FOUR IN ONE
Processing of CIGS modules

PROCESSES FOR TOMORROW
A look into the 4JET lab
Here to stay

As a technology company, we are constantly finding new opportunities. The laser as a multi-functional tool and our expertise in the field of surface technology can be applied to almost every industry. But just as a laser beam only does its job when it is in focus, we are concentrating on specific sectors rather than dipping into all areas.

And while some companies enter and leave markets as if they were riding on a bus, we see our commitment to the tire industry, to solar technology and to each newly tapped market as a long-term one.

Part of that commitment is the readiness to remain loyal to a sector even in weaker years and to invest continuously in product development and service. In fact, since the end of the automotive crisis in 2009 we have seen stronger and stronger demand from the tire industry, which we have been able to respond to with a number of successful new product launches.

And we see the same development in the solar industry, which has been experiencing some serious bumps recently. As part of the needed market realignment, manufacturers will invest in new and more efficient production processes that are already being developed in our laboratories or on customer pilot lines.

You will find a preview of some of tomorrow’s applications and products and a look behind the curtains of our development labs in this edition of 4SURfaces.

Yours sincerely

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Customers have a tough choice to make when building new production facilities. Every customer wants the best available system technology for each production step, but, at the same time, would like to keep down the number of suppliers and work with as few, competent partners as possible.

The new CIGS line from 4JET provides a cluster of four backend production systems for laser drilling bus bar vias, laser edge deletion, bus bar exposure and cleaning module edges.

The system, typically designed for 50 MW lines, is fully interlinked and can be integrated into any factory via an MES interface. The modular system platforms can be adapted to suit all common substrate types and are fitted with process and system controls.

Tuning the different processes to each other significantly reduces the number of interfaces for the end customer. All the systems have been tried and tested in thin-film photovoltaics in numerous installations and can also function as a stand-alone tool.

4JET provides manufacturers of CIGS solar cells with a complete integrated solution for all processes from structuring to contacting solar modules.

All inclusive

An interlinked solution for CIGS modules
Flexible thin-film solar cells, OLEDs and other electronic foils can be structured on-the-fly with the new roll to roll system from 4JET.

The patented beam and foil guidance system guarantees a constant working distance between the laser optics and the foil surface. A vision system controls the positioning of up to 10 parallel laser beams with fast and highly accurate axes.

Chemically strengthened glass for smartphones, touchpads and other displays are marvels of technology. Less than a millimeter thick and feather-light, they are significantly more scratch-resistant and flexible than “normal” glass.

What is an advantage for day-to-day use is a major headache in production and processing. Conventional processing of strengthened glass is slow and has low yields with glass getting damaged in the process.

The new GDS process module from 4JET makes it possible to drill and separate thin glass layers in a multistage, controlled laser process, delivering sharp edges with minimal chipping and reproducible bending strength.

The company was founded in 2005 and produces thin-film solar modules based on cadmium telluride (CdTe) technology. The expert team in the appropriately named Solar Valley in Saxony-Anhalt is industrializing a highly innovative glass coating technology from the US company Solar Fields. The technology deposits thin layers of semiconductors using atmospheric deposition technology.

Calyxo initially set up a pilot line with a production capacity of 8 MWp in Bitterfeld-Wolfen/Thalheim (Germany) to show that the technology could be transferred to mass manufacturing and rapidly commercialized. The pilot line became operational in summer 2007 and shortly thereafter was stepped up to 25 MWp. Since then, 4JET has been Calyxo’s partner for laser edge deletion.

The existing CX-3-series module from Calyxo has an average efficiency of 11.9 percent based on the aperture area. The current champion module has reached an output of 88.7 W, equivalent to an efficiency of 13.4 percent.

“The Calyxo development team rapidly reached another milestone in its efficiency roadmap, aiming for even higher efficiencies in the near future. High module efficiencies in combination with our low-cost atmospheric deposition technology are decisive factors for cost-competitive solar energy”, explains Chief Technology Officer Michael Bauer.

Sealing around the edges and cover glass protects the modules from the environment, acting as a barrier to humidity and vapor and thereby ensuring long service life. IEC 61644 and IEC 61730 certification with doubled inspection times and success in the noxious gas test are clear evidence of the strength of the modules. Calyxo offers a 10-year product warranty for CX3-series modules and a performance warranty of 90 percent in the first 10 years and 80 percent in the following 15 years.

In 2012, Calyxo will bring another production line into operation and will then have production capacity of 110 MWp. A 4JET edge deletion system will be installed as well.

Calyxo was the latest technology for encapsulation. The edges of the substrate glass are deleted after coating and structuring. Calyxo was one of the first manufacturers globally to replace aggressive mechanical blasting and grinding processes with the less destructive laser cleaning process, setting a new industry standard.

Optional add-on modules for marking, inspection and cleaning plus integrated printing technology make new production designs for flexible electronic components reality.

