

Rejects from crystal growth and from polysilicon plants in 2000 account in total for 2500 to 3000 MT at most, whereas the consumption has been at least 3500 MT and most probably 4000 MT. The balance has necessarily been covered by standard semiconductor grade polysilicon, either prime grade or a grade produced on purpose for PV customers by some polysilicon producers. As pointed out the present polysilicon capacity exceeds the actual demand by some 5000 MT. It may therefore be attractive for some producers to offer a solar grade in order to optimise their overall costs by operating their plants at higher capacity. This option will be valid for a few years (2–4) as long as installed polysilicon capacity exceeds the semiconductor demand.

Driven by the semiconductor business, polysilicon capacity will not grow as fast as the solar cell market demand. As the semiconductor market matures, the historical growth rates of 15 to 20% appear difficult to sustain; more conservative annual growth rates of 7 to 10% have been projected. Having gone through several high growth/negative growth cycles, the polysilicon producers are now adding capacity only on demand from the semiconductor industry, with guaranteed supply contracts. The producers attempt to avoid large oversupply and inventories, thereby reducing the quantity of polysilicon feedstock available to the PV industry. An annual growth of 20% is predicted as an average or “business as usual” growth rate for the solar market. The polysilicon feedstock shortage for PV can therefore only become worse. The challenge is to develop an alternative source of silicon feedstock competitive in quality and price. The fast-growing solar cell market needs to have a feedstock supply independent of the semiconductor market cycles and growth limitations.

This source must emerge as soon as possible and no later than 2004 to 2005, when polysilicon capacity has been planned to be fully booked again by semiconductor demand. This source should be readily scalable to provide more than 10 000 MT by 2010 at a price less than half the price of semiconductor grade polysilicon.

5.6 REQUIREMENTS OF SILICON FOR CRYSTALLINE SOLAR CELLS

Before exploring the potential routes to solar grade silicon, it is worth looking at the structural and chemical limitations imposed on silicon to reach optimal performances for crystalline and particularly for multicrystalline solar cells. After a short description of the valid principles of crystallisation, we will examine the effect of various impurities and the effect of structural imperfections.

5.6.1 Solidification

When silicon solidifies, a homogeneous melt will normally not result in a homogeneous solid. Concentration gradients will appear as shown in the Figures 5.6 and 5.7.

A schematic phase diagram of the silicon corner is shown in Figure 5.6. When cooling a melt of composition X_0 , it starts to solidify at a temperature T_0 . At a lower temperature, T_1 , a fraction has solidified. At equilibrium the fractional compositions of