# SOLAR MAGAZINE

September 2011
PV SEC Hamburg

# Innovative solar technology from the Netherlands

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# Innovative solar technology from the Netherlands

**Dutch companies, knowledge institutes and government authorities are working flat out on new technologies and countless innovations in the field of solar power. They are deeds and answers appropriate for the global push for power transition. They are deeds that will not just shape the future of the Netherlands, but the future of the entire world.**

A future in which the Netherlands will hopefully lead with innovations. In which dependency on fossil fuels will decrease. A future in which the Netherlands will globally play a role of crucial importance. The potential is there. The Netherlands does not just have a knowledge institute in the Energieonderzoek Centrum Nederland that enjoys global status, it also has companies like OTB Solar, Tempress Systems, Smit Ovens, Scheuten Solar, Rimas, Solland Solar, DHV and many others that score high internationally. And that is without even mentioning the promising start-ups like Levitech, SoLayTec, Helianthos, RGS Development, TULiPPS Solar, ProxEnergy, LineSolar, SRB Energy, Dimark Solar and RUV Systems. You can read more about them in this special English edition of the only Dutch magazine for the solar industry. The sound journalism and editorial approach of this magazine sketches the full spectrum of the Dutch solar industry.

For many years, the Photovoltaic Solar Energy Conference and Exhibition (PV SEC) has been the platform for presenting innovations for practice. This is the reason why we have chosen the title 'Stop thinking, start acting' for this magazine. Indeed, it is up to the Dutch solar industry to put into practice the many new technologies and corresponding opportunities. After all, there can only really be talk of innovation once the new technical opportunities have led to market opportunities and sales. The Dutch solar industry – present in great numbers during the PV SEC – will demonstrate during this event that they are able to transform opportunities into business.

There is a lot of positive news to report on regarding knowledge, abilities and sales. Like the funding of Solliance and the installation of the Solliance Industry Board, which you can read all about in this magazine.

There is also a part for the Dutch government to play in the marketing of new technologies through the creation of an industry-friendly home market and the stimulation of innovation. The Dutch government increasingly supports test and demonstration projects within the field of solar power. A step that hopefully the Dutch authorities will take in the foreseeable future will be the step towards a sound grants scheme that will stimulate people to purchase a solar panel. It can facilitate the acceleration of new technologies that make a sustainable future possible all the sooner. Providing we all continue to innovate and providing we manage to continue to raise the level of the development of knowledge. At any rate, the Dutch solar industry is well on its way.

Now all that remains for me to do is to wish you, on behalf of the entire team behind the Solar Magazine, an enjoyable read of this special PV SEC edition of our magazine and every success at the PV SEC 2011 at the city of Hamburg. Hopefully, when you reflect on this week, you will remember the Netherlands when you are looking for an innovative partner for your business in the solar industry!

***Edwin Gelissen-Van Gastel***
*Solar Magazine editor in chief and publisher*


# BRAINPORT
# CREATING THE INDUSTRIES OF THE FUTURE

Brainport Eindhoven Region is a cornerstone of the Dutch economy, along with Rotterdam (seaport) and Amsterdam (airport).

Top technology region Brainport is a breeding ground for innovation and the home base of world class companies, knowledge institutes and research institutions. Together they design and manufacture the technology of the future to ensure a safe, green and caring society and a sustainable economic development of the Netherlands.

**Solar industry champions located in Brainport Eindhoven Region**

Brainport Eindhoven Region is a top location for manufacturers of photovoltaic equipment. World-class knowledge institutes with an enviable reputation in renewable energy, like ECN, TU/e, Holst Centre and TNO, cooperating in Solliance, form a strong cluster of R&D activities. Moreover, Brainport's competitive supply chain of production equipment and parts includes major players such as OTB Solar and VDL ETG as well as several dynamic young companies developing thin film and establishing production lines for silicon and solar cells.

The prospects for growth of the solar industry is boosted and accelerated by the presence of other related industrial sectors such as coatings, semi-conductors, mechatronics, materials, displays and optical storage. Brainport Eindhoven Region can consider itself very well represented by leading international companies in these sectors, including DSM, Fuji Film, Assembléon, Océ and NXP.

With all these knowledge institutes, established and new companies, Brainport Eindhoven Region is a highly attractive place for the development and production of future photovoltaic systems, crystalline silicon solar cell technology and thin film.

By allocating national and international R&D and by strengthening the solar industry's competitiveness, Brainport Eindhoven Region wants to make solar one of our industries of the future.

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CREATING THE INDUSTRIES OF THE FUTURE

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## High Tech Campus Eindhoven positions itself as a solar hotspot

High Tech Campus Eindhoven is making great efforts to position itself as a solar hotspot. The Campus is amongst the seventeen percent largest science parks in the world (resident population) and is characterised by an R&D eco system where more than ninety companies and knowledge institutes with over eight thousand researchers, developers and entrepreneurs work on the technologies and products of tomorrow. The Campus initiator was Philips. At the end of the nineteen nineties, the company's R&D activities were spread across Eindhoven and Philips wanted to create a single Campus location for all the national R&D activities. The open atmosphere and the concentration of high-level knowledge resulted in considerable interaction between the researchers from the different technological disciplines. To speed up this process even more, Philips decided to open the Campus to other technology companies in 2003. The Campus is characterised by Open Innovation. The companies and knowledge institutes here share R&D facilities in order to achieve faster, better and more customer-oriented innovation. Together, they create innovations in the areas of Health, Experience and Energy. A new Campus pillar is the solar cluster, from solar generation with cells, modules and systems to solar storage with materials and applications. Companises from the solar industry that stand out include OM&T, Philips Innovation Services, SunCycle, ECN, TULiPPS Solar, Holland Innovative, SRB Energy and Greentech Engineering.

## Solar Technology Transfer founded

Peter van der Vleuten established Solar Technology Transfer. The company is to build a bridge between European and American R&D and solar cells and Asian solar cell manufacture. From the High Tech Campus in Eindhoven, the company analyses the trends and opportunities within the industry and disseminates this information along the chain of relevant knowledge institutes, R&D parties, manufacturers and investors. The first project is an idea for the vacuum-free mass production of CIGS panels.

## Phoenix Contact expands its product portfolio

Phoenix Contact has recently added various new products for photovoltaic systems to its portfolio. For example, it introduced the monitoring system Solarcheck as a reliable instrument for monitoring fault flows in large photovoltaic installations. The simple to integrate system recognises power dips that can occur as a result of soiled or damaged panels. This facilitates rapid response in measures that can be taken to restore the availability of the system and, in doing so, improve the yield. The two-part monitoring system comprises a measurement module and a communication module. New compact spring pressure diode clips have been introduced (STME 6-DIO HV) that can protect the film modules from return current. In addition, the product family Sunclix for Phoenix Contact has been expanded with the new junction box for crystalline or thin film photovoltaic solar panels. During development, special attention was paid to automation and process safety. The junction boxes make a marked contribution to the optimisation of the manufacturing processes in panel manufacture.

## SunCycle produces the first CPV panels

Suncycle has entered a venture with voetsalpine and Neways Electronics for the manufacture of its concentrated PV solar panels. Neways Electronics is to take care of the electronics and voetsalpine of the manufacture of the larger components and assembly. TNO and Radboud University Nijmegen are also contributing. In the project Agro Solar Realisation (ASORE), Suncycle is going to test its innovative solar collectors in the agricultural sector, starting with five hundred square metres of roof on a farm. Following that, the year 2012 is planned by Suncycle as the year for the product launch.

## Start-up SunNed facilitates Dutch installation sector

For installation companies, solar power is important and this importance will only continue to increase. It is for this very reason that the company Facility Service & Management started the formula SunNed own system house for the installation sector. As the format provider, SunNed organises the manufacture, transport, advertising and countless other matters concerning solar panels. On the 1st April, the SunNed format was officially launched and, in the meantime, several dozen installation companies have signed up.

## SPEQUEST system extended with IQE and OBIC measurements

The well-known Quantum Efficiency measurement system, SPEQUEST, manufactured by ReRa Systems, has been extended. It is now possible to measure the solar cell reflection and transmission to determine the Internal Quantum Efficiency (IQE) instead of only the External Quantum Efficiency. This new extension is based on a high quality integrating sphere, measuring the specular and diffuse reflection on solar cells. Furthermore a software controlled XY-table can be integrated to measure position dependent QE. With this new option, SPEQUEST can be used as an Optical Beam Induced Current (OBIC) system. 3D Current maps can be produced, revealing even more of your solar cell characteristics.

