Beacons of hope for photovoltaics

Drastic cuts to subsidies in many European countries are forcing the solar industry to implement immediate cost reductions. This has resulted in a greater focus on multi-crystalline silicon cells again, a technology that delivers value for money and an efficiency that can be increased with relatively little effort. Sebastian Pflügge and Brigitte Küppers report.

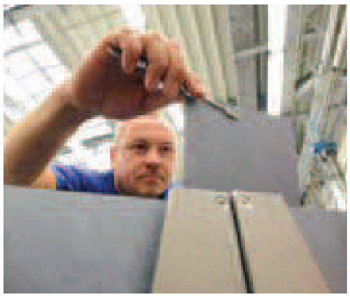
Technology should no longer be an issue. When there was growing demand for photovoltaic systems in the 1990s, solar cells made from multi-crystalline silicon were already regarded as obsolete. These cells were too bulky and their average efficiency of a mere 10% was inadequate. Soon therefore, they were replaced by thinner and more powerful absorbers.

In the 1990s, the US government invested over a billion dollars in the development of thin-film cells and multiple cells. While thin-film cells aroused considerable interest in research due to their reduced material requirements, multiple cells fascinated researchers with their high level of efficiency. Under this technology, nearly 40% of light is converted to electricity, involving the use of up to five different layers of semi-conductors.

At the same time, in Japan, research concentrated on pure mono-crystalline silicon. Take, for example, so-called heterojunction cells (HIT); to avoid loss of charge carriers, they are additionally surrounded by a further protective layer of amorphous thin-film silicon and achieve efficiency levels of over 20%. In Germany, on the other hand, companies continued to work with multi-crystalline silicon despite reservations. "Industry in this country invested not so much in revolutionary cell technologies but more in the evolution of existing methods" says Eicke Weber, head of the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg. With hindsight, it has since then become obvious that this was intuitively the right way forward. Multi-crystalline cells are still dominating photovoltaics, according to market researcher Navigant Consulting, with a 47% market share that is clearly ahead of mono-crystalline cells (38%). These are followed at quite some distance by thin-film cells, with a share of 14%, while multiple cells do not figure in market statistics at all.

UNDERESTIMATED TECHNOLOGY

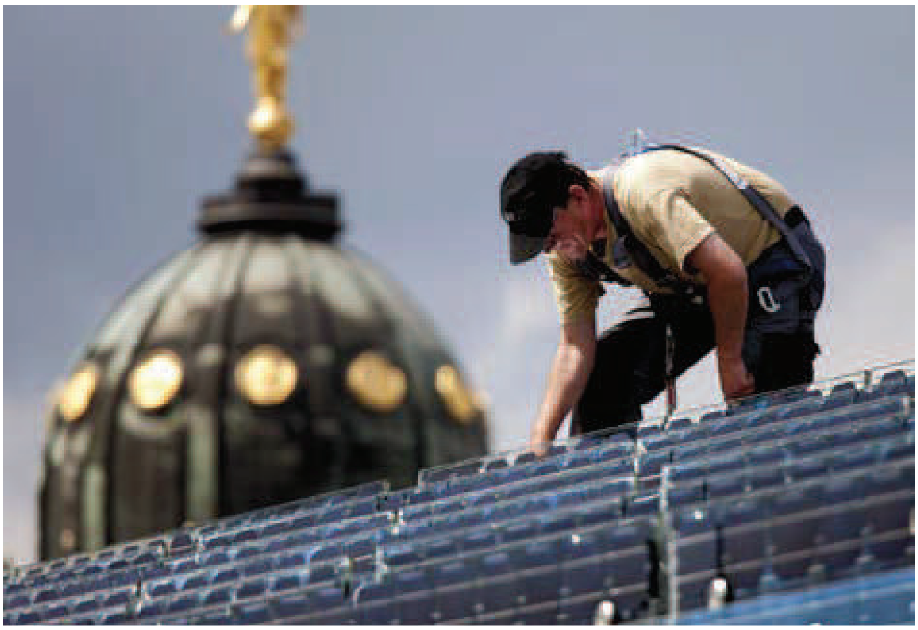
So far, however, there has been no way round multi-cells. The reason is quite simply that innovations tend to arise much faster here than in any competing technologies. "Over the last 10 years, average efficiency has gone up from 10% to 15%" the ISE's Eicke Weber confirms. At the same time, material requirements have gone down. In fact, silicon wafers are 0.2mm in thickness, which is about a third less than 10 years ago. Also, standard multi-crystalline cells are easier to make than the latest products. This means that manufacturing lines can be set up quickly and the effects of scale can be achieved through greater production volumes.



