation, etc) require slight modifications of the process and the materials.

7.8.1 Cell Matrix

In a module, the cells are usually arranged in series. After cell finishing, tinned copper ribbons (tabs) are soldered to the bus bars at the front (Figure 7.17a). It has to be noted that tabs must overlap a long distance along bus bar length since the conductance of the printed bus bars is too low. Conductive epoxies can replace conventional solder alloys and illumination used instead of iron heating.

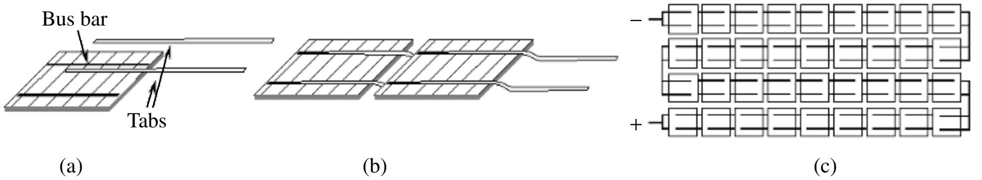

Figure 7.17 (a) Cell interconnection with tabs; (b) two cells in series; and (c) layout of 36 series-connected cells