

Technology Highlights 2018

Increments and innovations: Whether a tweak to push faster throughputs or higher efficiencies from an already proven process, or a bold new step into unknown territory, innovation is the force behind solar's phenomenal growth in recent years; and will continue to cement its position as a clean and commercially viable source of energy.

The fourth edition of **pV magazine's** Technology Highlights counts down some of the top new and improved products and processes from across the upstream supply chain, from polysilicon production down to post assembly module testing, all of which have made a valuable contribution to boosting solar's potential, and pushing down its prices.

A jury of experts from across the industry, assembled by **pV magazine**, has

reviewed and ranked 25 entries. Of these, six were chosen as finalists to be further picked over by the assembled experts who, after plenty of discussion and deliberation, selected the technologies named below for recognition as the top Technology Highlights of 2018.

The six finalists will automatically be candidates for the inaugural **pV magazine** award, to be given at the end of the



year. The recipient of this award will be chosen from the top submissions to multiple features running throughout the year, covering all of the biggest industry segments.

Photo GT Advanced Technologies



Top innovation:

GT Advanced Technologies Polysilicon Tube Filaments

Runner up:

3D-Micromac Microcell OTF

Photo: 1366 Technologies



Technology to Watch:

1366 Technologies Direct Wafer Process

Photo: 3D-Micromac



pV magazine would like to thank all of the companies that took the time to share details of their latest innovations with us, and the jury members for sharing their valuable time and considerable expertise.

The Award Jury



Andrew Blakers

Andrew Blakers is a Professor of Engineering at Australian National University.

His research interests include photovoltaic and solar energy systems, concentrator solar cells, components, and systems, and sustainable energy policy.

“One thing that comes out of being involved in awards like this is to see that there is no end in sight to the cost reductions in a silicon solar cell.”



Peter Fath

Fath is Managing Director of RCT Solutions, and Chair of the Solar Equipment Machine Maker Group at the German Engineering Federation (Verband Deutscher Maschinen- und Anlagenbau). Fath has held senior positions with equipment makers including Rena GmbH and centrotherm, and lectures on manufacturing technology in PV at leading institutes including the University of Stuttgart and University of Applied Science, Ravensburg.



Rainer Gegenwart

As CTO at Phanes Group, Gegenwart is responsible for a diverse pipeline of PV projects with a focus on the Sub-Saharan Africa and MENA regions. Gegenwart also leads the team to develop off-grid and hybrid solar solutions. Previously, he was Managing Director at ANTEC Technology and between 2003 and 2005, he oversaw the setup of First Solar in Germany. He also founded cleantech advisory and project development company Heliosmax in 2010.



Pierre J. Verlinden

Verlinden is Managing Director of PV consulting firm Amrock. Verlinden has worked in PV for more than 39 years, and published over 200 technical papers. From 2012 to 2018, he was Vice President and Chief Scientist at Trina Solar, and Vice Chair of the State Key Laboratory of PV Science and Technology. Verlinden received the 2016 William Cherry Award, from the Institute of Electrical and Electronic Engineers (IEEE), one of the highest distinctions in PV research.



Xiaoting Wang

Xiaoting Wang is an Energy Specialist at Bloomberg New Energy Finance, and has been conducting research into the PV industry since 2012.

In total, Xiaoting has published more than 100 insight notes. The scope of her research and expertise covers the global PV supply chain, including supply-demand relationships, cost and price variations, technological progress, and the impacts of international trade disputes.



Edurne Zoco

Edurne Zoco is Research Director, Solar & Energy Storage at IHS Markit. Her main focus areas include module intelligence services, which track PV manufacturing trends and monitor the module and polysilicon supply chain to develop detailed analysis and projections.

Zoco has been involved in solar for more than a decade, offering insights and market data to develop company individual growth strategies, market entry plans, and competitive analysis.

1

GT Advanced Technologies Polysilicon Tube Filaments**Reducing energy consumption and increasing productivity**

GT Advanced Technologies (GTAT) is bringing its Tube Filaments to the polysilicon production market, a solution which it says can reduce the energy needed in Siemens process polysilicon production by as much as 20%, while increasing annual production rates by more than 30%.

According to GTAT, the tube filaments function as a direct replacement for the standard filaments used in any Siemens process reactor. This means that manufacturers will be able to take advantage of the improved performance, without any disruption to their production, or any need to invest in expensive new machinery. The company claims that by leveraging all of the benefits of its tube filaments solution, capacity improvements of 75% or higher are possible on existing production equipment.

Key to the innovation is the Tube Filament's increased surface area, which is

five times greater than typical thin silicon filaments. Increasing the surface area five times, says GTAT, shortens the deposition growth cycle and allows the deposition to operate at a highly efficient and productive level throughout the growth cycle.

A further benefit outlined by GTAT is improved reliability, and reduction in early run aborts: "The hollow design of Tube Filaments enhances reliability at the end of the run by allowing for large rod diameters without risk of melting, and eliminating rod stress," GTAT explains. The structure of the filaments also enables them to be made taller without the risk of leaning or swaying, further increasing productivity.

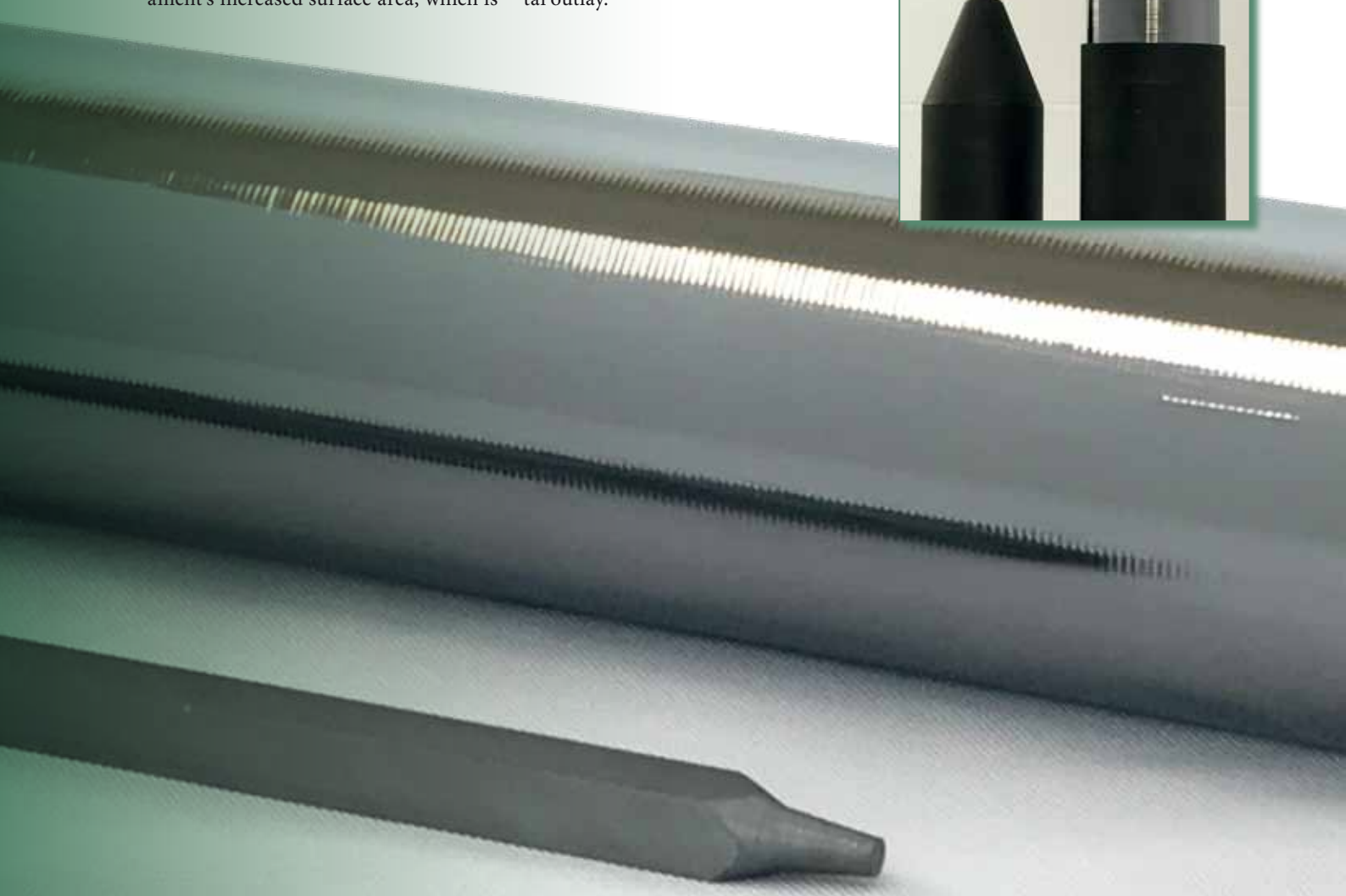
The company offers its Tube Filaments directly to polysilicon suppliers as a consumable with immediate benefits to polysilicon production with zero capital outlay.