The specialists from Bitterfeld see the collapse in solar module prices and the turmoil in the solar industry as an opportunity: “With the financial contribution of our long-term shareholder Solar Fields, we will reduce our costs by the end of this year to less than 0.60 EUR per Wp, which corresponds to a cost reduction of nearly 30 percent from the recent level”, says Michael Bauer.

Calyxo milestones at a glance

2004 Solar Fields researches CdTe technology
2005 Calyxo GmbH founded
2007 Calyxo USA Inc. founded, Solar Fields becomes shareholder
2008 Capacity ramp up to 25 MWp
2012 Champion module achieves 13.4% efficiency expansion of capacity to 110 MWp
150 employees
The most promising means of reducing costs is to increase the efficiency of solar modules using methods that entail no or only limited additional costs.

The structure of a thin-film solar cell made from amorphous or microcrystalline silicon is as follows: The base is a glass substrate to which various layers are applied. First, a layer of transparent conductive oxide (TCO) is applied as the front contact, then the actual photovoltaic absorber made of silicon layers and finally a layer of silver as back contact.

The incidental light is scattered into the silicon absorber layers by texturing the TCO front contact. The aim is to scatter the light so that it is reflected as many times and as powerfully as possible within the cell with minimal loss of light. This is referred to as light injection or light trapping.

What is it actually about?

The texture of the front contact is therefore a key component in the manufacture of highly efficient silicon thin-film solar cells. It must be possible to define the structural dimensions and the shapes of the texture accurately and in a targeted way to optimize front contact textures and thereby maximize the efficiency of the cells. Texturing methods to date – chemical vapor deposition or etching – have not been able to do this, but a laser process provides just this possibility. Laser texturing can generate structural dimensions in the micro- and nanometer range in a reproducible and targeted manner.

4JET will purchase a scanning electron microscope (SEM) in order to organize the application experiments as comprehensive as possible. It will be utilized to inspect the structures on-site following any laboratory trial and define possible improvements, if necessary.

Once the partners have defined the optimum texturing, they will develop a machine design in the following stage to implement laser texturing on an industrial scale. The cost factor will play a very significant role alongside all the technical aspects of the project. Ultimately, the project is all about reducing the costs of photovoltaics to a level at which photovoltaics can become established on the power generation market.

If the aim of the project is achieved, the door will be open to further potential industrial applications of laser processing, as structured TCO layers are not just used in silicon thin-film photovoltaics, but in numerous other solar cells, display technology and in organic LEDs (OLEDs).

If the laser process provides optimum light injection into solar cells, it is only a small step to reverse the process and optimize light emission from OLEDs.

4JET's experience of laser processing thin-film solar modules will have a key role to play. System designs that have already been developed can be modified and applied to texturing TCO front contacts.
GREAT STEPS thanks to short pulses

Even after 40 years of industrial application, laser technology is still developing in great strides. Beam sources are becoming more and more powerful, opening up new applications, and making established laser processes even faster and more economical.

That is why 4JET is completely redesigning its STMCS product family for cleaning tire molds.

The system platforms for mobile in-press (tire mold cleaning system/TMCS) and stationary offline (stationary tire mold cleaning system/STMCS) mold cleaning, tried and tested worldwide in industrial applications, now come with even greater cleaning performance at the same level of perfect quality. The complexity of the systems and the installation size have both been reduced as well.

New high-performance beam sources have been used to reduce cleaning times to less than 20 minutes in some cases for a tire mold. The exact processing time is dependent on the mold geometry, the degree of contamination and the mixtures and release agents that are used.

4JET uses laser sources that emit some ten thousand very short light impulses per second for cleaning. Each individual pulse is just a few nanoseconds long – just a few billionths of a second. During the brief exposure time, contamination in an area the size of a pinhead is blown off without affecting the mold surface beneath. The rapid sequencing of individual laser pulses allows large surfaces to be cleaned extremely quickly.

The lasers used by 4JET also function for some ten thousand hours without requiring significant spare parts and without costly maintenance. Besides electrical energy, the laser systems do not require any other media such as compressed air, gases or abrasive material. At around 1 €/h, the variable operating costs are just a fraction of the cost of conventional cleaning with CO2 dry ice.

The exceptional beam delivery system of the multi-axis process head allows to clean even unusually complex tread patterns with perfect results.

02:12: It is morning in Japan and service technician Torsten is starting his shift. The systems for a number of Japanese customers are up for annual maintenance. “The laser systems have to be checked and serviced regularly to ensure they run smoothly”, says Torsten, who has got to know Japan very well during more than 40 tours of duty.

04:15: The on-call service technician this week is Marcel. And, straight away, he gets a call on his standby mobile from a German tire factory – a laser system is reporting a sensor error. The system status is identified over a secure VPN connection and the possible causes of the error are narrowed down. A maintenance worker employed by the customer identifies a defect that can be corrected immediately.

