

Berlin in blue: Crystalline silicon cells are leading the way in Germany's photovoltaics. A solar power plant is being installed on the roof of the German Ministry of Justice

BEACONS OF HOPE

Multi-crystalline Solar Cells Drastic cuts in 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 easily be increased with relatively little effort.

Technology should no longer be an issue. When there was a rising demand for photovoltaic systems (PV 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 ten percent was inadequate. Quite soon therefore they were replaced by thinner and more powerful absorbers. In the 1990s the US government invested over a billion dollars of funding in the development of thin-film cells and multiple cells. While thin-film cells aroused con-

siderable interest in research due to their reduced material requirements, multiple cells fascinated researchers with their high level of efficiency. Under this technology, nearly 40 percent 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 instance, 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 percent. 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," said 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 researchers Navigant Consulting, with a 47 percent market share that is clearly ahead of mono-crystalline cells (38 percent). These are followed at quite some distance by thin-film cells, with a share of 14 percent, while multiple cells do not figure in market statistics at all.

Underestimated Technology

So far, however, there has been no way round multi-cells, and the reason is quite simply that innovations tend to arise much faster here than in any of the competing technologies. "Over the



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Promising Outlook

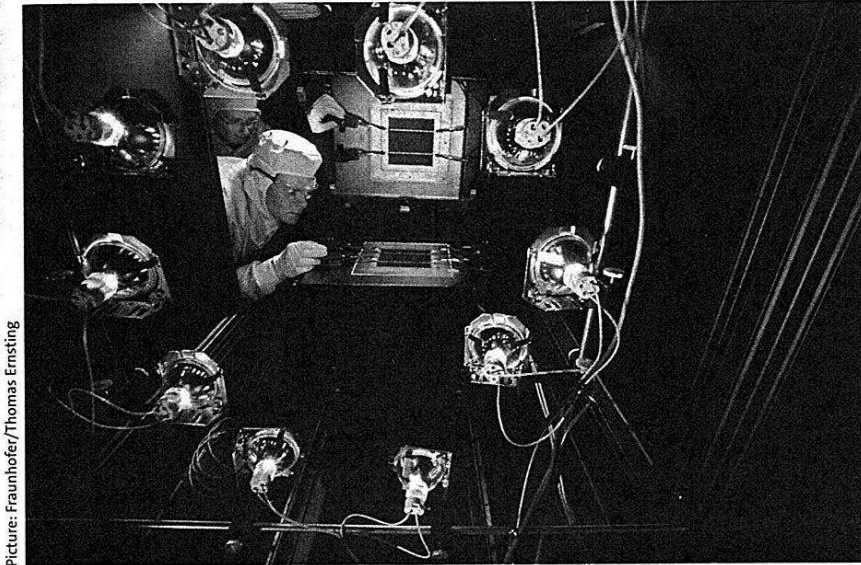
- Multi-crystalline cells are still dominating photovoltaics with a 47% market share.
- So far, however, there has been no way round multi-cells, because innovations tend to arise much faster here than in any of the competing technologies.
- Experts estimate that the efficiency of multi-crystalline modules can be increased to 20%.
- One promising technology which is currently moving into many factories is multi-crystalline cells with passivated emitter and rear contact (PERC).

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 instance, the solar power feed-in tariff is set to be reduced by up to 40 percent, 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

From today's point of view 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



Picture: Fraunhofer/Thomas Ernsting

A much-coveted trial object: There's no other country where multi-crystalline cells have been researched as thoroughly as in Germany.

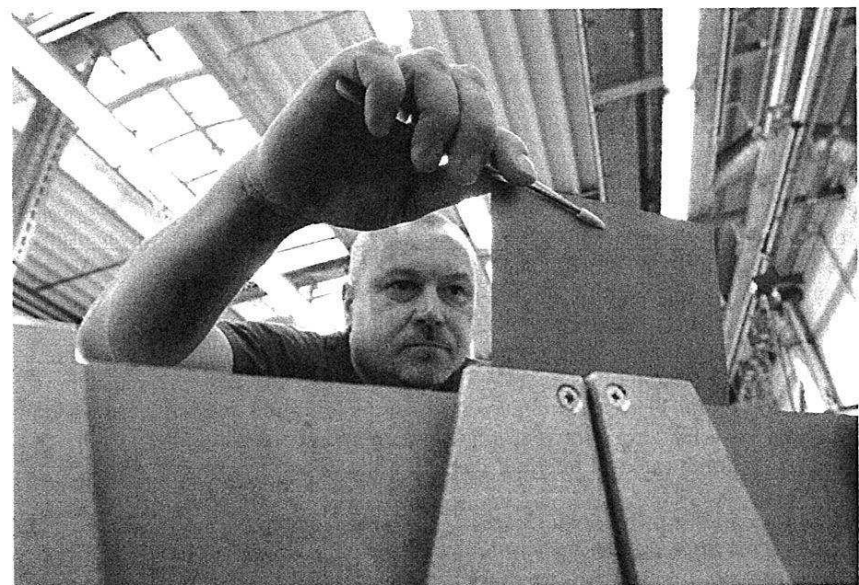
last ten years average efficiency has gone up from ten to 15 percent," says Weber. At the same time material requirements have gone down. In fact, silicon wafers are 0.2 millimetres in thickness, which is about a third less than ten years ago. Also, standard multi-crystalline cells are easier to make than the new products. This means that manufacturing lines can be set up quickly and effects of scale can be achieved through bigger production volumes.