It is only through so-called texturising that the silicon wafers receive their characteristic blue colour (Solarworld).

Thanks to improved and increasingly bigger volumes, costs have gone down dramatically. In February 2011, the online platform pvXchange published wholesale prices of about €1.70 per watt for crystalline modules made in Germany. Since then, manufacturers have reduced their prices by about a third, to €1.10 per watt. And this technology is set to become even cheaper. "I am confident" says Eicke Weber "that the efficiency of multi-crystalline modules can be increased to 20%." Any rise in efficiency automatically leads to a drop in material requirements and costs.

Considerable innovation potential can undoubtedly also be observed in thin-film and multiple cells, although technical progress is slower in this area. For example, thin-film cells



Crystalline silicon cells are leading the way in Germany's photovoltaics. A solar power plant is being installed on the roof of the Germany Ministry of Justice (Justizministerium/Paul Langrock).

Originally published in Glass Worldwide, preferred international journal of AIGMF

based on semi-conductors – ie copper, indium and gallium (CIS) – reached 13% but failed to undercut their crystalline competitors and CIS modules are still €1.50 per watt, according to pvXchange. "Developing larger production capacities for CIS is more difficult than expected" admits thin-film expert Michael Powalla from the Centre for Solar Energy and Hydrogen Research in Baden-Württemberg. Even multiple cell production lacks economic efficiency, due to its low level of automation.

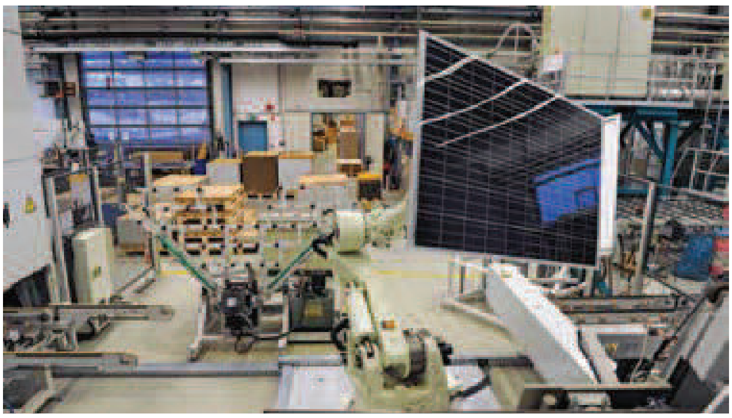
The problem is that the solar industry is running out of time to be competitive with photovoltaics. Nearly everywhere in Europe, countries with feed-in tariffs for solar power have radically cut those tariffs because the increase in solar installations was getting out of control. In Germany, for example, the solar power feed-in tariff is set to be reduced by up to 40%, according to the latest plans of the German government. "Anyone wanting to survive in this difficult market will need to cut their prices even more radically" says analyst Mathias Fawer from the Swiss bank Sarasin.

NO TIME FOR EXPERIMENTS

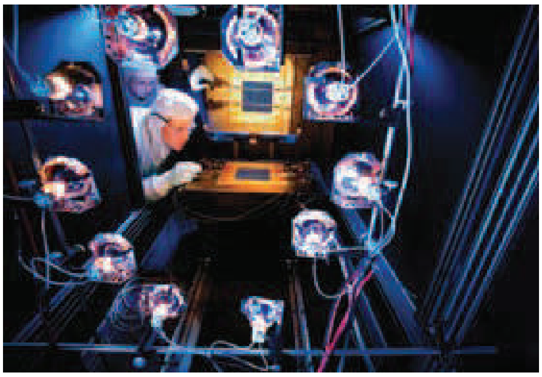
Today, multi-crystalline cells are the most appropriate technology for their purpose because they display the steepest learning curve. Germany's solar equipment manufacturers are the technology leaders in multi-crystalline technology and are aware of the decisive elements that are required for further innovations. Companies such as Bürkle, Centrotherm and Grenzebach provide equipment for all areas of the crystalline value chain, from silicon production to the manufacture of modules. Their machinery and automation solutions ensure fast gains in efficiency and reductions in production costs.