05:27: While Germany still sleeps (except for Marcel at his computer ...), service technician Ben is working in Hsinchu in a solar cell factory at 4JET’s partner company DKSH Taiwan. He is setting up a new processing recipe for a via drilling system. He received the software update by email from specialists in Alsdorf the previous evening.

08:21: Julia is processing queries that have come in from international customers overnight. A classic request – a spare part query with a photo and no part number. “Identifying parts is sometimes a bit like detective work”, explains the after sales agent, who joined the 4JET service team after completing her studies and living in Japan for a number of years.

09:05: In Spain, service technician and SPS specialist André is setting up new software functions at a plant. “The customer commissioned us to upgrade his software. I could do the programming at 4JET, but setting up and testing are best done on site.”

10:09: Service manager Bernhard welcomes 4JET partners from Hungary at the front desk. There are regular meetings with distribution partners from all over the world. “Our local partners do not just handle distribution, but customer after sales support as well. They are an important interface between the customer and 4JET”, explains Bernhard.

10:30: Janine not only manages the front desk at 4JET, but arranges a large number of business trips as well. She is currently organizing a flight, hotel and rental car for a trip from China to the USA. “International reservations are part of the daily routine. A US customer wants to move a system. A service call in China is just finishing, so our colleague can take the job and fly straight to the US.”

13:00: It is 20:00 local time in Shanghai. Service technician Michael is finishing his shift. “I frequently do overtime in Asia, as the working hours are just longer. Technicians have to adapt to the local conditions to a certain extent. Tomorrow, I’ll be leaving here and traveling on to the US”, explains the cosmopolitan frequent flyer, who worked, among other things, as a gravestone designer before joining 4JET.

14:20: Telephone conference between Julia and service technician Torsten, calling from his maintenance job in Japan. Torsten gives a brief summary of the status and passes on a spare parts list to be offered to the client.

16:50: Internal discussion on working processes with quality manager Thomas and the service department. “We are always striving to improve our processes. In terms of service, the installed base is growing every month with every delivery of machines. Processes help us to be able to react more quickly by giving us a best practice approach for recurring tasks”.

21:05: Lunch break for Udo, currently overseeing the commissioning of a system in the Silicon Valley. “Service technicians get to know the machines right from final installation and commissioning. That increases our understanding of the system technology, the software and the laser process”.

01:00: Evening in the US, a night’s rest in Germany and a new day in Asia. Let’s do it again – twenty-four-seven!
As winner of the Gründerpreis Award, 4JET has won a consultancy project with Porsche Consulting AG. The sport car manufacturer’s in-house consultancy specializes in introducing “lean management” principles to companies. Porsche advises automotive, aerospace and engineering companies on how to develop efficient working processes under its claim “100% performance, 0% fat.”

The consultancy project for 4JET involved two teams each working for five weeks to optimize project management and assembly. Tangible results were achieved. Material supply, progress monitoring and resource planning in final assembly were optimized jointly with specialists from Porsche. Visible results include the newly introduced Kanban storage system for assembly materials and a picking system alongside wall charts and redefined assembly bays.

4JET project management was further optimized in the second part of the consultancy project. All projects now follow a standardized system of milestones by which defined work content has to be achieved and approved by the project board. The new system, supported by the in-house ProJET software, provides project participants with maximum transparency in terms of progress, scheduling and cost planning and is an important component for the successful completion of any project.

The Deutscher Gründerpreis is awarded by four partners: Stern magazine, the savings banks (the Sparkassen), the German public TV channel ZDF and Porsche. The partners have been promoting entrepreneurship and an entrepreneurial culture since 1997. In addition, the Deutscher Gründerpreis Award’s Board of Trustees undertakes to mentor the nominees and prize winners. Patrons of the Deutscher Gründerpreis include Bertelsmann AG, Gruner + Jahr AG, the Süddeutsche Zeitung and the Sparkassen Versicherung. The Federal Ministry of Economics and Technology is also a cooperation partner of the Deutscher Gründerpreis.
“Trial and Error”

To do so, 4JET has not only developed in-house software models to calculate temperature profiles in layer systems, but has also invested heavily in analytics. A 3D laser microscope with a resolution of below 10 nanometers, a spectrometer and (in the near future) a scanning electron microscope are all available in the laboratories, alongside a range of optical microscopes.

For special applications, the 4JET specialists also develop custom test procedures, such as a measuring station for electroluminescence, or a test frame for high voltage testing of solar modules.

The applications laboratory does not just test for feasibility at the start of each project – it also guarantees exceptional service quality thanks to seamless adjustment of laser processes when products change. “Customers change input materials or product designs. Any adjustment to the processing parameters in systems that have already been installed can be prepared in the laboratory and then installed in the system. In many cases, we can simulate the processing conditions in the field. A change to a product can then be implemented without risk and more quickly than directly on a production system that has already been installed”, says Stefan Bergfeld.

The company also uses its excellent range of equipment to process small pilot series, however typical job-shop work such as laser marking is not offered, as 4JET stays true to the principle of only specializing in applications that (almost) no one else can do.