Jury Comments

- "This approach to designing the filaments is quite smart, and overcomes quite some issues in polysilicon deposition efficiency."
- "A new deposition base for more efficient polysilicon growth replaces the old setting and is easy to operate. It could become a new standard for the industry."



Photos: GT Advanced Technologies



2 3D-Micromac microCELL OTF 8000

Upgraded dual line laser processing system for Si cells

3D-Micromac's microCELL OTF 8000 is a versatile laser system for processing of mono and multicrystalline silicon wafers, including latest technologies like laser contact opening for PERC cells or doping. It is an upgraded version of the previous tool microCELL OTF 3600, embedded with new HMI functions and extra hardware options.

The critical feature of OTF 8000 is that it is advanced to a two-lane design, allowing for double the throughput. Both lanes work independently of each other. 3D-Micromac claims that with the increased throughput to 8,000 wafers per hour the cost has not been doubled, com-

pared to the previous machine version. Moreover, it fits better with in-line integration into print lines or to comparable long process cycle times like doping.

The operator can easily change between different patterns (line, dot, dash, or customized) and select laser parameters with a drop-down/value input feature. The benefits of contactless wafer transport on an air cushion, supporting also the further decrease in nominal cell thickness, and the fire on-the-fly high scan speed

technology for unbeaten throughput remain. The tool uses laser sources only. The standard used are 1064 nm wavelength ns-fibre lasers, with the option to equip the tool with customer specified solutions, including different wavelengths, pulse duration, or source manufacturer on request.

3D-Micromac mentions that particular attention was paid to designing the air management with the exhaust. Apart from health and safety measures, the control of dust removal is raised to tighten the process control without accidental loss of laser power in the dust cloud above the substrate.

Photo: 3D-Micromac



Jury comments:

- "A great innovation to improve throughput and reduce COO of laser ablation for PERC cells. 8000 UPH with no-contact transport is very impressive."
- "The wafer is processed as it is transferred from one end to the other of the machine. I think that's an excellent idea: Higher throughput means fewer laser heads per line."

3 1366 Technologies Direct Wafer Process

Multi wafer with zero kerf and cutting

Now well on the way toward large-scale commercialization, the patented Direct Wafer Process developed by 1366 Technologies is an alternative method for wafer manufacturing which exhibits various advantages over traditional cast and saw methods, and could bring about major cost reductions to wafering – one of the most expensive stages in PV production.

According to 1366, the current technology cuts costs to \$0.26 per wafer, around half that of leading manufacturers using the traditional process, and the company's technical road map could bring this down even further to \$0.15/wafer.

The process creates standard silicon wafers directly from molten silicon, which, as well as reducing waste from kerf, offers several other advantages. Wafers created this way can be designed in 3D – extremely thin to reduce material consumption, but with thicker, reinforced sections where needed.

The company also states that wafers made this way benefit from higher purity, and better, more uniform microstructures. The technology also provides the opportunity to manipulate dopant concentration – potentially a powerful tool in boosting cell efficiency.

"Today's wafer manufacturing processes are based on 40 and 50 year old technologies. While incremental improvements (such as diamond wire sawing) and economies of scale bring some cost reduction, ingot-based wafer manufacturing has inherent efficiency and cost limitations," says 1366 Technologies. "The Direct Wafer manufacturing process fundamentally changes the role of the wafer in the silicon value chain. New wafer features, impossible through wire sawing, can bring further cost reduction and efficiency gains."



Photos: 1366 Technologies

Highlights for 1366 Technologies over the past year include achieving an average cell efficiency of 20.3% with partner Hanwha Q CELLS, the completion of the first commercial installation featuring wafers made with the Direct Wafer Process – a 500 kW array in Japan, and the beginning of work on its first commercial factory in Southeast Asia.

Jury comments:

- "It is a wonderful innovation, though there are still some problems to overcome before implementing it in production."
- "The approach is very novel – if they can reach the goals they have set it would really be a big decline in wafer prices."
- "The Direct Wafer approach fundamentally changes the way wafers are produced, and leads to lower energy and material consumption."



4 Meyer Burger DW291

Next generation diamond wire saw platform

The introduction of diamond wire sawing to PV production was a massive step in bringing down the costs of PV production, and indeed, Meyer Burger's original diamond wire platform was the top ranked innovation back in 2016's Technology Highlights.

Now, with its new DW291 platform, the Swiss equipment provider is introducing a series of innovations to further reduce the cost of wafer production, through reduced material consumption, conversion cost, and resources deployed.

DW291 utilizes diamond wires just 50 microns thick, with an upgrade path to 40 microns, and can produce wafers as thin as 100 microns (mono c-Si) and 140 microns (multi c-Si). The tool boasts a 50 MW throughput – increased by 43% from 35 MW in the previous iteration.

The tool boasts several major innovations over its predecessor the DW288

Series 3, including a completely redesigned drive train, which increases load length by 28%, and an improved motor which allows the tool to operate at higher speeds and achieve its increased capacity.

Meyer Burger has also been able to reduce the amount of diamond wire consumed, through an innovative new management system. Through optimized pulleys and a new machine structure, unguided wire length and tension fluctuations are reduced, allowing the tool to cut using a 50 micron diamond wire, and use only 0.8 meters of diamond wire to slice wafer, in comparison to other tools which require more than 1 meter.

The company estimates that the thinner diamond wire it is working can save 0.6 grams of silicon per wafer sliced, leading to 4% more production from the same amount of material (based on 180 micron wafer thickness).



Photo: Meyer Burger

Jury Comments:

- “The diamond wire tool is feasible for mono and multi c-Si, and requires 25% less equipment for the line – in terms of capex that’s very interesting. In terms of demand, I think this equipment fits the market at the moment.”
- “Diamond wire has been such a huge success already – it will probably reach 100% of production next year. From what I read here from Meyer Burger, it’s a great incremental innovation.”