## SolarExcel starts test factory for solar cell foil

SolarExcel is to build a test factory in North Limburg for the manufacture of light management foil for solar cells. The foil eliminates the reflection of light on solar cells, increasing the yield from the solar cell and optimising the wavelength of the incidental light. The foil was developed by Ben Slager, Bart Kranz and Ko Hermans, supported by a number of investors.

## National Campaign Zonnestroom wants four gigawatts of solar power by 2020

During this decade, the Dutch solar industry will finally get the home market they have been hanging out for. A wide ranging cluster of government authorities, companies and knowledge institutes have linked up to realise four gigawatts of installed capacity by 2020 through the Nationaal Actieplan Zonnestroom. The campaign is to be presented this autumn. A few points where extra attention will be focused are: professionalization and improvement of the installation industry through certification for solar power installation companies and installations; harmonisation of local government policy; and inclusion of solar power in the energy label for homes.

## SMC introduces a compact membrane pump

The demand from machine builders for a small membrane pump for use with water or chemicals has been answered with the launch of the new PB series of membrane pumps from SMC. The R&D engineers at SMC have made the existing PB series of membrane pumps both smaller and lighter, but they have improved their performance and operational life cycle, too. The membrane pumps are now available in three models operated with air or magnetic valves. Small enough to hold in the palm of your hand, these pumps deliver a flow rate of between 8 and 2000ml/minute. Above all, they are suitable for use with a wide range of liquid chemicals and the air-operated version is the perfect solution for use with inflammable liquids. The improved PB series of process pumps are suitable for the transfer of liquid chemicals, DI water, reagents, refrigerants and cleaning solvents.

## Alrack launches fire protection and monitoring for solar panels

Alrack has launched two new products in the Solexus 1100 series for the solar power systems: a fire protector (Solexus 1100FP) and a monitoring unit (Solexus 1100MT). It is Alrack's intention to monitor, check and improve and, at the same time, increase safety with the various products from the Solexus range. The Solexus 1100FP offers the possibility of cutting off all the solar panels on a roof with a single press of a button. 'This eliminates all risk for the fire service during any extinguishing activities', explains Van der Ven. 'The fire protector can also be enhanced through an alarm system or a remote alarm centre.' The Solexus 1100FP is being launched across the market, because it is possible for both module manufacturers and solar installation companies to integrate the product. The most important markets for Alrack are Germany and the Benelux. In addition to the fire protector, a monitoring unit has also recently been launched with the Solexus 1100MT. This unit can measure the voltage, current and temperature, making the yield of individual solar panels transparent. The unit also switches off modules as they become overheated.

## TNO develops BIPV road surface

TNO has presented the first Dutch road surface with integrated solar cells, called SolaRoad. SolaRoad was developed in collaboration with the province of Noord-Holland, the Ooms Avenhorn Group and Imtech. TNO wants to open its first pilot project in the form of a solar cycle path in Noord- Holland in 2012.

# Dutch solar landscape displays a vivid range of colours

**The Dutch solar industry has chalked up an imposing track record over the last twenty-five years. Not just in the field of research, but also in manufacture and applications for photovoltaics (PV). The Netherlands is one of the leading countries where pioneering work takes place in the field of research & development into solar energy. In the last year alone, the Netherlands was fortunate enough to welcome approximately twenty new solar start-ups. Whether it is TULiPPS Solar, SRB Energy, Line Solar, ProxEnergy, PeerPlus or Dimark Solar, each and every one of them introduces applications based on new innovative technologies to the market.**

Now that the interest for solar power is increasing hand over fist worldwide, the number of newly established companies in the Netherlands is growing at just as rapid a pace. On the side of the solar system installation companies, but also at the beginning of the chain in the form of technology start-ups. Last year, the outside world was provided with an insight into the innovations by start-ups such as Levitech, SoLayTec, Helianthos and RGS Development. In the meantime, renowned players like OTB Solar, Scheuten Solar, Solland Solar, Smit Ovens and Tempress Systems made announcement after announcement. This year, new players like ProxEnergy (with former Scheuten CEO Frans van den Heuvel as founder) and TULiPPS Solar greet the world at large.

**Sun on the Netherlands**

At the beginning of this year, the Dutch PV industry presented an important document with its joint roadmap 'Sun on the Netherlands' that will most likely form the seedbed for many more solar start-ups. The stakeholders – from government, to knowledge & educational institutes and companies – hope that the roadmap will create a strengthened and expanded ecosystem for solar energy in the Netherlands. An ecosystem that has sufficient strength to play an internationally meaningful role. With the roadmap, immediately applicable insight is acquired into knowledge, competencies, networks and improvement options in the field of solar technologies and corresponding company strategies. Tremendous hard work is currently being ploughed into the formulation of follow-up projects to actually achieve progressive

steps forward based on the knowledge garnered from the roadmap project. The roadmap Sun on the Netherlands does not solely provide an overview of the Dutch, European and global development in the field of solar PV (in terms of technology, players and international competition, manufacture and market segments), but states four domains where the Netherlands can fulfil an important role. Successively, they regard applications, product technology, manufacturing technology and ecosystems. Action has to be taken along these four main lines that have been defined in the roadmap, through the development of new products for high-potential areas.

**Broad spectrum**

As stated, the roadmap also provides a unequivocal picture of the Dutch PV ecosystem. From significant innovations regarding high performance, commercial crystalline Silicon technology, to the development of entirely new options such as thin films and polymer solar cells, the Dutch solar landscape covers a broad spectrum including materials and processes, devices and systems. R&D is conducted at the universities of technology like the Universities of Eindhoven, Delft and Twente, as well as at institutes such as the internationally leading energy research institutes ECN, TNO and the Holst Centre and at Solliance. Also, large companies such as OTB Solar, Smit Ovens, Scheuten Solar, Solland Solar and Tempress Systems have extensive research programmes. The collaboration between these research institutes and private companies is strong and has led to numerous technology spin-offs.

Meanwhile, the local authorities and Dutch government recognize the importance of solar energy for the creation of a sustainable society and support and encourage the use of solar energy by making it an integral part of its long-term energy policy. Consequently, many innovative projects receive financial support (also see the article on page 15), the province of Noord-Brabant has provided an injection of tens of millions through the new research body Solliance and various development agencies invest in solar start-ups. In brief, the Dutch solar landscape has blossomed with a vivid range of colours.

## Overview Dutch solar landscape

*Research Institutes:*
- Solliance
- Energy Research Centre of the Netherlands (ECN)
- Advanced Dutch Energy Materials Innovation Lab (ADEM)
- Foundation for Fundamental Research on Matter (FOM)
- The Netherlands Organization for Applied Scientific Research (TNO)
- Holst Centre
- Dutch Polymere Institute

*Universities:*
- Delft, Eindhoven, Utrecht, Nijmegen, Groiningen, Wageningen and Amsterdam

*The physical infrastructure contains:*
- Avantis European Science and Business Park, Heerlen
- High Tech Campus Eindhoven
- Energy Valley in the North of the Netherlands
- Solar Valley in the South of the Netherlands
- Application Centre for Renewable RESources (ACRRES)

*Leading companies within the Dutch solar industry:*
- APA, Eurotron, Mastervolt, Oskomera, OTB Solar, Solland Solar, Ubbink Solar, Scheuten Solar, Tempress Sytems, Sunergy, Smit Ovens, Philips and OM&T
- Solar start-ups like Helianthos, RGS Development, Levitech, SoLayTec, ProxEnergy, PeerPlus, Dimark Solar, Alinement and TULiPSS Solar

# Dutch solar industry succeeds through joint innovation projects

**Over the past few years, the Dutch solar industry has made large-scale efforts in the creation of new innovation projects. Through various grant schemes – including the European stimulation programme OP-Zuid and the Netherlands regional development programme Pieken in de Delta – companies have been able to acquire financial support through various government authorities. 'All these schemes have been established with the intention of, on the one hand, maintaining innovation and, on the other, stimulating it further', explains John Blankendaal, programme manager with the Noord Brabant Development Agency (BOM).**

'As a development agency, we play an important role in the establishment of innovation projects', continues Blankendaal. 'If you want to innovate as a company, you have to work with others. It isn't possible to have all the wisdom in house. For a high-tech industry such as solar, this is increasingly true. Companies can't afford to have a sizeable R&D department of their own. In brief, collaboration with other entrepreneurs and knowledge institutes is imperative. Both the innovation projects within the scope of Pieken in de Delta as well as those running under the banner of OP-Zuid, are good examples of this.'