From 23 to 26 October 2012, at solarpeq, the international trade fair for solar production equipment and the parallel glasstec event, manufacturers will have opportunities to learn about their suppliers' innovative products and about cost reductions which they might achieve through them. Moreover, at glasstec, numerous exhibitors will present solutions for the use of solar end products in building envelopes.

One promising technology which is currently moving into many factories is multi-crystalline cells with passivated emitter and rear contact (or PERC cells, for short). In today's commonly available standard cells, electrons migrate towards the negative terminal at the front and electron holes migrate towards the positive terminal at the rear. The electric current flows off via an aluminium contact, which covers a large part of the wafer. Although the aluminium ensures good contact with the positive terminal, direct contact between the metal and the semi-conductor means that negative and positive charge carriers cancel each other out on this border; they 'recombine', as it were. Developers therefore use a simple trick: They replace the aluminium with a coat that reduces any loss of current; a so-called dielectric passivation layer, which may consist of silicon nitride, silicon oxide or aluminium oxide. However, the disadvantage of such coats is that they are non-conductive and therefore need to be open in several places in order to take through the metal power connectors and combine them with the semi-conductor.



Automation can lead to a clear reduction in manufacturing costs. Therefore, photovoltaics manufacturers use state-of-the-art equipment (image: Solarworld).



There is no other country where multi-crystalline cells have been researched as thoroughly as in Germany (image: Fraunhofer/Thomas Ernsting).

MULTI-LAYER DEVELOPMENTS

Thanks to Perc, Schott Solar, for example, has reached a module efficiency of 18%. However, the company wants to go one step further and make these cells from so-called quasi-mono silicon in the future. This semi-conductor, which is a multi-crystalline silicon, is regarded as a springboard into competitiveness within the industry. Like simple multi-crystalline material, it is made in crucibles, although it has the properties of the mono-crystalline material, which is of a higher quality. "We're hoping to boost efficiency by up to 2%, while keeping production costs at the same level" comments Schott Solar's Head of Development, Klaus Wangemann.

Normally, silicon is melted in a special crucible and is subsequently cooled down in a controlled manner. With ingot casting for multi-crystalline blocks, the crystals align themselves in different directions. So-called grain boundaries form in the spaces between them, ie the kind of irregularities that reduce the electric power output. Schott therefore, wants to insert a plate of mono-crystalline silicon at the bottom of the crucible, as seed crystals. When the semi-conductor cools down, it solidifies on this crystal and largely adopts its alignment. This avoids efficiency-reducing defects in the material. Schott is hoping to use its quasi-mono material in cells for the first time in 2013.

Finally, with decreasing costs of material and production, a technology is now attracting attention among manufacturers that has so far been avoided, as production was relatively difficult; so-called metal-wrap-through (MWT) cells. Under this method, which was developed by the Dutch energy researcher ECN, the busbars are led through internally, at the rear. As a result, there are not as many conductor paths on the front that might keep the light from the cells. This leads to an increase in efficiency and makes it possible to use better production methods for the modules.

As many as five companies – Schott Solar, Bosch Solar, Ja Solar, Kyocera and Canadian Solar – now want to mass-produce this equipment, understandably so, as it allows modules with an efficiency level of up to 16%. It means that multi-crystalline technology is moving into an efficiency range that has so far been reserved for more expensive mono-crystalline modules. ■

ABOUT THE AUTHORS:
Sebastian Pflügge and Brigitte Küppers are responsible for solarpeq 2012 publicity

FURTHER INFORMATION:
solarpeq 2012 exhibition, Düsseldorf, Germany
web: www.solarpeq.de

glass WORLDWIDE

Originally published in Glass Worldwide, preferred international journal of AIGMF