Advertisement

TBEA

TBEA Solar Inverter Always Reliable

Stable operating on thousands of PV stations around the world ☀

Continuously enduring all kinds of harsh environment test ☀

Excellent and reliable quality won customers' unanimous recognition ☀



IEC61683 IEC62109

TBEA Xi'an Electric Technology Co., Ltd., 18 years' focusing on R & D of PV grid connected equipment, business covering more than 10 countries in four continents.

Web: <http://www.tbeapower.com> Tel: +86 29 68760537

India Sales Contact

Delhi

Sumit Sharma Cell: +91 90398 88132
E-mail: sumit@tbea.com

Mumbai

Jigar R. Soni Cell: +91 8169608842
E-mail: jigarrameshsoni@tbea.com

Bangalore/Chennai

Kevin George Cell: +91 7358333852
E-mail: kevingeorgechittu@tbea.com

Pune

Sagar Kale Cell: +91 9890000975
E-mail: sagarkale@tbea.com

5 centrotherm c.DEPO LP LPCVD system

Bringing high efficiency to mass production

The c.DEPO LP from German supplier centrotherm is a high throughput system for the deposition of passivated contacts on p-type silicon wafer. The tool works on a batch-type production, which centrotherm says offers advantages in terms of flexible production load, varying process sequences, and continued operation in case of single tube maintenance, shut-down of process optimization.

The low pressure chemical vapor deposition (LPCVD) process utilized by c.DEPO was used in February by Leib-

niz Universität Hannover and the Institute for Solar Energy Research Hamelin (ISFH) to create a p-type monocrystalline cell of 26.1% conversion efficiency – a world record for a cell of such material.

The tool, according to centrotherm, achieves excellent passivation quality in two ways: through a thin interfacial oxide (1.3-2.4 nanometers) leading to low recombination loss at the surface, and moving the highly doped area from the c-Si substrate into the poly-Si on top of the thin interface oxide.

Centrotherm points out that, while p-type wafer currently has a market share of more than 90%, conversion efficiencies in excess of 25% have so far only been achieved using n-type silicon wafers, which will require significant investments in new equipment and processes to ramp up. The company points to its collaboration with leading German research institutes as evidence that its technology enables cost-effective, very high efficiencies using p-type silicon wafer.

Jury comments:

- “This tool offers the potential for a substantial increase in cell efficiency, which propagates over the entire value chain.”

Photo: centrotherm



6 Meyer Burger SWCT Stringer

Cell connection beyond busbars

Meyer Burger's SWCT stringer boasts a throughput of 1,666 cells per hour on a footprint of 10 m², adding up to 130 MW annual capacity, which Meyer Burger says makes it the smallest stringer available in the industry.

The stringer utilizes a new approach to grip and hold the cells during stringing. The nature of the SmartWire cell connection technology (SWCT) means that no additional components are required, other than the cells and the foil wire assembly.

Seen by many as the next step in cell interconnection, SWCT utilizes a foil wire electrode to connect cells, greatly reducing the consumption of costly silver in cell production by up to 65% in PERC/

PERT modules, and by up to 75% for heterojunction technology.

The round wires used in SWCT also reduce shading on the active cell surface by up to 25% compared with standard busbar technologies, says Meyer Burger, due to the sunlight being reflected on the round surface and back into the module. In December 2017, Meyer Burger announced it had achieved a 335 W power output on a heterojunction module utilizing SWCT.

SWCT can also boost a module's lifetime and durability, by creating a dense wire contact matrix on the cell, able to cope with increased power extraction.

Meyer Burger states that the gripper technology utilized in this stringer rep-

resents a completely new approach to holding cells in place for stringing, and does not use mechanical stress and partial stress, but rather applies a uniform on the surface of the cell.

Jury Comments:

- "This tool offers several notable advantages over traditional metallization processes."
- "The SmartWire technology is very innovative, but what I see in the industry is everybody moving in the direction of multiwire, rather than smartwires."

