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Semiconductor Industry Steps Into the Solar PV Market

By Craig Addison and Eddy Blokken

The solar photovoltaic (PV) market has demonstrated an aggregated global growth rate of more than 40 percent per annum over the last 10 years. Few industries can boast equivalent numbers, but solar PV has two big challenges ahead. Production costs need to go down in order for it to become more economically sustainable, while production capacity must continue to grow in order for PV to become a significant player in the global energy market.

In order to make the PV industry viable in the long run, the price of electricity per energy unit (cost/kWh) generated by a photovoltaic system needs to be comparable to the electricity market price during peak time. This cost target is 20 Eurocents/kWh. In order to achieve this, significant efficiency improvements are needed in the production process, as well as in balance-of-system costs such as rectifiers and installation.

Over the past four decades the semiconductor industry has developed enormous know-how about silicon in its different forms, as well as its interaction with other materials, such as aluminum and copper. This knowledge is very useful in analyzing the behavior of silicon-based solar cells and in optimizing their efficiencies. For example, the Belgium-based research institute IMEC is using knowledge from advanced deep-submicron research for its own work in thin-film PV cells. The understanding of epitaxial growth of silicon and its interaction with the substrate has enabled IMEC to grow large silicon crystals on low-cost substrates, enabling efficient PV cells at a significant lower cost.

Chip equipment manufacturers are also using their experience from the semiconductor industry as a basis for entry into the PV market. In September 2006 Applied Materials announced the acquisition of Applied Films, an expert in PVD systems for the deposition of thin coatings on different substrates. This technology is used to coat architectural glass with heat reflecting films or plastic foils with a thin layer of aluminum. This kind of technology is also applicable for the creation of thin-film PV systems on architectural glass, or in the future even roll-to-roll photovoltaic foils. The latter case is perceived as the ultimate low-cost PV system of the future.

However, entering the PV field is not necessarily a “free lunch” for semiconductor players because major research is needed to adapt semiconductor processes to the manufacturing needs of PV. Microelectronics has traditionally been a batch-based process which allows the manufacturer to process different devices in the same production line, keeping setup time to a minimum. In PV manufacturing, maximizing throughput at a predefined process quality is the main objective. Batch processes are inherently less efficient than continuous systems because of the queuing of batches between the process steps.

Since 2005, demand for silicon has increased significantly in the PV industry, even overtaking the capacity needs of the semiconductor industry. This has resulted in unprecedented high prices for silicon on the spot-market as well as PV production facilities working at less than full capacity. To address this problem, the PV industry saw the need to agree on long-term capacity forecasts in order to secure the raw material for their production lines. Because it takes about two years to build additional raw silicon capacity, it will likely be 2008 or beyond before silicon prices return to normal, which is between US$30-40/kg for solar-grade silicon. An additional advantage of this evolution is that more solar-grade production will become available, which will be cheaper than the semiconductor grade silicon because purity requirements are less stringent for the PV industry.

Another interesting development is the use of cheaper alternative techniques to create solar grade silicon. Some suppliers are commercializing a chemical purification method that claims to be significantly less expensive than traditional methods. Dow Corning announced recently that it is offering solar grade silicon derived from metallurgical poly-silicon feedstock. As production cost can be lower for this process, it offers opportunities to lower the overall cost of the PV cell once sufficient solar grade silicon feedstock is available. At this moment however it is still unclear what the effect on cell efficiency will be if such new material is used.

In 2005, Sharp of Japan was the only PV-cell manufacturer that had more than 400 MW/year production capacity, equivalent to about a 25 percent market share. Second was Q-Cells of Germany, with 160 MW/year. Q-Cells expects to cross the 400 MW/year threshold in 2007, as do Japanese companies Kyocera and Sanyo. Industry experts believe that within four years leading PV cell makers could be operating facilities with capacities of 500 MW/year, which is considered the threshold for the manufacture of economically viable PV cells.

Some analysts predict that a consolidation of current PV players will take place in the next 5 to 7 years. In the more distant future, we can expect to see a market consolidation in several parts of the value chain of the industry where a handful of players will produce the bulk of commodity solar cells, while smaller players will migrate to specialized niche products.

Another challenge facing the industry is the lack of technical standards. Because several of the larger PV cell manufacturers are vertically integrated they have developed proprietary in-house standards. However, as new players enter the market they will look to third party equipment suppliers in order to build a complete production line. This approach can only succeed if industry standards are agreed upon for the interfaces that are used by these systems. This can be in the form of simple agreements -- such as the height and other dimensions of the input and output for a continuous flow system -- or more sophisticated interfaces, such as machine-to-machine interfaces and their related software protocols for the advanced process control of the full production line.

Beyond standards, there are production improvements that can be made in order to increase the economic viability of PV solar cells. There is still scope to decrease the thickness of the wafers which in turn would increase the output of the industry. For example, if the silicon used for crystalline silicon cells can be reduced by 30 percent the PV industry could produce 8.5 GWp/year of capacity instead of 5.6 GW/year -- from the same amount of feedstock. However, there are limiting factors such as the bending and breaking of cells during the manufacturing process, and the recombination of electrons that migrate through the cell to the contacts at the back.

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