This in turn verifies the importance of a properly adjusted and controlled crystallisation speed. In order to assure an effective impurity segregation for high-quality multicrystalline silicon, specifically in regions with increased defect densities (e.g. ingot bottom part), solidification at a low crystallisation speed is essential.

6.4 WAFERING

More than 80% of the current solar cell production requires the cutting of large silicon crystals. Multicrystalline ingots grown by the Bridgman or gradient freeze technique now reach cross sections of more than 50×50 cm^2 and weigh over 250 kg; monocrystalline Cz crystals have diameters of up to 20 cm today. While in the last few years the cost of solar cell processing and module fabrication could be reduced considerably, the sawing costs remain high.

Figure 6.14 shows that the sawing costs are a substantial part (29%) of the wafer production cost and thus contribute considerably to the total module cost. Since the sawing of the crystals is connected with high material losses (about 50%), ribbon growth techniques or the thin film technology, which avoid the sawing step, have a high potential for developing cheaper solar cells. However, both technologies still have to overcome serious difficulties and their development will probably take another 5 to 10 years. The present task is therefore to optimise the sawing technique for further cost reduction in mass production.

At the beginning of the PV industry, the available sawing technology of the microelectronic industry was used. The ingots were mainly cut by inner diameter (ID) saws. This technology is, however, relatively slow and not economical for mass production [26]. It was therefore gradually replaced by the multi-wire slicing technology [27]. The advantages are the higher throughput of about 500 to 700 wafers per day and per machine, a smaller kerf loss of about 180 μm and almost no restrictions on the size of the ingots. Currently, wafers between 250 and 350 μm are usually cut, but a wafer thickness down to about 100 μm can be achieved by the technique. Since the technology is relatively new and still under development, most wafer manufacturers have to optimise the sawing process by their own experience. The sawing process depends on several variable parameters as will be described next, which makes it difficult to optimise the process in view of throughput, material losses, reduction of supply materials and wafer quality.

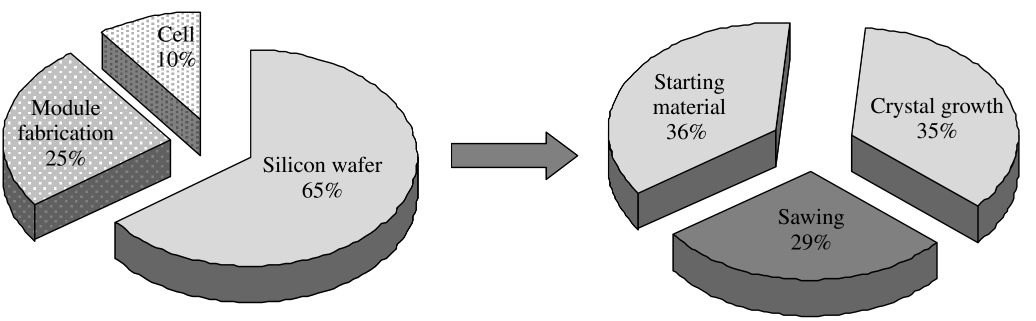

Figure 6.14 Cost distribution for modules and silicon wafers