**Pieken in de Delta**

The main theme of the Pieken in de Delta scheme intended by Dutch central government is the expansion of areas of specific economic strengths in six Dutch areas including the South East Netherlands with its high-tech industry. The following solar-related innovation projects are part of Pieken in de Delta:

- *CIGSelf:* research and development of new manufacturing processes for CIGS solar cells at an industrial level. The cooperative venture comprises coordinator Smit Ovens, Dutch Space, ECN, Holland Innovative, OTB Solar, Philips Applied Technologies, Scheuten Solar, TNO and TU/e.
- *Solar Focus Zuidoost:* following the execution of the project, a production line can be rolled out that is competitive with fossil fuel generated electricity for the Concentrated PV (CPV) concept by SunCycle. In addition to SunCycle, KMWE Precisie Eindhoven, Neways Technologies, TNO Industry & Technology and the Radboud University Nijmegen participate.
- *FAST ALD:* in this project, the TNO spin-off SoLayTec focuses on the acceleration of the Atomic Layer Deposition process by a factor of one hundred, to facilitate the economically feasible manufacture of solar cells.
- *Zonnedag:* within Zonnedag, new materials are investigated and applied with which the performance of solar panels is considerably improved. Above all, the improvement of measurement and control systems is explored, the so-called junction box.

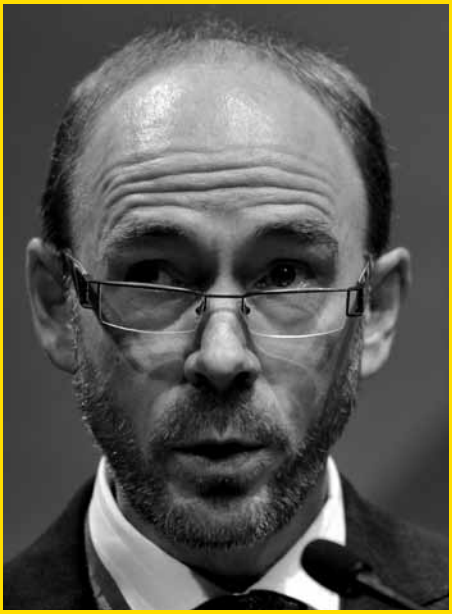

- *ProDuZo:* the design and construction of a new machine for the series connection of thin-film solar cells with very accurate laser and print technology. Main applicant is CCM and Singulus Mastering, IBS Precision Engineering, Stork Prints, TNO and ECN also participate.
- *Smart Chain:* the development of new module concepts for solar energy in buildings and the corresponding production lines that are functional, flexible and aesthetically appealing. Main applicant is Rimas BV.
- *'Old' projects:* at the end 2009, three Pieken in de Delta projects got underway in the field of solar energy geZONd under the auspices of Philips, Zonprom supervised by OTB Solar and 'Zon op het zuiden', where a roadmap was created for the various kinds of solar cells.

**OP-Zuid**

The Operational Programme South-Netherlands (OP-Zuid) is a joint grant scheme programme set up by the provinces of Limburg, Noord-Brabant and Zeeland, partly financed by the European Fund for Regional Development. This scheme – which runs from 2007-2013 – currently includes the following eight solar-related innovation projects:

- *SmartTab:* robotic connection of solar cells with conductive adhesive at Machinefabriek Van de Weert.
- *Dova:* development of a new continual system for the selenisation process of CIGS panels in which the selenium is used in a solid state, headed by Smit Ovens.
- *DEPx NG:* expansion of manufacturing opportunities for the DEPx strength of OTB Solar.
- *Screen Screen:* printing process for conductive contacts on the front and rear of solar cells OTB Solar.
- *Soldeerstraat:* development of an automated process with which the positioning and soldering of connectors and transverses can take place at Machinefabriek Van de Weert.
- *Crack detection:* detection of cracks in wafers at Rimas.
- *TFSE:* first in-line process for laser scribing, inkjet printing and sputtering of P-N junctions for thin-film cells at OTB Solar.
- *Solexus:* development of connection techniques for busbars, panels and inverters at Allrack.

# Grid parity: Holy Grail or hype?



**The term 'grid parity' is often used in relation to the competitive position of photovoltaics. In the usual definition it describes the situation where the generation cost of solar electricity is equal to the (all-in) price of retail electricity at the point of connection. For consumers in Europe the latter is typically in the range of 0.10 – 0.25 €/kWh. In countries with favorable insolation conditions and medium retail electricity prices as well as in countries with moderate insolation and high prices grid parity is said to be 'just around the corner' (or already reached). In most other countries grid parity is expected to be reached a few years later, but before 2020. So far, so good, one could say.**

Apparently it will not take decades for PV to become competitive, as some people still think, but rather years. That is good news. The confusion and the debate arise when it is suggested that grid parity is something well-defined and that reaching grid parity is a sufficient condition for large, self-sustained PV markets to emerge. The concept of grid parity in its simplest form relies on a comparison of the so-called levelised cost of PV electricity (LCoE) with the actual price of electricity from the grid. There is, however, no unique relation between the turn-key PV system price and the LCoE, not even when the annual electricity yield can be predicted accurately. The calculated value of the LCoE depends, among others, on the cost of capital (or alternatively, the return on investment required). This, in turn, is dependent on many factors and choices made and may result in at least a factor two difference between calculated LCoE values for identical system prices and annual electricity yields. When other categories of investors and types of ownership are included in the comparison (which may then not just be with retail prices), the situation becomes even more diffuse.

Moreover, for the concept of 'grid parity' to have practical significance for system owners it is essential that the value of all PV electricity produced is equal to the price of electricity from the grid. In other words, that some form of 'net metering' may be applied. This is by no means trivial and already subject of severe debate in several countries. Finally, even when definitions are agreed upon and net metering applies, reaching grid parity is a necessary condition, but not automatically a sufficient condition for large self-sustained markets to develop. This also requires the grid to be ready (and open) to accept large numbers of PV systems, to mention just one important other condition.

Besides 'grid parity' there is another concept, called 'investment parity', originally introduced by the European Photovoltaic Industry Association EPIA and AT Kearney in their study 'SET for 2020' on large-scale PV deployment in Europe. 'Investment parity' refers to the situation where the total costs associated with PV electricity generation calculated over the (economic) lifetime equal the total avoided costs of electricity purchase over the same time. Whereas 'grid parity' may be seen as a snapshot of the competitive position of PV, 'investment parity' is rather a movie of that position and takes into account expected price increases of electricity from the grid. The investment in a PV system provides hedging against such price increases, which is given a value in the comparison.

The term 'grid parity' should be caressed ánd handled with great care. It has proven to be very useful in general communication, when details and disclaimers are unwanted. However, when it comes to professional discussions we need a lot more to describe where PV is on its way to full competitiveness. Not the Holy Grail, but certainly not a hype either. PV progress is real and there is no stopping it now. PV is beyond the tipping point.

*Wim C. Sinke*
*ECN Solar Energy*


# OM&T | Moser Baer Technologies enter 'harvest year'

**'Thin-film silicon isn't dead, but does demand the right and timely technological innovation. Our linking of cell and light interception returns thin-film silicon to the field of influence of the various PV technologies,' explains Jan van den Brink, managing director at OM&T | Moser Baer Technologies.**

OM&T's roots lie, as do many other Dutch high-tech companies', with Philips. In this capacity, OM&T took care of the development of all relevant optical disc formats, including the CD and DVD. Since 2007, the company shares have been in the hands of the Indian company Moser Baer and the company is now known as OM&T | Moser Baer Technologies. OM&T relocated to the High Tech Campus in Eindhoven last year. Van den Brink: 'The campus generates cross-pollination. The R&D network there continues to develop – through for example Solliance – and that's why it's so interesting for us to have a presence here.'

**Transfer**

'We concentrate our activities on two markets – solar and organic LEDs – that dovetail into the knowledge and skills that we've developed in the past', continues Van den Brink. 'In the last few years, we've made a complete transfer from an optical disc to the development of thin-film applications. For solar, there are three matters that we're extremely good at: making regular and tiny structures, encapsulation and, finally, thin-film technology in general.'