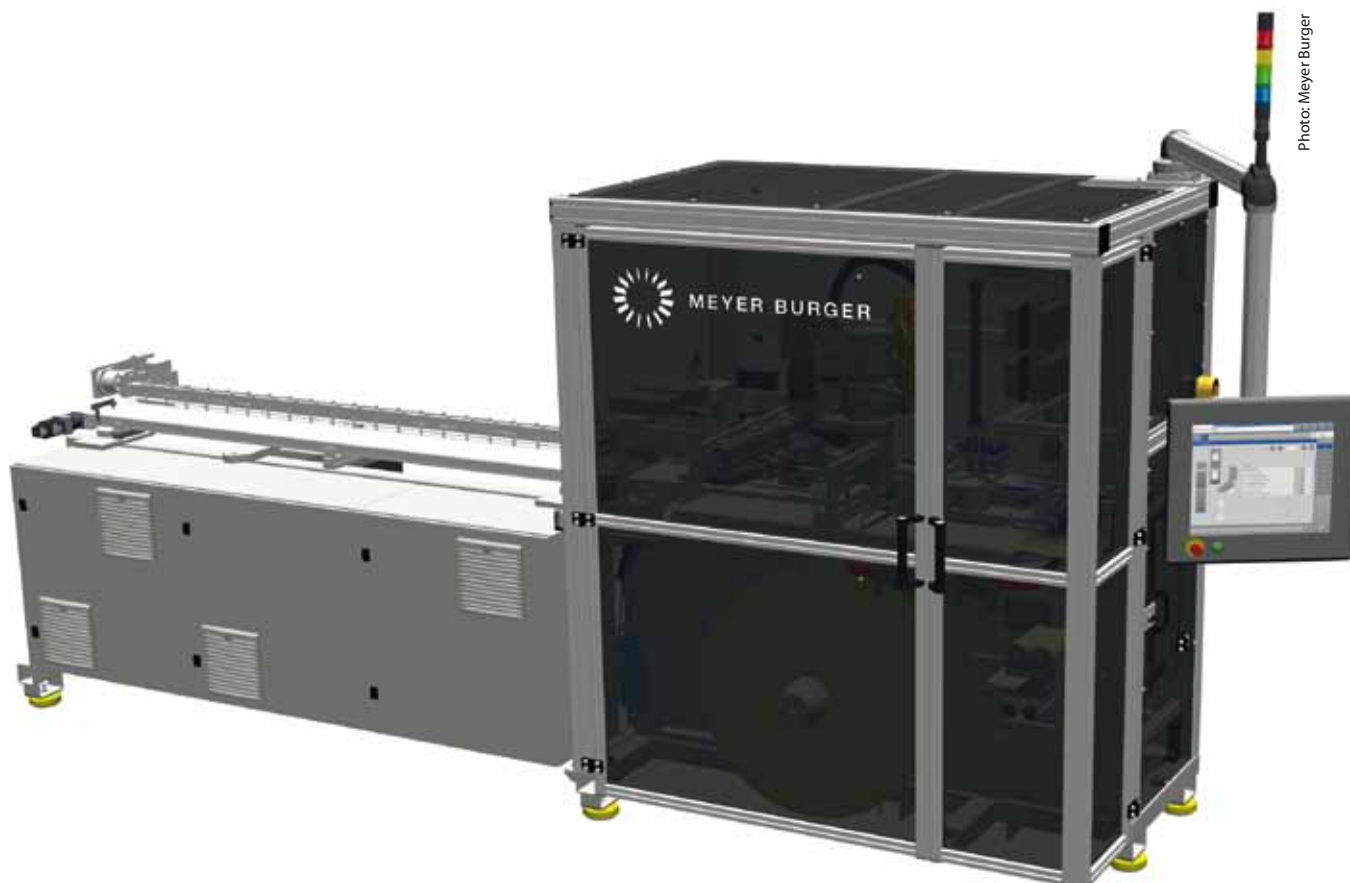


Photo: Meyer Burger

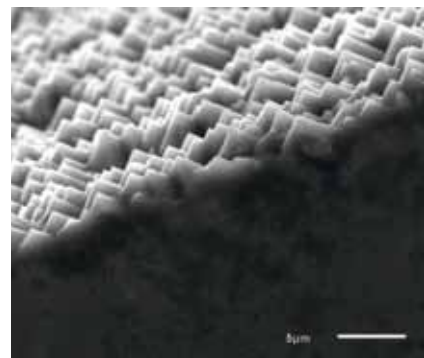
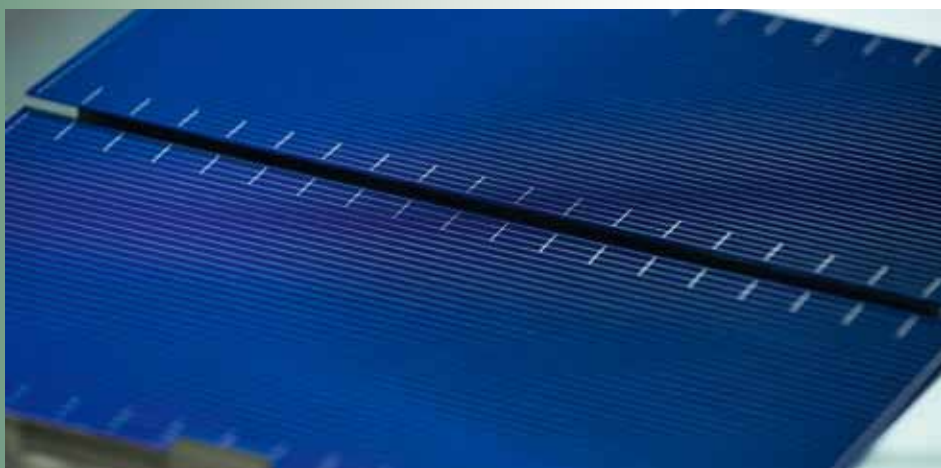
7 Innolas Solutions Laser Direct Cleaving

Zero ablation cell cutting from Innolas Solutions

With many tier-1 manufacturers moving into commercial production of half-cut cell technology, plenty of attention is currently being placed on processes for cell cutting. Using half-cut cells reduces resistive losses, and with the right process, this can be a simple way for man-

ufacturers to increase module power output without radically altering their production setup.

German laser specialist Innolas Solutions has introduced a cutting process named Laser Direct Cleaving, which separates the cell using tension created by a



Photos: Innolas Solutions

laser. The process is entirely ablation free, which, according to the company, results in significant savings by eliminating the need for additional process gas, cooling material, or filtration and dust collection – as no material is removed from the cell during the process.

Wafers cut using this process, says Innolas, do not exhibit any weakness or molten areas, resulting in low breakage rates and increased mechanical strength.

Innolas Solutions' Laser Direct Cleaving tool can process up to 6,000 wafers per hour, and as well as halves can also dice cells into quarters or any number of pieces in mass production.

8 h.a.l.m. cetisPV-EL-package

Integrated EL measurement and defect detection from h.a.l.m.



Photo: h.a.l.m.

h.a.l.m.'s cetisPV-EL-package integrates electroluminescence (EL) imaging with I-V testing, an innovation which it says reduces footprint and component requirements in cell production, while providing high quality data on cell defects for binning and sorting.

The cetisPV-EL-package utilizes the latest generation of h.a.l.m.'s PVControl-EL-eval 2.0 software for automatic defect detection and stores EL and I-V test results in one database, allowing for combined approaches and analysis correlating I-V abnormalities with EL visible defects.

EL images are acquired in the same contacting station as the I-V test and typically take 120 milliseconds or fewer. This allows for throughput of up to 3,600 cells/hour on a single lane machine. The system is modular, with the possibility to upgrade parts such as the camera or I-V tester, without the need for an entirely

new tool. Automatic defect detection algorithms make the system suitable for all common cell technologies, including PERC, HJT, and multicrystalline silicon.

The solution facilitates an industry 4.0 approach, allowing for automated error analysis, and introducing combined data analysis approaches to the industry by a cell-wise correlation of EL and I-V data. EL imaging, says h.a.l.m., is ideally suited to minimizing downtime and the testing required to trace back problems in a production line. Integrating EL imaging into the I-V testing station removes the need for a second contacting of cells, optimizes data correlation, and minimizes operator, component, and footprint costs.

Jury Comments:

- "A significant improvement in cell characterization technology."

9 Eternal Sun High Performance Light Soaker

Temperature control and in situ I-V testing for a better understanding of LID

Eternal Sun's High Performance Light Soaker (HPLS) allows for highly accurate testing of modules at different temperatures to provide reliable representation of light-induced degradation (LID), light and elevated temperature induced degradation (LeTID), and regeneration effects.

HPLS reduces inaccuracy to 4%, which the company says represents a 50% gain over comparable solutions. The tool features 350-1200 nm, AAA (IEC60904-9 ed.3) steady state light sources, and an integrated temperature chamber with temperature stability of $\pm 1^\circ\text{C}$. It also allows for real-time I-V measurements during light soaking which eliminates the need to interrupt light soaking for off-line P_{MAX} determination, potentially compromising data quality.

Investor confidence and risk mitigation are two of the biggest factors in allowing solar to continue its growth.

With new high efficiency technologies of more responsive external quantum efficiency, issues of LID and LeTID, which though manageable are still widely perceived as high risk and affect a project's bankability, can be mitigated. Eternal Sun states that its HPLS solution allows users to accurately study a full year's degradation, and equally importantly regeneration, in just seven days, making energy yield predictions more robust. Based on market feedback, Eternal Sun is aiming to foster a better understanding of LID, LeTID, and regeneration mechanisms, which heavily depend on irradiance and temperature. Studies show that these can cause major efficiency losses, particularly in PERC technologies. The HPLS also aims at improving knowledge of modules' behaviour in different conditions, as solar spreads into more locations the world over.

Jury comments:

- "An important product for testing LID, CID, and LeTID in a controlled environment."



Photo: Eternal Sun

Advertisement

STRINGER TT1600ECA

Advanced adhesive technology for HJT cells



VISIT US!

May 28-30, 2018
Booth E3-365



STRINGER TT1600ECA - A smart solution

- Innovative string production technology using electrically conductive adhesive (ECA)
- Reliable process technology with a proven standard STRINGER
- Ideal for processing HJT high performance cells and busbarless cells
- Possibility to use light capturing ribbons, LCR™
- Lead-free adhesive technology
- Cost-effective and economical production

www.teamtechnik.com

**team
technik**
PRODUCTION TECHNOLOGY

10

Meyer Burger FABiA

3-in-1 machine for anti-reflection, rear, and front passivation processes

FABiA stands for Front and Back in-line Apparatus. It combines three processes: anti-reflection coating, and rear and front passivation of PERC cells in one machine, and offers benefits for future upgrades as a flexible modular system in mass production.

