Table 6.1 AM1.5 cell efficiencies for non-textured BSF cells on tri-Si and mono-Si substrates. Cell area is 103 × 103 mm^2 pseudo square

Material (non-textured)	Thickness average [μm]	Average efficiency [%]	V_{OC} [mV]	I_{SC} [mA/cm^2]	FF [%]	Rho [ohm cm]
Tri-Si	140	15.5	615	33.4	75.5	4
Mono-Si	200	15.2	612	32.7	76	1

6.3 BULK MULTICRYSTALLINE SILICON

Multicrystalline silicon besides monocrystalline silicon represents the basis of today's photovoltaic technology. Multicrystalline silicon offers advantages over monocrystalline silicon with respect to manufacturing costs and feedstock tolerance at, however, slightly reduced efficiencies. Another inherent advantage of multicrystalline silicon is the rectangular or square wafer shape yielding a better utilisation of the module area in comparison to the mostly round or pseudosquare monocrystalline wafers. The efficiencies of multicrystalline silicon solar cells are affected by recombination-active impurity atoms and extended defects such as grain boundaries and dislocations. A key issue in achieving high solar cell efficiencies is a perfect temperature profile of both ingot fabrication and solar cell processing in order to control the number and the electrical activity of extended defects. Moreover, the implementation of hydrogen-passivation steps in solar cell processing turned out to be of particular importance for multicrystalline silicon. With the introduction of modern hydrogen-passivation steps by Si_3N_4 layer deposition, the efficiencies of industrial multicrystalline silicon solar cells were boosted to the 14 to 15% efficiency range and consequently market shares were continuously shifted towards multicrystalline silicon as the standard material of photovoltaics.

6.3.1 Ingot Fabrication

Two different fabrication technologies for multicrystalline silicon, the Bridgman and the block-casting process (see illustrations in Figures 6.6 and 6.7) are employed. In both processes the solidification of high-quality multicrystalline silicon ingots with weights of 250 to 300 kg, dimensions of up to 70 × 70 cm^2 and heights of more than 30 cm have been successfully realised. While the Bridgman technology is a quite commonly used technique, the only two companies mainly employing the casting technology are Kyocera (Japan) and Deutsche Solar GmbH (Germany) [17, 18].

The main difference between both the techniques is that for the melting and crystallisation process only one crucible (Bridgman) is used, whereas for the crystallisation process a second crucible (block casting) is used.

In the case of the Bridgman process, a silicon nitride (Si_3N_4)-coated quartz crucible is usually employed for melting of the silicon raw material and subsequent solidification of the multicrystalline ingot. The Si_3N_4 coating thereby serves as an anti-sticking layer preventing the adhesion of the silicon ingot to the quartz crucible walls that owing to the volume expansion during crystallisation of the silicon material would inevitably lead to a destruction of both the silicon ingot and the crucible. Concerning the block-casting