multicrystalline sawn wafers accounted for just half of the single-crystal shipments. In 1998 both technologies were equivalent in size. Two years later, multicrystalline technology surpassed single-crystal technology by 55%.

The consensus is that crystalline silicon is and will remain for at least a long decade the workhorse of this growing market. Long-term visionary forecasts predict that by 2050, 30 000 TWh PV electricity will be generated annually worldwide. This will require an installed PV output capacity totalling approximately 15 million metric tons (MT) of solar grade silicon feedstock, assuming that silicon remains dominant and that cell efficiency and material yields have steadily improved. To build up such a capacity over fifty years will represent an annual production of 300 000 MT solar grade silicon feedstock. The annual present consumption of pure silicon for photovoltaics is approximately a hundredth part of that (i.e. 4000 MT), whereas production of metallurgical grade silicon for all purposes in 2000 was approximately one million metric tons. This clearly poses the question of material feasibility and availability. The present chapter is therefore dedicated to silicon, its extraction, purification and availability by current and future practice.

5.2 SILICON

Silicon (Si) is the second member in the Group IVA in the periodic system of elements. It never occurs free in nature, but in combination with oxygen forming oxides and silicates. Most of the Earth's crust is made up of silica and miscellaneous silicates associated with aluminium, magnesium and other elements. Silicon constitutes about 26% of the Earth's crust and is the second most abundant element in weight, oxygen being the largest.

5.2.1 Physical Properties of Silicon Relevant to Photovoltaics

Silicon is a semiconductor with a band gap E_g of 1.12 eV at 25°C. At atmospheric pressure, silicon crystallises into a diamond cubic structure, which converts into a body-centred lattice when subjected to ca 15 GPa. Under some circumstances, slow-growing

silicon the balance, that is, close to 90% of which 49% (141 MW) are cells made of multicrystalline sawn wafers, 31% (90 MW) of single-crystal wafers and 10% (28 MW) are cells based on various crystalline silicon technologies, for example, ribbon (15 MW or 5.1%), amorphous silicon on single-crystal silicon slices (12 MW or 4.2%) and others (approx. 1 MW or 3.5 per thousand).

Solar Modules Shipment by Technology (Source: PV News 2001)

Technologies	Shipped output in 2000
Amorphous silicon	27 MW (9%)
Single crystal silicon wafers	90 MW (31%)
Multicrystalline sawn silicon wafers	141 MW (49%)
Various crystalline silicon technologies (i.e. ribbon, films, amorphous on single crystal)	28 MW (10%)

Other sources available in May–November 2001 at the time of writing this chapter, such as the German magazine Photon International March 2001 published congruent data for the same period. Statistics from non-commercial entities as those edited by the International Energy Agency (IEA-PVPS programme) covering 21 industrialised countries, members of the OECD-organisation, show over years the same trends [1–4].