The new tool is a combination of previous industry renowned machines developed by Meyer Burger: SiNA, and MAiA. The company claims that FABiA, with its advanced interfaces and no vacuum breakage, provides further improved cell passivation resulting in increased cell efficiency and equipment reliability. It is also qualified for other technologies like PERx, p-type, and n-type covering both mono and multicrystalline wafers.

With this new machine, the manufacturing footprint is 50% smaller than that of single step equipment, and its fully automated process sequences simplify cell production complexity. It saves over 1,000 m² of production floor space per gigawatt manufactured.

Meyer Burger states that the new tool minimizes mechanical and operator wafer handling during deposition, thus, less cell contamination during the deposition process. Overall this results

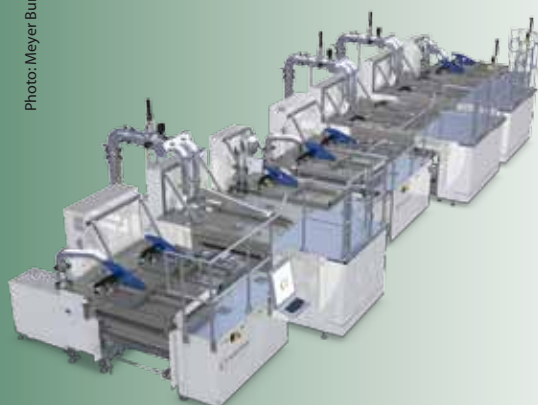
in a maximized mechanical yield with PERC cells consistently achieving >22% efficiency in mass production. The company says that FABiA has an average production throughput of over 4,000 wafers per hour.

The company also claims that with the optimized process, the process gases requirement is reduced by 35%. Thanks to the reduction of two steps, the electricity consumption can be reduced by 35%. The overall result is a reduction in the total cost of ownership for PERC cell manufacturers.

Jury comments

- “With optimized design and the integration of three steps, Meyer Burger’s new generation tool for PERC processes is expected to achieve better economics.”

Photo: Meyer Burger



11

RENA BatchTex N

Low footprint, low cost wafer texturing from RENA

RENA Technologies from Germany has long been a pioneer in the texturing space for mono wafers, and this year has a new ozone-based additive called BatchTex N, a range of solutions for high throughput wafer texturing on a low footprint.

Previously, wafer conditioning in this segment had typically been done by alkali

line cleaning – a process that uses large amounts of hydrogen peroxide (H₂O₂), a costly chemical process that has led to increased wafer prices.

The new RENA solution, the BatchTex N400, which can work with RENA’s existing monoTEX texturing additive, utilizes instead an ozone (O₃) based cleaning process that is substantially cheaper than H₂O₂ and is also suitable for shorter

processing times. The O₃ solution is also more environmentally friendly and does not require any poisonous precursor gases, RENA says.

This critical processing step for high efficiency cells ensures a high level of cleanliness before thermal diffusion of the p-n junction. By performing this action using O₃, costs can be reduced by around 30%, RENA CEO Peter Schneidewind says. “We are continuing to support our customers with such cost-down measures allowing them to keep up in the race for ever-declining cell and module ASPs,” he says. “We expect to see more and more O₃-based processes in this application as it enables lower operating expenses in cell fabrication.”

RENA cites cost of ownership calculations showing costs per wafer can be reduced to below \$0.035/wafer – a saving of half a million U.S. dollars for a single 200 MW production line annually.

Photo: RENA Technologies GmbH



12 Ecoprogetti ECOSUN Bifacial

Shedding light on both sides

Ecoprogetti's ECOSUN Bifacial is an LED sun simulator designed to simultaneously test both sides of a bifacial module. The test is carried out in one step, with no need to move or flip the panel and repeat. One LED is placed on top of the module, illuminating at $1,000 \text{ W/m}^2$, and the second unit illuminates the rear side at between 100 and 1000 W/m^2 .

According to Ecoprogetti, the machine is suitable for 60, 72, and 90 cell modules of all commercial technologies, and the LEDs can perform more than 50 million pulses at a stable irradiation level without the need to recharge in between tests. The machine can be integrated into production lines or used as a standalone tester after shipment to an installation site.

ECOSUN Bifacial is fitted with 11 different LED types, to best simulate the full irradiance spectrum of sunlight. The light source provides flexibility, allowing the machine to replicate site-specific



Photo: Ecoprogetti

light conditions including albedo, altitude, tilt angle, and reflective surface size. This, says Ecoprogetti, will allow users to have a precise idea of power output corresponding to module behavior in particular conditions.

Ecoprogetti goes on to say that by eliminating any need for recharging between tests, and performing the test of both sides simultaneously without any need

to handle the module manually, it is able to keep up with the rising throughputs seen in module production today.

Jury comments

- "Bifacial module testing is gaining momentum and is very important. An LED Solar Simulator for n-type bifacial and all high-efficiency cells is critical. I am glad to see it available."

13 Singulus Linex DW

In-line texturing process for diamond wire cut multi c-Si

Since the advent of diamond wire sawn wafers first raised its head a few years ago, developing a solution to the smooth, highly reflective surface the saws leave behind on multicrystalline wafers has been a key priority for solar equipment suppliers.

Diamond wire sawing is faster than slurry saws, and also produces less waste and more wafers per silicon block. Previously, the technology had been limited to use in monocrystalline silicon, as on multi, the saw left behind a surface too smooth and reflective to make a useful solar cell.

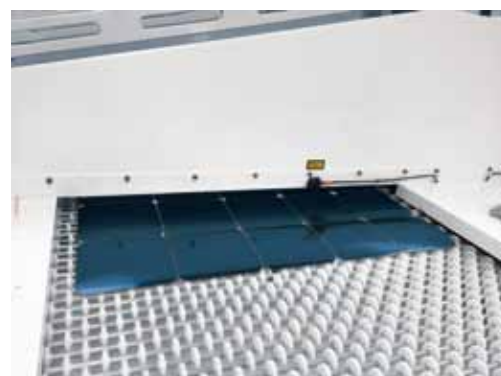
In December 2017, Singulus launched the Linex DW – in-line wet processing equipment, with an additional new integrated process for diamond wire cut wafers. The solution incorporates two distinct steps developed inhouse by Singulus: the use of new additives, and ozone for post cleaning, which the company says

results in a cost-effective method on the same footprint as previous iterations of its wet chemical processing platform.

Linex DW also features a newly developed conveyor system, which Singulus says guarantees gentle handling throughout, and results in a greatly reduced breakage rate (less than 0.05%).

The tool is designed as a drop-in replacement for existing wet chemical processes, on the same footprint. Linex DW is available as a 5 or 10 lane tool, with rated throughput of 4,200 to 9,000 wafers per hour.

"The texturing of wafers is a step that has a major influence on the efficiency of the solar cell," says Singulus CEO Stefan Rinck. "We have equipped the Linex in-line processing system for wet chemical surface treatment with the new combined process, which means we can bring costs down significantly while also improving cell performance."



Photos: Singulus



14

Agfa's UNIQOAT

Single-layer backsheet

UNIQOAT is a PET-based single layer backsheet. It requires just one integrated process for producing a full backsheet film, and at no stage in production is more than one layer involved. UNIQOAT offers manufacturing advantages over conventional backsheets, which require

several processing stages, including the application of an adhesive and a laminate film, curing in a heat chamber for several days, and repeating for each side.