Parent company Moser Baer, in turn, manufactures crystalline silicon and thin-film silicon solar cells. Van den Brink: 'It's our task to provide our parent company with the latest thin-film technology or to supply application builders who can transform this technology into manufacturing equipment. Therefore, our activities dovetail seamlessly together.'

**Light interception**

One of the most important breakthroughs that OM&T has recently made is a light interception technology that can increase the efficiency of thin-film tandem cells by up to fifteen percent. 'This is a very important step that could put thin-film silicon technology back on the map', says Van den Brink. 'In the coming period, we intend to industrialise our idea. The effects have been demonstrated on a surface about the size of an A4. It's now a matter of scaling up. We've also established the manufacture for R&D cells – single and tandem junction thin-film silicon cells – that has already shown a very promising yield of about ten percent. All in all, we have recently witnessed important technological breakthroughs.'

According to Van den Brink, the parent company Moser Baer is now aware that, for the time being, no overall winners have emerged from the various technologies. 'So, as a subsidiary, we can't just back a single horse either. This is part of the reason why we're currently undertaking an exploratory project in which OPV, CIGS and hetero-junction cells are being miniaturised. As far as other matters are concerned, we can consider we've achieved success if our light interception method has landed with an application builder next summer and, on the other hand, the first initiatives have commenced to transfer this to our parent company. We've invested for the last five years and now, this year, it's time to reap the harvest. The developed technologies have to land and follow-up projects will be defined.'

### Key competences OM&T

OM&T is the European R&D centre of Moser Baer India:

- main focus today is the field of energy-efficient devices, such as photovoltaics and OLED;
- using knowledge of lithography, electro-plating, replication, thin-film technology and system integration;
- aim of the R&D programmes is to generate new business opportunities for Moser Baer India.

# OTB Solar continues to invest heavily in R&D and new applications

**OTB Solar is one of the gems of the Dutch PV cluster. The company is a textbook example of the successes that innovation can lead to. Important elements of OTB Solar's strategy are continuous development of new applications, extensive specialisation, and close collaborations with partners along the value chain.**

OTB Solar's core competence is the development and manufacturing of automated integrated process equipment for the manufacturing of solar cells (see box for details). As a result of the company's tremendous performance, it was taken over by the larger German PV equipment supplier Roth & Rau in 2010. Just recently, Roth & Rau has in turn been taken over by the Swiss company Meyer Burger.
During a recent visit to Eindhoven Peter M. Wagner (Chairman Meyer Burger Technology) and Peter Pauli (CEO Meyer Burger Technology) got a good impression of the OTB Solar organization. Meyer Burger sees good opportunities for OTB's existing and newly developed technologies. The strong belief of Meyer Burger to increase the value of their investments is a strong motivation for future integration of OTB in the Meyer Burger Group.

**Upcoming markets**
OTB Solar CEO Claus Lichtenberg explains that OTB Solar focuses on three different activities with which the company is striving to provide higher value to the customer. Two of them are already applied in and supplied with the DEPx machine. The first is plasma enhanced chemical vapour deposition (PECVD) using a proprietary plasma source technology. The second is fully integrated wafer handling automation. The third activity that the company is currently heavily investing in is inkjet printing. 'The solar market has considerable business potential for this technology. In order to accelerate the development of new ink-jet printing applications, we have installed equipment at Roth & Rau's technology development center. It is our goal to offer common process solutions together with Roth & Rau. On the other hand, we are increasingly winning market share in adjacent markets like medical devices, MEMs, and OLEDs. This is important to guarantee the continuity of our business since it is impossible to absorb the ups and downs of the solar market if you are only active in that particular market. To balance the volatile nature of the solar market, we identified and advanced into new markets. This is one way in which we will add value within Meyer Burger Group.'

**Plug-and-play**
'We are currently field-testing a plug-and-play solution that will significantly improve cell efficiency. We use our DEPx machines to deposit a combination of silicon oxide (SiO2) and silicon nitride (SiNx) to solar cells. Properly tuned, these stacks increase cell efficiency by up to 0.6 percent', continues Lichtenberg. 'While other equipment suppliers need three or four steps to achieve this kind of improvement, we can do it in a single step. This is possible due to a new process that we are able to run on our new generation tools. Since this process is compatible with standard cell production, this upgrade is an attractive option for all customers who are looking for ways to increase the output of their lines and produce premium quality cells.' At the PVSEC in Hamburg OTB Solar will be displaying solar cells with this new technology. 'Furthermore we will launch our new wafer handling systems with record low breakage rates. And our PiXDRO team will demonstrate several new inkjet applications, some of which will be commercially released in the coming years. The growing Dutch solar PV cluster with leading companies and research institutes is supporting and accelerating our commercialization efforts. It helps us to develop and produce new technologies and applications faster. Short time-to-market is essential to succeed in the volatile solar market environment.'

## Key competences OTB Solar

Solutions for automatic solar cell manufacturing

**DEPx**
The world's highest speed PECVD system with high throughput and smallest footprint. DEPx is a successful modular product platform based on a proprietary Expanding Thermal Plasma source. Due to the modular design, the DEPx combines maximum flexibility with the highest deposition speed, which is an enabler for multiple layer applications requiring thin film coatings like silicon nitride, silicon oxide and amorphous silicon.

**AUTOMATiON**
Robust wafer handling solutions for superior equipment performance
Automation improves the productivity of solar cell factories. The AUTOMATiON product family is based on a transparent, smart, and simple design which ensures high flexibility and best equipment performance. AUTOMATiON solutions have high throughput and uptime and low breakage rates.

**PiXDRO**
Ink-jet printing for product development to pilot and mass production
Using flexible and highly adaptable system architecture, the PiXDRO ink-jet printing platform serves a broad portfolio of applications serving the solar, medical, plastic electronics, and security printing markets.

# Tempress Systems plucks the fruits as the solar industry embraces the N-type solar cell

**'The N-type silicon solar cell is the technology of the future. Under the guidance of Yingli, this solar technology is making a strong upturn. An interview with Fokko Pentinga (President Amtech-Tempress)and Rob de Jong (Area Sales Manager) from Tempress Systems.**

Tempress Systems was one of the first Dutch companies that managed to build an international market position in the solar industry through supplying manufacturing equipment. Today, it is still the market leader in solar diffusion process manufacturing equipment. Diffusion furnaces are shipped worldwide from its factory in Vaassen every week. For the last three years, the Chinese company Yingli has been an important customer.

**N-type solar cell**

Two and a half years ago, Tempress started – together with the Energieonderzoek Centrum Nederland (ECN) – the development of the N-type solar cell, for which Yingli (Panda cell) was the first customer. The cell design originated from ECN, Tempress supplied the technology for the diffusion process and Yingli managed the process technology. 'The machines have already been modified from the first type that we supplied Yingli with', explains Rob de Jong. 'For example, the automated processes have been revised. Yingli is extremely happy with the performance of the machines and the N-type cell.' 'This N-type cell remains a silicon technology that we, ECN, Yingli, and also other market parties expect a lot more from in the future', adds Fokko Pentinga. 'The first competitors have appeared on the horizon. In the meantime, the demand from the market for our technologies and services has escalated. We're currently in talks with several companies concerning building similar diffusion processes.' The Jong adds: 'Many PV manufacturers in the global top 20 of silicon solar cell manufacture already knew their way to Vaassen's door. In the next five years, we hope to add a great many more companies to this list with the N-type solar cell. The major benefit of the manufacturing process is that it is relatively simple to incorporate in an existing factory.'

**Ion implant**

To maintain its position as market leader in the future, Tempress invests continuously in R&D, according to De Jong and Pentinga. 'We've mastered the finer details in the processes for diffusion furnaces and we intend to lead here in the future, too. Our collaboration with ECN is essential, as well as permanent research into silicon solar cells. In the coming years, we want to explore – together with ECN – the possibility of marketing the latest technologies, such as CVD.'

One of the investments that Tempress made this year, together with its parent company Amtech Systems, was the takeover of the Chinese company Kingstone. De Jong: 'This company is working on a new technology – ion implant – that could expose an entirely new market segment in the future of the solar industry with ultra high-efficiency solar cells. Above all, it's a technology that supplements our diffusion furnaces.'

