Squeezing more out of modules

Many industries have, not surprisingly, attempted to talk themselves out of the global downturn, but very few have the statistics to back up their optimism. Thankfully, the PV industry is one of this select few. And it seems as if module production is leading the charge…

Last year, PV panel makers and their suppliers were feeling the recession's bite and wondering whether the industry could survive. But unexpectedly strong demand in Germany and the rest of Europe pulled solar manufacturers out of their decline. And according to research, global solar panel shipment in the second quarter of 2010 is up 92 per cent from a year ago.

Solar panel makers shipped 3.7 gigawatts of solar panels in the second quarter and generated $7.1 billion in revenue in the process, according to research institute IMS. And there is hope that 14.6 gigawatts of solar electricity generation capacities will be added worldwide this year, almost doubling the capacity added in 2009.

The dramatic increase in manufacturing over the past year is inevitably throwing up innovative and more efficient methods of module production. For example, new research from the Technical University of Delft, Netherlands, has found that using hydrogen in the production of amorphous silicon, or "thin-film," cells can increase their efficiency from the usual seven per cent to roughly nine per cent.

Researcher Gijs van Elzakker simply diluted the silane gas already used to produce the solar cells with hydrogen to achieve the results, meaning that the improvement is essentially free. Elzakker has already taken his findings to the German company Inventux Technologies, where he works.

However, the basic process of PV module manufacture remains constant. To make solar cells, the raw materials—silicon dioxide of either quartzite gravel or crushed quartz—are placed into an electric arc furnace, where a carbon arc is applied to release the oxygen. The resulting pure silicon is then treated with phosphorous and boron to produce an excess of electrons and a deficiency of electrons respectively to make a semiconductor capable of conducting electricity. The silicon disks are shiny and require an anti-reflective coating, usually titanium dioxide.

The solar module consists of the silicon semiconductor surrounded by protective material in a metal frame. The protective material consists of an encapsulant of transparent silicon rubber or butyryl plastic (commonly used in automobile windshields) bonded around the cells, which are then embedded in ethylene vinyl acetate. A polyester film (such as mylar or tedlar) makes up the backing. A glass cover is found on terrestrial arrays, a lightweight plastic cover on satellite arrays. The electronic parts are standard and consist mostly of copper. The frame is either steel or aluminium. Silicon is used as the cement to put it all together.

The completed semiconductors must then undergo electrical tests to see that the current, voltage, and resistance for each meet appropriate standards. An earlier problem with solar cells was a tendency to stop working when partially shaded. This problem has been alleviated by providing shunt diodes that reduce dangerously high voltages to the cell. Shunt resistance must then be tested using partially shaded junctions.

The final test for solar modules is field site testing, in which finished modules are placed where they will actually be used. This provides the researcher with the best data for determining the efficiency of a solar cell under ambient conditions and the solar cell's effective lifetime, the most important factors of all.

The process of laminating is one of the key manufacturing stages for PV modules and has a distinct bearing on their quality and longitude. Solar module manufacturers need optimal laminating conditions which ensure that the module is protected against the weather, particularly moisture.

A recent get-together of PV manufacturers and customers in Switzerland, at the invitation of 3S Swiss Solar Systems, a group company of Meyer Burger Technology AG, saw an important exchange of know-how in the process of laminating. The focus was on the latest technological developments for the industrial structuring of the process and, en route to future mass production of solar modules in gigawatt-production facilities, discussions focused on the process and machines being further optimised and new machinery concepts developed.

The latest laminating lines from 3S Swiss Solar Systems are based on a process with three chambers and enable a five-minute cycle in the production of solar modules.

"With our new laminating process, we have been able to significantly improve the one that has existed until now and achieve a cost-optimised, stable, reliable process with highest throughput", says Ronald Lange, Chief Innovation Officer at 3S Swiss Solar Systems. "Nevertheless, the future of solar module production will very soon lie in production lines of gigawatt size. For those new dimensions, we are today developing the appropriate machinery concepts by going completely new ways.

"We can only research and design future solutions for efficient and low-cost solar module production if we do it together with our customers, scientists and other partners from the solar industry. In our view, those future solutions will go far beyond the design of the solar modules that we know today. It will be exciting to see how the solar module of the future will look and with which technologies solar module producers will structure their manufacturing in times of grid parity."

Of course, the innovations in module production aren't restricted to Europe. Chinese company JA Solar Holdings Co. Ltd. has recently partnered with the Energy Research Centre of the Netherlands (ECN) to introduce the metal wrap-through (MWT) solar cell and module technology into production.

Through this partnership, JA Solar and ECN are working together to produce cost-effective, high-efficiency solar modules. The MWT technology minimises shading loss at the front cell surface, resulting in an increased active front-surface area of the solar cell. Modules can be assembled in a fully-automated process with Eurotron equipment.