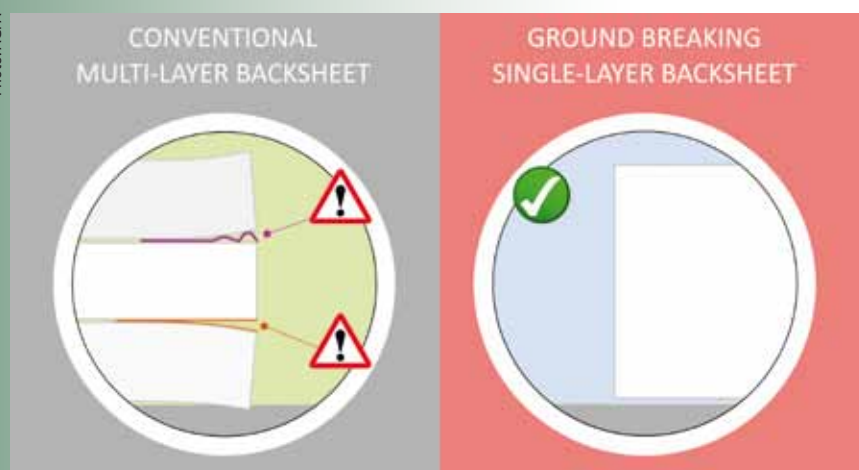
The new single-layer backsheet has no interlayer lamination, and no coextrusion of different PET grades or other

enhanced layers. Therefore, according to Agfa, UNIQOAT totally eliminates the risk of intra-backsheet delamination. Also, the backsheet has an average adhesion to EVA of >100 N/cm.

Whereas traditional laminated backsheet includes a dedicated air-side layer, UNIQOAT acts as an airside layer in its full thickness: Even if several micrometers were eroded or accidentally damaged, the full thickness of the material is still hydrolysis and UV resistant.

According to Agfa's reflectivity measurements, across the entire light-spectrum, UNIQOAT performs up to 20% better than other PET-based materials chosen by Agfa for comparison (TPT, TPE, KPE, PPE, and PO – basis: testing 2017). Agfa claims that UNIQOAT's high reflectivity – varying with different UNIQOAT products – can increase power output by 0.3 to 0.5%, thus helping to reduce the cost per watt.

Photo: AGFA



15

Tempress SPECTRUM Ox-Poly

LPCVD System for in situ oxidation and deposition of polysilicon layers

Developed by Dutch equipment maker Tempress, part of the Amtech Group, SPECTRUM Ox-Poly is a system for the production of passivated contacts on crystalline silicon cells – a technology which can eliminate losses from recom-

bination due to screen printed metal contacts.

The tool performs in situ oxidation and subsequent LPCVD polysilicon layer deposition, which it says allows for well controlled stack formation without

breaking vacuum. It also provides the possibility for doping of the polysilicon during deposition, eliminating the need for a separate dopant diffusion step.

Tempress states that its tool can achieve 5% uniformity within a wafer, 8% wafer to wafer, and 3% run to run. This is achieved at a throughput of up to 4,000 wafers per hour. The company claims its tool is the only one in the industry to combine in situ oxide deposition with the deposition of intrinsic or doped polysilicon at such a high throughput.

The company notes that SPECTRUM Ox-Poly has already been deployed at more than 10 locations, and has demonstrated efficiency gains of 0.5-1.0% at cost of ownership levels less than \$0.012 per cell.

Based on this figure, Tempress says it expects its passivated contact technology to become at least as widespread as aluminum oxide PERC in the cell market.

Photo: Tempress



16

Borosil 2 mm fully tempered solar glass

Ultra-thin and durable solution for glass-glass modules

India's Borosil has unveiled a new 2 mm fully tempered solar glass that it says can become the standard bearer in the solar industry. According to Borosil, the new glass is the first such glass to be mass produced at 2 mm, and thus could usher in a new standard thickness for solar glass (the current standard is 3.2 mm) that yields a range of benefits, including weight, cost, durability, and increased solar irradiance for the cells.

Typically, 2 mm glass is available with heat strengthening, a process that leaves the glass significantly weak compared to a fully tempered glass. Borosil states that its new glass has been tempered as per the EN 12150-1: 2015 standard, thus fully qualifying it as a safety glass.

Because the 2 mm fully tempered glass is thinner than standard glass used in PV, it boasts increased light transmission performance of $\geq 91.5\%$ without anti-reflec-

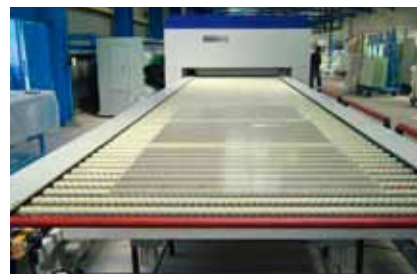
tive coating and $\geq 94\%$ with anti-reflective coating. Allied to this is a minimum 90 MPa mechanical strength as per normal tempering regulations.

Borosil claims that this glass can withstand wind loads greater than 2,400 Pa, and snow loads greater than 5,400 Pa.

In the unlikely event of breakage, the fully tempered glass has a small particle breakage pattern, which proves far safer than the large and sharp pieces that result in a heat-strengthened glass breakage. Plus its low weight and suitability for frameless modules makes the glass suitable for BIPV, rooftop, and cladding applications too.

Finally, the glass is more uniform than industry standard glass, which means it can dissipate heat more effectively and thus support stable lower temperatures in glass-glass modules, thereby aiding energy yield increase. Borosil also states

that the service life is expected to reach 40 years with minimum degradation.



Photos: Borosil



Advertisement



THE POWER OF RISING VALUE



Global, Tier 1 bankable brand, with independently certified state-of-the-art automated manufacturing, capacity 6.5GW



Industry leading lowest thermal co-efficient of Power



Industry leading 12 years product warranty
25 years linear performance



Excellent PID resistance at 85%RH, 85°C, -1000V



Welcome to visit us:
Booth No.: **N1 515**
28th-30th May, 2018
New International Expo Center, Shanghai, China

RISEN ENERGY CO., LTD

Tashan Industry Zone, Meilin, Ninghai, Ningbo, China
Tel: +86 574 59953077 Fax: +86 574 59953599
E-mail: info@risenenenergy.com Website: www.risenenergy.com

17

Singulus GENERIS PVD

Sputtering deposition system for heterojunction layers

Germany's Singulus introduces its GENERIS PVD system, designed to meet requirements posed by heterojunction technology (HJT). The tool is designed for deposition of transparent conductive oxide layers such as indium tin oxide (ITO) and aluminum zinc oxide (AZO).

Singulus states that GENERIS PVD is optimally designed to provide maximum

optical transmittance, matched refractive index, optimum electrical conductivity, and optimal charge carrier mobility – key parameters in HJT cell production.

The tool can deposit layers on the front and rear of wafers with no need to turn, and no vacuum interruption. Annealing and deposition of full area metal coatings can be integrated optionally.

According to Singulus, the tool does not cause sputter damage to amorphous silicon layers, and allows for full substrate temperature control throughout. GENERIS PVD provides conversion efficiencies of more than 22%, as well as reduced manufacturing costs.

Among the tool's innovations are optimized chamber volume, leading to reduced energy consumption, and the use of rotatable sputtering magnetrons, which achieve high target utilization and therefore low production costs. GENERIS PVD is available in two versions, offering throughput of either 2,600 or 5,200 wafers per hour, and a smaller lab version. The tool can also be used to deposit anti-reflective coating layers, barriers, precursor layers, and different metallic layers. The tool uses an in-line process, whereby substrates are transported on specially designed carriers, providing edge isolation simultaneously.