**Key competences Tempress Systems**

- Development and manufacturing of vertical and horizontal Diffusion & LPCVD furnaces;
- the product range encompasses R&D, pilot to fully automated production furnace systems for processing up to 210 mm wafers.

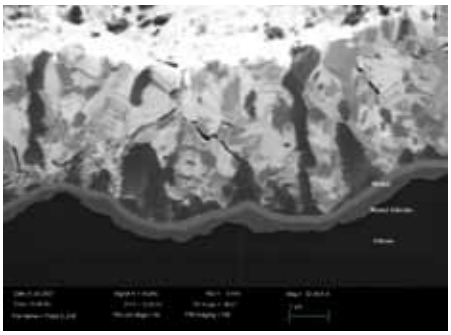
# Enthone is making considerable headway with electroplating for solar cells

**Enthone Inc. (Cookson Group) is working hard on the development of new plating technologies in order to establish a leadership position. Their core competence, electroplating chemicals, can be utilized for both thin film and silicon solar cells.**

Within the solar industry, Enthone is busy introducting its speciality: developing (electro)chemical processes for the (electro) plating of surfaces. 'Plating technology is a method that utilizes electricity or electrons to cover an object with a layer of metal', explains Jan Hendriks, R&D group leader PV and electronic materials. 'This is how we provide steel with a layer of zinc, nickel or chrome to make it more resistant to corrosion. The principle of galvanic deposition of metals can also be used for thin film and silicon solar cells.'

**Holy grail**

'The most common option for applying conductors to silicon solar cells is through screening with silver paste', continues Hendriks. 'It's also possible to apply these conductors directly to the silicon using electroplating techniques. The advantages are improved conductivity thus lower resistances with smaller tracks (increased efficiency) and material reduction (cost reduction). At the same time, the productivity can be enhanced as galvanizing is a continuous process and the application of silver pastes is in principle a batch-based process. We've now reached product qualification phase with a number of major global solarcell manufacturers.' Electroplating is not exclusive to silicon, but can also be used for thin film solar cells. Hendriks: 'It doesn't matter if it concerns copper, indium or gallium or other elements from the 'stack', all of these can be deposited through electroplating. This is far less expensive than the chemical PEVD process and/or the use of vacuum technology. The cost price is well on track and we're also



making good headway with the yields, which are currently about ten percent. We are close to the target efficiencies required. For further development, we're parterning with other industrial companies who intend to supply turn-key systems using (partly) electroplating. We therefore anticipate volume manufacturing to happen within a couple of years.'

# GreenTech Engineering supports companies from lab to fab

**On the 1st of January 2011, the Netherlands PV cluster once again witnessed the founding of a start-up. Marcel Grooten established the engineering and service agency GreenTech Engineering. The company aims to suppport the industrialisation of technology in for example the PV industry.**

'In other words, facilitating the challenging step from lab to fab not solely for lots of solar start-ups, but also for known PV companies who regularly encounter difficulties here', according to Grooten. Grooten has an impressive track record in the PV industry. In 2010, he decided to leave OTB Solar and start his own company.

**Competency**

'The PV industry is an excellent example of one of the sectors on which we are focusing with GreenTech Engineering, in addition to the semicon, LED and automotive markets', explains Grooten. 'Solar is a market in which new technologies are constantly making their entrance. The sector has perhaps another five to ten years of industrialisation ahead of it before it actually reaches maturity. Industrialisation is not only a necessity for the start-ups, but also for the OEMs and their suppliers. This is to whom we can provide industrialisation competency.'

'Already only in the Netherlands enough examples are available of companies who have a need to industrialise a particular technology', continues Grooten. 'For example, Helianthos solar foil, SunCycle's CPV technology and the ALD start-ups like SoLayTec and Levitech. This is also true for 'established' companies like Scheuten Solar, who are industrialising CIGS technology, and a company like OTB Solar. For OTB Solar we are involved in a development and industrialisation project related to inkjet technology. We don't just focus on the Netherlands, but are in discussion with several companies in Germany and start-ups in India and Macedonia.' Within five years, Grooten wants to expand from the current start up small size into a company with at least forty to eighty employees. 'We will act as competency provider for existing companies and as an established industrialisation partner for techno start-ups. As an engineering service provider, we have the ability and ambition to tackle and deliver industrialisation turnkey projects.'

*Marcel Grooten*

# Scheuten Solar has started roll-out of premium modules

**'The PV market is increasingly flooded by standard modules. Requirements are changing as a direct result of market development, for example with a view to integrated systems. This creates space for the introduction of premium modules. With the launch of our glass-glass module Multisol Vitro, we've made start with the large-scale application of such premium modules,' says Theodoor Scheerder, Director Sales & Marketing at Scheuten Solar.**

Scheuten Solar is part of Scheuten, an internationally prominent player and manufacturer of comprehensive solutions in glass and solar energy systems. Scheuten Solar, in turn, is active in the field of design, manufacture, distribution and installation of PV modules. One of the company's most recent achievements is the introduction of the Multisol Vitro, a so-called glass-glass module. After pilots were run at the end of last year, the module was definitively launched on the market in the first months of 2011. 'This module has resulted from our innovation focus on the residential market', says Scheerder.

**Robust**

'On the European market, we're active in the residential and industrial segment', Scheerder continues. 'Where it comes to industrial installation, we supply systems of between fifty and a few hundred kilowatt peak. In the south of Europe, we also focus on utility scale power plants, from 1 MW to 5 MW. For all segments, innovation is the core of our business activities. As stated, the Multisol Vitro is one of the latest novelties. Our combined knowledge of solar and glass has enabled us to launch this glass-glass module on the market.'

This state-of-the-art module consists of a glass-glass laminate. The cells are embedded in a front-glass and back sheet. Scheerder: 'We've generated this solution to create a robust module. Normally, the most vulnerable component of a PV module is the synthetic back sheet. When glass is used, there are no condensation issues. Partly because of this, we give no less than a thirty year yield guarantee on this module and a twelve-year product guarantee.'

**Premium**

Besides the technological performance of the Multisol Vitro, Scheuten Solar is also taking a giant aesthetic leap with the product. 'The demand for modules with an attractive design is increasing hand over fist, as well as the demand for BIPV solutions', says Scheerder. 'Our module is frameless and aesthetically very attractive. In addition, the Multisol Vitro can be used in portrait and in landscape format in combination with our Integra roof products for in-roof application.' Strategically, in Scheerder's vision, Scheuten Solar introduced the glass-glass module at exactly the right moment. 'We're witnessing the flooding of the market with large quantities of standard modules that differ very little from each other. With a view to the future, we want to focus increasingly on premium modules. They should be available for only a marginally higher price, but lead internationally in aesthetics, quality and functionality.'

Now that the market is becoming saturated with standard modules, opportunities are arising for Scheuten Solar to launch premium modules on the market. Scheerder about this: 'In the past, this market space didn't exist. We can now market new products that match our portfolio perfectly. We're therefore expecting to continue our growth with premium modules in important countries such as Italy, France, Germany and an up-and-coming country like Belgium in the near future.'

### Key competences Scheuten Solar

- Developing, manufacturing, distributing and designing PV solar modules & solutions
- PV system integration
- Development and realization of turnkey PV systems

# Masévon grows and raises its international profile in the PV industry

**'As an Original Module Manufacturer, the PV industry is a growth market for us in which we want to continue to expand in the coming years through raising our international profile,' says Henk Kieft, director of Masévon, in Hardenberg.**

Masévon is part of the Triumph Group. This group – which also includes the engineering works Machinefabriek Tuin (supplier of high-quality machine components) and Vernooy Vacuum Engineering (specialised in vacuum technology) – has developed during the last few years to become a very flexible and high-quality manufacturer of machinery and equipment for highly demanding markets such as the solar industry. 'For example, at the beginning of this century, Masévon was involved in the creation of the vacuum deposition systems that OTB Solar became famous for', relates managing director Henk Kieft. 'From this point of view, we're a renowned player with a considerable track record within the solar industry. Not just in vacuum technology, but also in handling systems and in first prototyping for start-ups.' Kieft believes that Masévon's strength is determined primarily by the managing Triumph Group. 'The combination of companies has allowed us to grow to become a full-service system supplier specialised in vacuum technology with both internal and external manufacturing capacity. The last decade has witnessed an annual autonomous growth of ten to fifteen percent. Above all, our portfolio of markets has diversified: from industries such as solar to chemical, semicon, medical and aviation. It's important to note that we don't have any products of our own, but that we follow the markets and customers.'

