Table 5.3 Solar modules shipment by technology Source: PV News 2001, Reference [1]

Technology	1998 [MW]	1998 [%]	2000 [MW]	2000 [%]
Single-crystalline silicon wafers	61.5	39.7	89.7	31.2
Multicrystalline silicon wafers	67.0	43.3	140.6	48.9
Ribbon/multicrystalline silicon film	6.0	3.8	16.7	5.8
Amorphous silicon/single-crystalline silicon	–	–	12.0	4.2
Amorphous silicon	19.0	12.3	27.0	9.4
Others	1.4	0.9	1.7	0.6
Total terrestrial PV shipments	154.9	100	287.7	100

(i) Amorphous silicon. Monosilane (SiH_4) is the source of silicon required for the deposition of silicon amorphous thin film in a glow discharge or low temperature plasma. Silane is mass-produced by the Union Carbide (ASiMI) and Ethyl Corporation (MEMC) methods, which are described above. The global annual output capacity is approximately 7000 MT including minor volumes produced in Japan. The major part of it is used to produce polysilicon on site (United States), the balance being sold through distributors, for example industrial gas companies, to a vast group of customers. The worldwide silane market for silicon films in the semiconductor, PV, glass and ceramic industries is about 500 MT. Applications include passivating and semiconducting layers for integrated circuits, epitaxial films, architectural glass coatings, special ceramics, surface treatment and amorphous silicon. Silane is available in quantities and purity exceeding the need of the PV market. Quantity and cost of silicon is of less importance for amorphous silicon since the specific consumption per watt output is 50 to 100 times less than that for crystalline silicon cells, that is, 100 to 400 mg/W versus 10 to 20 g/W.

(ii) Crystalline silicon. Regardless of the technology, significant quantities of silicon are required to produce multicrystalline silicon solar cells. In the present stage of the technology, 15 to 17 g/W (estimated average value) are consumed. In 2000 this had represented a quantity of approximately 4000 MT. It is expected that this specific consumption per watt will decrease with technology improvement. Firstly, up to 60% of the purchased silicon feedstock is presently wasted during the manufacturing process. Secondly, the thickness of the silicon wafer is unnecessarily high with respect to light conversion. It is presently a mechanical requirement for the further handling of the wafers and the cells. Assuming continuous growth at the same level as during the last decade, several market forecasts predict that the requirement for silicon feedstock will in 2010 reach at least 12 000 MT. If the growth is accelerated as the more recent trends seem to show, the volume demand may be as high as 30 000 MT.

Commercial silicon bulk material is of two types:

- The metallurgical grade, global annual output: 1 million MT, price 0.8 to 1.5 US$/kg.
- The semiconductor grade, global annual output: 20 000 to 25 000 MT, price 35 to 55 US$/kg.

Chemical purity of typical metallurgical grade is given in Table 5.2. For some price premium, silicon producers could upgrade it to higher purity by metallurgical treatment