Photo: Singulus



18

Nanoscale wafer texturing from SERIS

Eco-friendly texturing process for multicrystalline silicon wafers

A new nanoscale multicrystalline wafer texturing technique has been developed by scientists at the Solar Energy Research Institute of Singapore (SERIS), which

aims to cater for the growing trend of diamond wire sawn (DWS) multicrystalline silicon solar wafers.

With more multicrystalline wafers now being cut by diamond-coated wires – a technique that allows substantial cost savings and waste reduction in comparison to traditional slurry-cut wafers – the resultant silicon wafer surface left behind where the diamond wire has cut the wafer now requires a new texturing process, to roughen the surface in order to minimize front surface reflection, enhance light trapping, and thus boost the efficiency of the cells.

Typically, the processes to create this type of surface involve the use of metal-catalyzed chemical etching (MCCE) or reactive ion etching (RIE) – two techniques that have high production costs and generate large quantities of chemical waste, due to their use of heavy metals to texture the wafers.

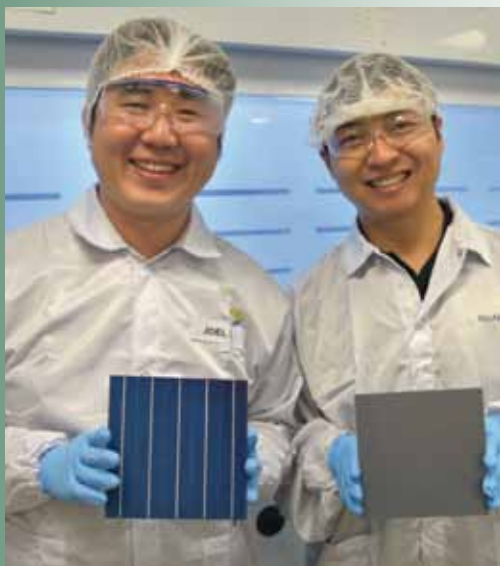
This new solution from SERIS is able to create a nanoscale texture on the wafer surface, without using either RIE or MCCE.

SERIS states that the technology has already demonstrated multi-PERC solar cell efficiencies of 20% or higher, weighted average reflectance of as low as 17%, and absolute efficiency gains of 0.3%.

The wet chemical technique employed by SERIS uses proprietary chemicals to etch the wafer surface, so that nanoscale features with dimensions smaller than the incident light wavelength are formed, trapping more light and reducing reflectivity.

These nanoscale features greatly increase the chance of light being coupled into the wafer and subsequently converted into electricity. The technique is low cost, scalable, and can be integrated quite simply into the processing tools of existing cell fabs, according to SERIS.

Photo: National University of Singapore



19 Borealis Quantys BPO

New polyolefin encapsulant aims to increase performance and reliability

Borealis has developed a new polyolefin encapsulant film for PV modules, called Quantys BPO, in collaboration with Boreouge, a joint venture with the Abu Dhabi National Oil Company (ADNOC).

Borealis claims that the new film brings a significant advance in the reli-

ability and affordability of encapsulant films used in solar panels. Thus, resulting in a lower levelized cost of electricity (LCOE).

The company mentioned that the Quantys BPO encapsulant film has superior resistance to ultraviolet rays, a low

rate of water vapor transmission, and no acetic acid or potential-induced degradation (PID). Moreover, the technology also offers a proven solution to increase power output and reduce output decay, with minimal risk of electrochemical defects.

Borealis claims that its innovative approach to the lamination process of the Quantys encapsulant increases module reliability and cuts cost by removing the need for a chemical reaction. This avoids any waste from chemical damage and reaction failures, significantly reducing the time and expense of manufacturing.

There are substantial savings for the end user too because this encapsulant solution is peroxide-free. Therefore, module makers can use cheaper membranes in their laminators that last up to five times longer. Thus, it helps to reduce the overall lamination process time compared to that for modules encapsulated with EVA and PO encapsulants.

Photo: Borealis



20 Oxford PV perovskite-on-silicon tandem cell

Pushing for commercial perovskite technology

By integrating its perovskite cell technology with silicon PV, U.K. and Germany-based Oxford PV aims to push efficiency beyond what is possible with silicon alone, and to leverage existing production capacities and established technologies for easier industry adoption.

The company has developed technology for full size (156 mm × 156 mm) perovskite-on-silicon tandem cells, which it says are on track to demonstrate 25% conversion efficiency by the end of 2018, and 30%+ further into the future. Additionally, Oxford PV states that its tandem cells have passed industry standard reliability testing under high temperature and humidity conditions for 1,000 hours.

Oxford PV plans to license its technology to silicon cell and module manufac-

turers, which would integrate equipment that puts perovskite cells on top of silicon cells into existing production lines.

large crystalline silicon cell and module manufacturer, and expects market entry around 2019.

An example provided by Oxford PV aims to demonstrate the cost saving potential of perovskite-on-silicon tandem cells: "A typical silicon solar cell today costs around \$0.22 per watt and produces around five watts," the company explains.

"Adding a perovskite device on top of the silicon cell increases the baseline cost of the cell by around 20%. However, the power would increase to around six watts.

Therefore, the net cost per watt remains about the same, but the tandem solar cells reduce the total system cost by 15-20%."

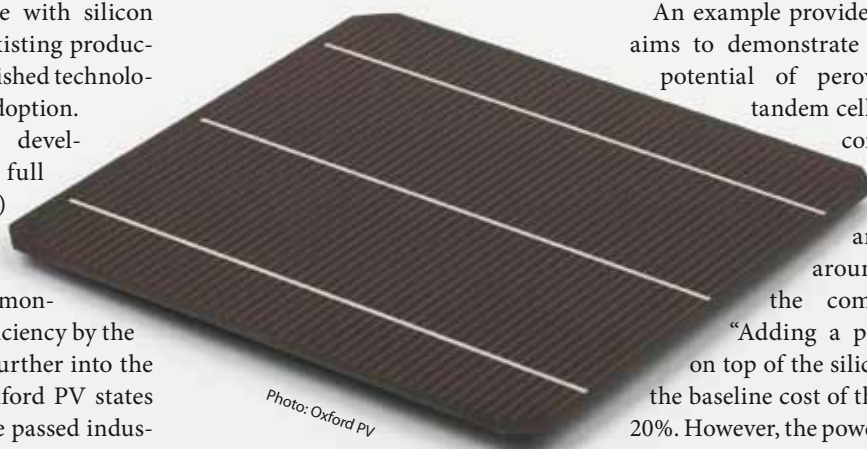


Photo: Oxford PV

In 2016, the company acquired a pilot line in Germany to produce prototypes to support the technology transfer. It also has a joint development agreement with a

21 Von Ardenne XENIA

Maximizing value in module manufacturing

XENIA is a newly developed sputter coating tool for wafers and glass that allows a highly reliable physical vapor deposition (PVD) process for metals, metal oxides, and absorber layers at the lowest possible cost. This process innovation enables thin film and high-efficiency crystalline PV module manufacturers to achieve competitive manufacturing costs.

Von Ardenne claims that with its XENIA tool, module manufacturers can process two or even more substrates per batch, up to a coating width of 2,700 mm in a so-called multi-batch process. These coaters can cover an annual capacity of 300 MW and more, compared with mono-batch processes covering only 150 MW capacity.