Thanks to improved and increasingly bigger volumes, costs have gone down dramatically. In February 2011 the online platform PV-Xchange published wholesale prices of about EUR 1.70 per watt for crystalline modules made in Germany. Since then manufacturers have reduced their prices by about a third, to EUR 1.10 per watt. And this technology is set to become even cheaper. "I am confident," says Weber, "that the efficiency of multi-crystalline modules can be increased to 20 percent." 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 instance, thin-film cells based on semi-conductors – for example copper,

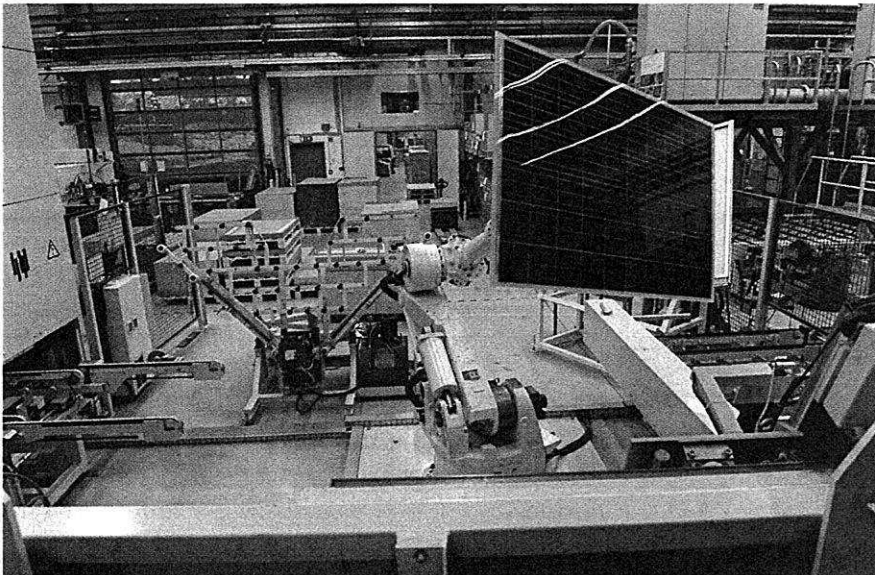
indium and gallium (CIS) – reached 13 percent but failed to undercut their crystalline competitors, and CIS modules are still EUR 1.50 per watt, according to PV-Xchange. "Developing larger production capacities for CIS is more difficult than expected," admits thin-film expert Michael Powalla from the Centre for Solar Energy and Hydrogen Research in Baden-Württemberg. Even multiple cell production lacks economic

"So far there has been no way round multi-cells"



Picture: Solarworld

Blanks for cells: It is only through so-called texturing that the silicon wafers receive their characteristic blue colour.



Greater speed – lower costs: Automation can lead to a clear reduction in manufacturing costs. Photovoltaics manufacturers therefore use state-of-the-art equipment

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,

ble 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

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from silicon production to the manufacturing of modules. Their machinery and automation solutions enable fast gains in efficiency and reductions in production costs.

From 23 to 26 October, at Solarpeq, the international trade fair for solar production equipment, and the parallel event Glasstec, the world’s leading trade fair for the glass industry, 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 be presenting solutions for the use of solar end products in building envelopes, as this biggest exhibition in the glass industry also attracts a large number of architects and building designers.

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 availa-

wafer. Although the aluminium enables excellent 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 new 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.

A Range of New Multi-systems

Thanks to Perc, Schott Solar, for instance, has reached a module efficiency of 18 percent. However, the company wants to go one step further and make these cells from so-called quasi-mono

silicon in the future. This new 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 two percent while keeping production costs at the same level,” says 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, for example 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 researchers 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 new equipment. Understandably, as it enables modules with an efficiency level of up to 16 percent. It means that multi-crystalline technology is moving into an efficiency range that has so far been reserved for more expensive mono-crystalline modules.

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