'We've grown to become an Original Module Manufacturer (OMM)', continues Kieft. 'The PV market is a top-three market for us, as is the semi-conductor industry. We execute projects on behalf of companies that are often based in Germany, the Netherlands and China. In the coming year, we want to increase our footprint in, amongst others, the solar industry through raising our international profile.'

# Bronkhorst continues to renew its portfolio

**Bronkhorst is the European market leader with its portfolio of mass flow, pressure and vapour controllers. The company hopes to be able to introduce a number of innovations to the growing solar market in the coming years and in, so doing, set forth the current growth.**

Within the solar industry, Bronkhorst is the supplier of thermal and coriolis mass flow controllers. These instruments measure the flow of various gasses and/or liquids for manufacturing processes in solar factories. All instruments are equipped with an onboard PID-controller that can control a valve or a pump. The combination of a sensor, a PID controller and an actuating device makes it possible to dose a very accurate quantity of gas, liquid or vapour that is needed in the manufacturing process in question. In solar factories, this concerns a wide range of gasses, from argon to ammonia, silane and hydrogen selenide and liquids like tin chloride, TriMethylAluminium and DiEthylZinc. 'Our sales have doubled every seven years since our establishment. Knowing that the solar market, which is so important for us, is to experience a gigantic boost in the coming five years, we set forth this ambition', Armand Bergsma from Bronkhorst adds. 'In turn the solar industry mainly expects products that are robust and continue to function without problems and in a reproducible manner'.

Bronkhorst, together with system builders like Lamers High Tech Systems, belongs to a selection of companies whose paths cross when building almost every new solar application or new machine. 'So, for example, we supply a product with Lamers that is essential for the operation of various solar cell manufacturing machines', says Bergsma. 'Our instruments play a key role in the manufacturing of solar cells. It's our ambition to simplify, together with our customers and system builders, the gas panels in solar factories with a whole series of innovations in the coming period. At the moment, the solar industry is especially interested in 'proven technology'. We're past masters at simplifying gas and precursor dosage and in, doing so, generate major cost reductions. Especially in the area of vapour dosage, there are large steps to be taken.'

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*INSPIRING INNOVATIONS*

# Test machine for 'Ribbon-Growth-on-Substrate' achieves desired yield efficiency

**In Broek op Langedijk in Noord-Holland, significant advances have been made this year in the development of Ribbon-Growth-on-Substrate (RGS) silicon wafer technology. 'The manufacturing process has been stabilised to a great extent and, as a result, the yield of the wafer manufacturing is now higher than eighty percent. The planned objective to deliver the first production line and, in doing so, equip the first commercial factory with RGS technology in 2013 is still right on track.' An interview with Axel Schönecker, managing director of RGS Development.**

'Within the manufacturing chain for solar panels, we're in the link that manufactures silicon wafers', continues Schönecker. 'This section of the chain has been hindered up until now by the quantity of material that is lost when the silicon blocks are cut into wafers. With the Ribbon-Growth-on-Substrate (RGS) technology – in which silicon in a liquid state is poured directly into thin wafers – we're able to prevent material loss. On top of the fact that we can make twice as many wafers with the same quantity of raw materials, the manufacturing process is far more efficient and, as such, it halves the cost of the wafers.'

**Road shows**

RGS technology involves heating the silicon to a temperature of 1410 degrees Celsius. After this, it is poured into a mould in a molten condition, where the silicon solidifies into a thin foil. This avoids the necessity for sawing and the corresponding material loss. 'Last year, we managed using our technology and the machine we developed to pour the first industrial-size 156mm wide wafer, and now we've also managed to achieve the desired yield efficiency', continues Schönecker. 'In doing this, we've demonstrated that the technology works and that we've mastered making the wafers. The machine has reached the so-called steady state.' That there is still a beautiful future ahead for RGS has been re-endorsed this year, according to Schönecker. 'Partly through the increasing international competition, we've had our confidence in the fact that we're on the right road with RGS reinforced. We've held various road shows to test the interest in our technology this year. This is partly why we've attracted the attention of a number of international solar companies from China and other countries. In brief, there is international support for our technology.'

**Developments**

In addition to the technological developments, Sunergy Investco has - as an RGS Development shareholder - decided to merge its RGS industrialisation team with the RGS Development team and to strengthen the board with the addition of Maarten den Heijer. Through this, development and industrialisation processes are brought together, achieving a maximum speed to market. All current developments together have convinced Schönecker of the feasibility of the time frame set by his company. 'We're almost one hundred percent sure that it will be possible for us to bring the first pilot production into operation in 2013. During the coming period, we're going to be concentrating on reducing the contaminations in the machine. This does not involve new or unknown factors, but matters that are difficult to measure and can influence the yield of the solar cells. All in all, it will result in the machine running at full capacity by the summer of 2012. One year on, we will build the first production lines and, following this, we will enter the commercial market on a large scale in 2015.

## Key competences RGS Development

Ribbon-Growth-on-Substrate (RGS) benefits:

- 20 times higher manufacturing capacity for each line in comparison with conventional technology
- Two hundred percent more wafers from the same amount of silicon
- Fifty percent less power consumption for each wafer
- Twenty percent lower investment for each wafer capacity

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# Lamers High Tech Systems launches evaporation cabinet for solar industry

**Lamers High Tech Systems is currently on a winning streak. During the last calendar year, the company attracted so much attention that - mid May - it was purchased by Aalberts Industries. The company also recently launched its, independently developed, evaporation cabinet for metal alkyds like TMA and DEZ. 'This achievement demonstrates our facilitating capacities to develop and build the appropriate and latest dosage and control equipment for the innovation processes within the solar industry', states Nico Nieuwland, managing director of Lamers High Tech Systems.**

Lamers High Tech Systems (Lamers HTS) is specialised in the design, construction and qualification of installations and control systems for high-purity gases and chemicals. They are sold to the semiconductor, aviation and space exploration, pharmaceuticals, LED and solar industries. Mid May, it was announced that Lamers HTS – part of the international Air Liquide group since 1999 – had been taken over by the stock-listed Aalberts Industries from Langbroek. 'The take-over offers us space to not only focus on the rapidly growing solar market, but also to realise considerable growth in, for example, the LED and other new markets', says Nieuwland. 'Above all, we strengthen the position of Aalberts Industries in the form of a technology partner in the semiconductor market with customised systems for high-purity gases and chemicals.'

**Physical effects**

As already mentioned, the takeover was not the only news-worthy development concerning Lamers HTS. The company recently launched an innovative evaporation cabinet. The system has already been sold to a number of ALD manufacturers. 'However, the cabinet could be used for many more applications within the solar industry', explains Nieuwland. 'We've completely developed the system in conjunction with the first purchasers. We had already made evaporation systems for the deposition of materials such as silicon carbide and oxide. The idea for this evaporation cabinet was derived from a joint WBSO project with Bronkhorst that was focused on the evaporation of chemicals.'

'Following the project, we felt a latent demand from the market for an evaporation cabinet capable of the more accurate regulation of TMA and DEZ, molecules commonly used within the solar industry', continues Nieuwland. 'An important improvement with regard to the traditional processes is the accuracy of the process. TMA and DEZ are expensive molecules that our cabinet, which produces a higher quality, manages to use far more sparingly.'

**Facilitator**

Lamer HTS' evaporation cabinet can regulate the quantity release during the evaporation phase very accurately. This process is affected dramatically by external physical effects such as air pressure and temperature. Nieuwland: 'Needless to say, it's a very complex and specialised system. With the evaporation cabinet as a platform, we can serve a very wide market.'

'It offers industries that work with ultra-pure gasses and liquid chemicals the possibility of working more accurately', continues the director. 'This was the first time that Lamers HTS developed a product entirely at its own risk. This platform provides us with the extra backing and a boost to continue with the independent development of systems. Frontiers have been pushed back and this has only made us hungry for more. As I've mentioned before, as a facilitator, we're able to develop and build the appropriate and latest dosage and control equipment for the innovation processes within the solar industry. The development of the evaporation cabinet is a manifestation of this. It lifts our company to the next level. There is demand for our high-tech speciality tools in the Netherlands and throughout Europe and we can cater to this demand.'

