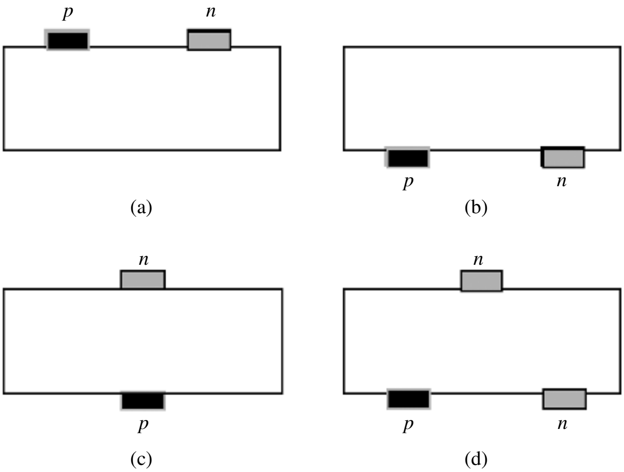

(a) (b)

(c) (d)

Figure 7.1 Contacting structures: (a) both contacts at the front; and (b) at the back; (c) both faces contacted; and (d) one carrier extracted at both faces. The structures with interchanged n- and p-types are also possible

Condition 3 mentioned above. This solution is being considered for concentration [32]. Putting both contacts at the back works the other way round (Figure 7.1b). Back-contacted cells exhibit record efficiencies under concentration and demonstrate very high values near 23% at one sun [33].

In most cells, each contact is placed on a different face, which is technologically simpler (Figure 7.1c). Minority carriers in the substrate are usually collected at the front since their extraction is more problematic because of their low density. The diffusion length describes the maximum distance from where they can be collected. Majority carriers can drift to the back contact with low loss. Several designs extract minority carriers both at the front and at the back (Figure 7.1d) [34], thus increasing the volume of profitable photogeneration.

Bifacial cells are designed to collect light incident at both faces, which allows a boost in output power if there is a significant albedo component. They can be implemented with any structure in Figure 7.1 on the condition that both surfaces allow light through [35].

Both 24.7% record-efficiency laboratory solar cells [36] (Figure 7.2a) and mass-produced industrial devices (Figure 7.2b), typically 15% efficient, display the contacting structure in Figure 7.1(c). They will be described in the paragraphs that follow with the aim of illustrating the amplitude and the reasons for the performance gaps between the ideal and the best Si cell, and between this cell and industrial cells.

7.3.2 Substrate

7.3.2.1 Materials and processing

Highest efficiencies are achieved with monocrystalline float zone (FZ-Si) material, which in addition to extreme crystalline perfection shows the lowest contamination levels of both