This technology allows handling of thin solar cells at high throughput and yield. ECN has recently manufactured high-efficiency MWT solar modules, achieving an efficiency in 2009 of 17 per cent (aperture area) for photovoltaic modules with multicrystalline silicon cells.

The role of the laser is also an integral part of the manufacturing process, employed as they are for cutting, drilling, texturing, soldering, edge isolation and tabbing crystalline silicon PV; and for scribing, patterning, edge cutting and edge deletion on thin-film PV.

Many of these applications are being studied by the EU-funded Solasys ("Next Generation Solar Cell and Module Laser Processing Systems") project, which involves 10 organisations from six European countries. However, while

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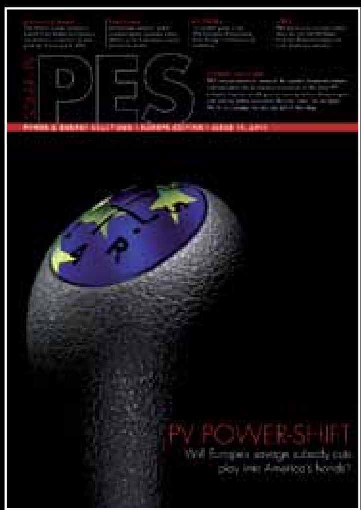

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some applications have become routine and are now widely used, such as edge isolation on c-PV and edge deletion on TF-PV, many are still either experimental or used only on specific designs or by particular cell manufacturers. Nevertheless, PV production processes are continually improving and several laser applications, now at the R&D stage, are likely to move into volume production within the next few years. Consequently, many of the world's leading laser manufacturers have developed systems for this industry including Coherent, Oxford Lasers, Rofin, JPSA, Spectra-Physics/Newport and Trumpf, a participant in the Solasys project.

Coherent has recently launched a new range of laser workstations for the PV market, which include the Aethon, which is aimed primarily at R&D and process development applications, and the Equinox family, employed in production-optimised, high throughput uses. Both can be equipped with a range of different diode-pumped solid-state lasers and are used in a variety of c-PV applications such as edge isolation, dielectric ablation, laser drilling and dopant diffusion. In January of this year, Coherent announced that it had received multiple orders from c-PV cell manufacturers for laser-based process tools, valued at more than $20 million, just three months after releasing the Equinox and Aethon products.

Edge isolation is one of the better established applications and involves the use of green or UV nanosecond laser pulses to scribe narrow grooves, which are typically 30-50 µm wide and 5-10 µm deep, between the finger grid and the cell edges. This is to prevent a short circuit between the active and back sides of the cell. Typical edge isolation scribing speeds are between 400 and 800 mm/second.

One of the as yet non-routine applications is laser drilling in wrap-through PV designs. These are one of several emerging approaches to achieving improved conversion efficiency. Here conductive pathways (vias) are drilled through the c-PV silicon substrate to allow contacts to be located at the rear of the cells. In the case of the


PV production processes are continually improving

metal wrap-through, 25-50 holes with diameters ranging from 300 µm to 500 µm are drilled into each cell and filled with a conductive material. In emitter wrap-through cells, the negatively doped layers are transferred to the rear of the cell and approximately 15,000 holes with diameters of 60-70 µm are drilled. Q-switched disc lasers are frequently used for this application and can achieve throughputs of up to 5,000 holes/second.

Another laser-based approach to enhancing efficiency in c-Si cells is the laser doping of selective emitter (LDSE) process. LDSE can improve the efficiency of these cells by 1.5 to two per cent through the creation of self-aligned, highly conductive front contacts with minimal shadowing.

The key factors driving PV developments are reducing material and manufacturing costs and improving conversion efficiency and lasers can contribute to meeting both of these aims. According to Herman Chui, Director of Product Marketing at Spectra-Physics, in addition to growth in existing application, the search for cost reductions will continue to drive the use of lasers. This may arise from laser systems allowing better throughputs and higher yields and perhaps also aid the use of new materials. With new applications under way in both c-Si and TF technologies, lasers will become increasingly important to solar cell manufacture.

All of which is good news for companies like Japan-based Sanyo, which is being forced to squeeze more capacity from its PV production plants Nishikinohama and Shiga due to PV module demand. A further 5MW per annum is expected from its plant in Nishikinohama due to productivity improvements from existing lines, taking capacity to 40MW. The main increase comes from its plant in Shiga, which will reach a capacity of 250MW by March, 2011. The Shiga plant is currently undergoing a 100MW expansion, doubling capacity but a further 50MW is now planned by adding more lines at the facility in the same timeframe.

Overall, Sanyo is planning on almost doubling its HIT solar cell production capacity to 600 MW, by March 2011. Current capacity stands at 340MW, according to the company.

Sanyo said that the Japanese market was expanding rapidly due to installation subsidies from the national and prefectural governments, as well as the national government's new surplus electricity purchasing programme for solar power. ■