'The TMA evaporation cabinet is actually part of a much wider portfolio', concludes Nieuwland. 'We can provide OEM suppliers with parts for machine construction and install all the gas and chemical systems in the factories where the machines are to be located. Finally, we can also supply the dispensing and evaporation equipment. It's important to note that our success is dependent on the success of the solar industry at large. We will grow alongside them, providing we fulfil our role as a partner. This is why we've turned flexibility into an art form.

# HIGH TECH CAMPUS EINDHOVEN

## Hotspot for Human Focused Innovation

Foto © Holst Centre

**Solar energy**
Traditionally, systems and technology involving semiconductors on thin film have been strong fields on High Tech Campus Eindhoven. This knowledge and expertise are extremely valuable assets for the development of solar energy systems, because they offer crucial research answers.

Several players in the solar energy business such as ECN, SunCycle, Free Energy Consulting and KIC InnoEnergy already enjoy the advantages of being located at the Campus. With knowledge providers such as Philips Innovation Services and Holst Centre, the expertise is enriched. Finally, the MiPlaza facilities complete the high tech ecosystem in the field of solar.

High Tech Campus Eindhoven is an R&D ecosystem of more than 90 companies and institutes, and some 8,000 researchers, developers and entrepreneurs, who together are working on developing the technologies and products of tomorrow. The preferred work approach at the Campus is Open Innovation. This means that Campus companies share knowledge, skills and R&D facilities in order to achieve faster, better and more customer-oriented innovation.
The companies on the Campus focus on such fields of technology as High Tech Systems, Microsystems, Embedded Systems, Life Sciences and Infotainment. Taking these domains as their starting point, they create global innovations, most notably in the application fields Health, Experience and Energy. The international community of the Campus shares a common drive for creating innovative solutions that make human life healthier, more pleasant, easier, more interesting and which contribute to a sustainable world. This makes the Campus a place where entrepreneurial spirit, high-end research and creativity can flourish and lead to successful new products for global business.
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# Brainport Eindhoven benefits from the energy research hub

**The high tech region Brainport Eindhoven forms part of the technological backbone of Europe. The region plays a major role in generating the innovative and economic power of the Netherlands as a whole.**

The innovative character of our region is supported by the facts. Brainport is a significant earner for the rest of the Netherlands, with 25% of all Dutch export coming from this region. Together with the mainports of Amsterdam and Rotterdam, Brainport is the bulwark of the Dutch economy. It is the combination and more importantly, the cooperation between the world class companies located here and a wide range of highly innovative small and medium enterprises (SMEs) that deliver their products in strong and interrelated supply chains, that sets this region apart.

The strong performance of Brainport can be attributed to the investments made by companies in research and development (R&D) into new technologies, products and services. Nearly 30% of all private R&D investments within our national borders happen here. And more than half of all patents originate in the Eindhoven region. As chairman of the Brainport Foundation, I am honoured to represent this important economic ecosystem. The current situation in Brainport is promising, but the world is changing rapidly. The societal themes of our era have considerable impact on the competitiveness of the region. The growing need for energy is an important theme, just as the scarcity of raw materials, ageing population, climate change, congested roads and strong international competition. Brainport Eindhoven is able to find solutions for exactly these issues; here solutions are found for problems that occur all over the world.

Smart, energy efficient cities are crucial in today's world where cities become more and more densely populated. Therefore, Eindhoven focuses at energy and has claimed to be energy neutral by the year 2045. The potential is here; Eindhoven is becoming a leading knowledge centre in the area of durable energy. This is shown, for example, by the Eindhoven Energy Institute (EEI) of the Eindhoven University of Technology (TU/e) that focuses on energy in the built environment. More than 150 researchers are working on renewable energy. Also, the Intelligent Lighting Institute recently started as a joint operation of leading businesses and knowledge institutions. In 2010 the Energy research Centre of the Netherlands (ECN) and FOM Institute for Plasma Physics Rijnhuizen, both decided to relocate research activities to contribute to the energy research concentration in Eindhoven. Furthermore, Eindhoven participates in the European Institute of Innovation and Technology (EIT) with a co-location of the Knowledge and Innovation Community (KIC) in the area of InnoEnergy. And also, Eindhoven is home to a solar research alliance of more than 250 researchers, Solliance, that works on photo-voltaic solar energy (PV).

Clearly, Eindhoven has a strong international research position in the area of energy. Bringing these technologies and innovation to the market is another, more difficult thing to manage. As mayor of an ambitious European city I experience this every day. Several initiatives in the region work on valorisation of research. The aim is clear: to develop new products and services from the pool of knowledge that results from research. The city of Eindhoven is now trying to develop a living lab (test beds) for energy production and energy saving to put scientific knowhow into practice. In this way Eindhoven and its citizens will be the first to benefit from its own knowledge creation in this field. The living labs will make it easier for regional industry to experiment and bring technology to the market. They can also function as means to involve customers actively in the innovation process.

Currently, Eindhoven is structurally stimulating the durable energy production within its municipality borders, it is working on 'strategical durability-planning' and focusing on electrical driving on several energy sources. Based on the excellent research position, durable energy applications should not be far away. Hopefully, Eindhoven can be energy neutral years before 2045! In short, Brainport Eindhoven is the place to be for those who want to start a company, or take advantage of rapid growth opportunities in the solar industry and/or other related sectors such as the battery technology sector. It is a solid and innovative environment for R&D and high-tech manufacturing. There is a high degree of confidence that Brainport will be able to continue to generate knowhow, innovations and bring them to the market successfully. Brainport is certainly living up to its slogan: Creating the industries of the future.

*Rob van Gijzel*
*Mayor of Eindhoven*

# VDL ETG continues growth as a tier-one contract manufacturing partner

**Almost four years ago, the VDL Enabling Technologies Group (VDL ETG) took its first steps into the solar industry. As a tier-one contract manufacturing partner, the Philips spin-off can borrow from many years of experience in the semi-conductor, space exploration, defence and medical industries. With this baggage, the company has already carved a very nice position in the market. 'The solar market is a growth market that we concentrate on. In one of our three specialities – handling, positioning and vacuum technology – we want to grow to become the global specialist', states Simon Bambach, CEO of VDL ETG.**

VDL ETG got off to a flying start in the solar industry during the last few years. With Applied Materials – and its subsidiaries Baccini and PWS – and Solyndra as customers, VDL ETG managed to firmly establish itself in the solar community.

**Enabler**

VDL ETG has various specialisations. The company builds vacuum deposition systems for its customers (both for crystalline and thin film technology), supplies vacuum chambers and designs and builds the handling equipment for various substrates; from wafers to large thin glass panels. VDL ETG are past masters in the increasingly important roll-to-roll manufacturing processes in the solar industry. 'We're old hands when it comes to manufacturing processes, so too with roll-to-roll', explains Bambach. 'In the past, we very often utilized our skills in the roll-to-roll field, for example in the wrapping and unwrapping of Proctor & Gamble products. As we speak, we are in talks with many customers from the solar industry regarding the supply of different roll-to-roll systems. This can be for sheet steel or copper strip and we see countless materials in the form of substrates. From glass to wafers and more flexible substrates.'

Bambach realises better than most that solar is not a run race. 'The winning technologies still have to be selected and the controlling and dominant players still need to be established. In the background, strong conglomerates are amassing, such as Maier Burger and Applied Materials. For us, the facilitation of these technological developments for these kinds of companies is our goal. This is also concealed in our company name. We are an enabler. As VDL ETG, we'll be more than happy if, in a few years' time, we have managed to become the supplier of choice for the dominant players on the solar market. We want to be a company that takes responsibility for the features in customer equipment. We don't want to just supply on the basis of a pile of drawings, but also assist customers in the invention, development and construction of their equipment.'

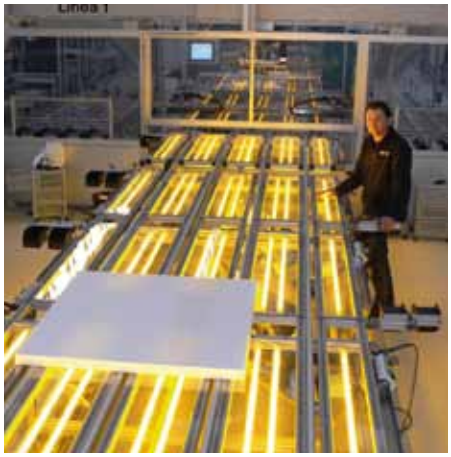
**Knowledge infrastructure**

Despite being a company that is a supplier, Bambach believes that there are many opportunities for his company too. 'We could, for example, become the specialist in roll-to-roll processing. Ultimately, it's our goal to grow to become the global specialist in one of our three core competencies – handling, positioning and vacuum technology.'

