mentioned, the very highly doped region exhibits almost no photovoltaic activity due to the presence of precipitates ("dead layer"). As a result, the collection of short-wavelength light is very poor and the J_0 large, irrespective of a hypothetical surface passivation is therefore not implemented. The advantage is that heavy phosphorus diffusions produce very effective gettering. Some ways of incorporating selective emitters to screen-printed cells are being considered, SiN_x appearing very well suited for surface passivation [55]. This, however, must be accompanied by a decrease in the finger width so that lower sheet resistances are tolerated.

7.3.4 The Back Surface

The majority carrier, back *p*-contact of industrial solar cells is usually made by printing, and subsequently, firing an aluminum-containing Ag-conducting paste.

The p^+ layer would be useful in decreasing contact recombination, as explained, but this is immaterial to the electrically thick ($w > L$) present industrial cells and it is not optimized for this purpose.

For high-efficiency cells, contact passivation is essential. A BSF is a first step (Figure 7.4a). Localized contacts, as shown in Figure 7.4(b), further reduce recombination. This structure is presented by some of the bifacial cells [56].

If the surface passivation is good, the BSF is restricted to point contacts, some microns in size, as in PERL and similar cells (Figure 7.4c) [57]. The back face of bifacial cells passivated with SiN_x is shown in Figure 7.4(d).

A shallow and light diffusion helps in decreasing surface recombination (Figure 7.4e). The diffusion can be the same type of the substrate, or the opposite one: so-called PERT (Passivated emitter rear totally diffused) [36] and PERF (Passivated emitted rear floating junction) [58] cells demonstrate these concepts. The latter structure benefits from the lower J_0 values of n^+ layers, and it is essential that no electron flow is injected from the *n* region to the *p* contact: the junction must be in open-circuit (a "floating" junction). Note that this structure has nothing to do with structures sometimes found at the back of industrial cells (Figure 7.4f) where a coarse metal mesh is fired through the parasitic n^+ layer formed during front diffusion. A mesh is preferred to a continuous layer for mechanical reasons. The junction is shorted and presents to the substrate a high SRV.

7.3.5 Size Effects

Substrate edges are highly recombining surfaces that adversely affect cell performance, especially for small size, large diffusion length devices. For laboratory cells, efficiency is defined on the basis of a design area. The emitter is limited to it by planar masking or mesa etching. The true edge is thus placed far away from the cell limit, and then recombination is reduced. For real applications, on the contrary, only the substrate area counts, and edge optimization is more complex. Advanced passivation schemes such as edge diffusions are being considered [59, 60]. In large industrial cells, this recombination is much less important.