The company claims that the new tool leads can reduce capital expenditure costs by up to 20%. Additionally, operational cost is reduced by up to 50%, and maintenance and material costs by up to 40% and 15% respectively. In comparison to mono-batch coaters, XENIA can save up to 20% in electricity consumption.

Von Ardenne notes that it has re-engineered the tool's thermal management system to achieve homogeneity of ± 2.5 K. The utilized area of heating elements has been increased to 90%, from the previous 75%. New component materials have also been developed to withstand temperatures of more than 600°C.

The company has achieved cycle time records below 20 seconds, where current times are 50 seconds or more. For thin film, a homogeneity down to $\pm 1.5\%$ across the diagonal of the substrate can be achieved. The core components of XENIA are patented by Von Ardenne.



Photo: Von Ardenne

22 DSM Anti Soiling Coating

DSM aims at putting a stop to soiling

With its anti-soiling coating, DSM aims to boost module performance in the field, as well as reduce O&M costs associated with cleaning. The coating minimizes dust adhesion, and maximizes removal, while also exhibiting strong UV resistance performance and excellent anti-reflective properties.

The coating is particularly targeted at PV installations in desert environments, where dust can cause serious performance issues. According to DSM, results of a 12 month outdoor test conducted in the Gobi Desert show that modules featuring the anti-soiling coating achieved 1.1% more output compared to panels without, and also required less frequent and less intense cleaning, creating an economic advantage for solar park owners and operators.

DSM's anti-soiling coating is based on the company's proprietary core-shell particle technology, an inorganic mate-

rial which does not contain fluorine or other halogen components.

Since being named the 'Technology to Watch' in the 2016 edition of **pv magazine's** Technology Highlights, the product has been commercially launched and the first commercial projects to feature it have been installed. DSM points out that leading manufacturers, including Jinko Solar, have already begun to include the technology in their commercial products:

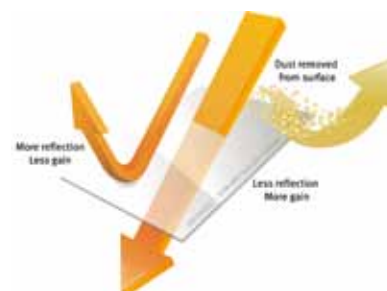
"As part of Jinko Solar's commitment towards building the most durable and highest-quality module, we're always actively looking for materials that will enhance module reliability. Our use of DSM's innovative anti-soiling coating reflects this commitment," says Jinko Solar Vice President Jin Hao. "This coating has anti-reflective and anti-soiling characteristics that both enhance module power output and maintain it for longer. For our customers, having DSM's anti-



Photos: DSM

soiling coating means increased power output and lowered cleaning costs, leading to lower LCOE and higher IRR."

DSM says it is also working with several leading academic institutes to continually advance its understanding of soiling, and also with cleaning robot manufacturers in order to ensure compatibility with the latest module cleaning technologies.



23 **Endeas Quicksun 540XLi-420** Solar simulator for BIPV modules

The building-integrated photovoltaics (BIPV) market has driven growing demand for larger solar modules, often up to 360×210 cm in size. Testing such modules has proven troublesome due to these unique dimensions, but Finnish firm Endeas Oy has created a bespoke solar simulator designed specifically for integration with BIPV production lines.

The Quicksun 540XLi-420 has a matrix of nine xenon flash lamps that can guarantee a better than 2% irradiance non-uniformity over the testing area. The machine's novel I-V curve measurement method guarantees accurate results for high efficiency modules, and thus the test delivers a class AAA solar simulation as standard.

Modules are tested sunny side up. Despite being designed to test larger BIPV modules, Endeas stresses that the Quicksun 540XLi-420 itself is relatively

compact, with overall dimensions of just $4.3 \times 3.6 \times 3.3$ meters, and so can be simply integrated into the lines on a much smaller footprint than the 10 meter long tunnel required by some solutions to achieve such a large test area.

An additional feature is the machine's compatibility with electroluminescence

(EL) imaging solutions, which conduct further tests for dark cells and areas on the modules. A guided procedure throughout allows the user to verify irradiance non-uniformity at regular intervals. The test procedures are fully compliant with the IEC 60904-1 and 60904-9 standards.



Photo: Endeas

Advertisement

FIRST

WORLD CLASS QUALITY

Your reliable Encapsulants
for Solar Module



EVA FILM & PO FILM BACKSHEET



Hangzhou First PV Material CO.,LTD.
Linan Hangzhou China
Url:WWW.FIRSTPVM.COM

E-Mail:Sales@Firstpvm.com
Tel:+86 571 63812086
Fax:+86 571 63710907

24 Heraeus SOL9651D front side silver paste

Adhesive paste for diamond-wire cut multi cells

The worldwide embrace of black silicon and diamond-wire cut (DWC) multicrystalline solar cells among leading module makers has prompted Germany's Heraeus to develop its new SOL9651D series of front side silver paste specifically for this growing market segment.

SOL9651D has been designed to overcome the adhesion challenges inherent in DWC cells as well as black silicon material, and will enable module makers to better optimize their busbar design for superior electrical performance, contact resistivity, and cost reduction.

Heraeus claims that its profound understanding of the microstructures of DWC and black silicon means that SOL9651D has a well-balanced metallization contact, and the new glass chemistry was developed to augment the excellent adhesion properties of the paste. "Due to the specially 'polished' surface of DWC cells, the organic vehicle of SOL9651D

has been fine-tuned for such textured surfaces, and [can] still provide fine-line printability without defects in mass production," the company says.

This allows for even greater versatility in the production stages, and as such has been termed a "product platform" rather than a product family. In other words, the SOL9651D acts as a basis for further product innovation and module design.

Heraeus also claims that SOL9651D paste helps raise the efficiency of DWC cells by between 0.05% and 0.2%, while delivering reduced paste usage per cell of around 10% in mass production. The new platform is also a suitable fit for many different printing technologies, such as both single and double printing, and knotless screen, with very little in the way of extra upgrade investment required.



Photo: Heraeus

25 Asys Alignus Speed Glide

High speed metallization from Asys

Germany's Asys has pushed the cycle time for its metallization line down to 1.3 seconds, meaning that it can process up to 133,000 cells in a day.

Alignus Speed Glide features integrated I-V and EL testing systems, provided by Asys subsidiary Botest. The testing platform supports edge alignment,

center of mass alignment, and structure alignment. "Recently busbars became thinner, and the requirements for cell alignment have substantially increased," explains Asys. "Asys offers the most reliable and accurate design for testing, suitable for busbar widths of more than 0.6 mm."

Key to decreasing cycle time is the use of vacuum transport belts, which allow higher throughput without additional stress on the wafer. Asys also points to the tool's accuracy and repeatability: "After alignment in the printer, the cell is not further moved. Therefore, Asys reaches market leading alignment repeatability of ± 12.5 micrometers at six sigma."

In keeping with its commitment to Industry 4.0, the tool is highly automated, and compatible with Asys's PULSE solution, where machine updates and warnings are sent to operators via tablet or smart watch. Single side operation also reduces the number of operators needed, a feature which Asys says is unique to its tool, and could save manufacturers as much as \$60,000 per line per year.

Asys also states that its metallization line operates on a multi-lane concept, which both maximizes the floor fill factor and reduces energy consumption.



Photo: Asys