Finally, Bambach sees the international threat for the Dutch solar cluster opportunities: 'It would be a tremendous pity if the Dutch cluster isn't able to produce a company that can measure up to the international top. The entire infrastructure to enable successful operation is in place, from knowledge institutes to suppliers. It's important that the Netherlands clusters the knowledge regarding manufacturing technology and endeavours to employ it competitively at an international level. As a supplier, VDL ETG wants to contribute towards this.'

### Key competences VDL ETG

- Vacuum deposition equipment, based on crystalline and thin film technology;
- Designing and building equipment for handling of the substrate.



# Rimas and OTB Solar raise control over solar cell manufacture by joint innovation

**Manufacture solar cells and panels more cheaply, better and faster. This is Rimas' and OTB Solar's ambition and the driving force in their joint innovation project ZONPROM. The project is to be officially concluded in the summer of 2012, but the first results are already visible.**

Within ZONPROM – which stands for solar cell manufacturing process control and measurement technology – RIMAS and OTB Solar are working with Holland Innovative, TMC Group, Mecon, TNO and ECN. With a grant from Dutch central government, the provinces of Noord-Brabant and Limburg and the Samenwerkingsverband Regio Eindhoven (Eindhoven Region Joint Venture), the organisations are working on a joint innovation project. The intention of ZONPROM is to develop new measurement methods that deliver knowledge regarding manufacturing processes. The new applications should not just lead to a reduction in the manufacturing costs, but also to better monitored production lines.

**Wafer tracker**

'The predetermined objective of the ZONPROM project is to raise the level of cell and module manufacturing', explains Jan Wemmenhove, who manages the project through his position as project manager with Holland Innovative. 'There are very few methods, measurement tools and standards in the field of manufacturing and quality. ZONPROM contributes in solving a number of these challenges. What logically started with a wider approach, has - through continuous convergence - led to a number of new measurement applications. As equipment builders, OTB Solar and Rimas are pushing hard with this project, TMC and Holland Innovative are responsible for the selected methods and process support, Mecon is involved in the engineering and ECN and TNO are functioning as knowledge institutes.' ZONPROM has already reviewed a great many subjects. Although some results are not yet definitive, Wemmenhove says that tangible results have already been achieved. 'Firstly, an interconnection tester for the measurement of the connections between wafers and strings has been developed. A prototype is already available. A test set-up has been assembled for the prediction of cell efficiency on the basis of bare wafers and a wafer tracker has been developed. Above all, within the project, the OTB lines logistics have been optimized and photoluminescence has been examined as a measurement technology. Finally, we're still working on the idea of a solar simulator, in other words an alternative flash tester based on new illumination ideas that will result in optimum efficiency in the production line.'

**Industrialisation**

'The ZONPROM project must be concluded next summer', continues Wemmenhove. 'The final phase of the project – that we've already commenced on – is based on the realisation of various prototypes and their validation. For our own company – Holland Innovative – and also for a company like TMC, ZONPROM will of course not result in final applications, but it will reinforce our position in the solar industry. It's a good contribution to the portfolio. Solar is one of the market areas in which we want to excel. A project like ZONPROM shows clearly what the Dutch cluster is capable of through joint innovation. The project is not just running smoothly, but is also leading to tangible applications.'

According to Wemmenhove, the industrialization process is running at an unprecedented pace, because the knowledge institutes are so closely involved in the project. 'Where normally knowledge institutes create a new technology and subsequently go in search of industrial partners, this process is accelerated considerably in ZONPROM. For example, the technology for the interconnection tester was only discovered during the course of the project and is being industrialised in record time. The strength is that the person who is to realize the final application is involved from the start and, as a result, the innovation doesn't get trapped at an academic level.'

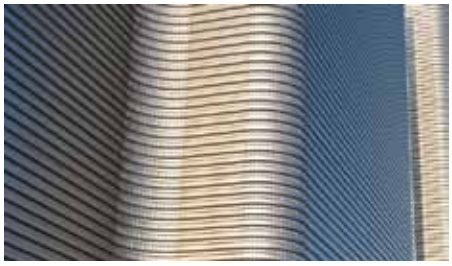
### Key competences project partners

- *OTB Solar:* solutions for automatic solar cell manufacturing;
- *Rimas:* turn-key solutions for solar module and cell equipment;
- *Mecon:* technology supplier of mechatronics products and systems;
- *TMC Groep:* consulting and engineering;
- *TNO:* independent solar research institute;
- *ECN:* development of high-level solar knowledge and technology;
- *Holland Innovative:* product and process development and project management.

# Consultancy and engineering firm DHV improves sustainability in solar industry

**An industry that supplies sustainable products is expected to manufacture sustainably itself. Naturally, this also applies to the solar industry. As a direct result, consultancy and engineering firm DHV sees the demand for sustainable designs of solar factories increasing rapidly. 'Our clients are not only thinking more and more in terms of making the manufacturing processes more sustainable, but are increasingly forced to do so by their customers', says Ad Schrijvers, business development manager with DHV.**






DHV is specialised in the design of process and building related utilities, the corresponding architecture and constructional supervision of solar manufacturing facilities. 'In the last few years, we have witnessed a trend where rapid development was considered to have top priority for many manufacturers', explains Schrijvers. 'They want to get to the market as fast as possible with their technology and the manufacturing facilities have to be built in no time at all.'

**Sustainability matrix**

According to Schrijvers, sustainability has chiefly gone ignored by many manufacturers in the initial and operational investment in buildings during the last few years. 'At the same time, you may well expect that solar companies – who supply green products – would have embraced green manufacturing. DHV highly values the cradle-to-cradle philosofy. This is also part of the reason why we recently developed the sustainability matrix. It enables us to make solar factories greener.'
DHV's matrix distinguishes four cost groups. 'The first being the investment group where no extra costs are involved. This can, for example, concern the location of the building. Which space goes where in the building, but also the location that can catch the maximum solar radiation. The second group encompasses matters with a very rapid return on investment, such as automatic awnings or blinds that keep the building cool. They seem to be obvious matters, but they are certainly not commonly employed in factories. The third cost group has a longer return on investment time, such as solar boilers and heat pumps. The last category is that of sustainable construction. Examples are landscaping on the roof and rainwater buffers.'

**Sustainability**

Cost-effective topics (growth scenario)
In the coming five years, DHV expects a strong increase in the interest in green factories and correspondingly an increased demand for the company's sustainability matrix. Schrijvers: 'Our clients are thinking more and more about sustainable manufacturing processes and they're also being forced to do so by their customers. In addition to a call for sustainability, manufacturers are focusing more on the total cost of ownership. This does not just consider the initial, but also the operational costs. So modular construction is gaining popularity. Manufacturers no longer want a factory with plenty of space for possible future growth, but they want a building that they can extend at a later stage at minimal additional cost.' To cater to this trend, DHV has developed a Utility Scan & Evaluation (USE). ' USE allows us to accurately evaluate if extra utilities are necessary in the set-up of new production lines. In the past, this was often done as a precaution and to be on the safe side. Nowadays, we attempt to avoid this in order to reduce costs.'
'All in all, in 2011 and 2012 we will be consolidating our worldwide top three position', concludes Schrijvers. 'In Germany, we're suffering increased competition. On the other hand, we're winning new markets in other parts of the world like North Africa and South East Europe.'

### Key competences DHV

- Consultants in feasibility studies, concept development and exploitation issues.
- Design of process systems and supply of utilities.
- Management of construction and environmental licenses.
- Total Design Management from architectural creation until hook-up of process equipment.
- Supervisory and construction management during the execution of the manufacturing facilities.

# Cell and module factory Alinement right on track

**At the end of last year, Henk Koerselman and Jac Hanssen announced that their new company Alinement had signed a 'memorandum of understanding' with two foreign technology partners: the German machine builder Roth & Rau and the Canadian module manufacturer Day4Energy. From next year, Koerselman and Hanssen are going to manufacture both PV cells and modules with Alinement. 'Everything is still on track for us to commence commercial manufacture in the third quarter of 2012', according to the two directors.**

During the last few months, Henk Koerselman and Jac Hanssen have been busy approaching market parties with their business plan. Following the international announcement of the establishment of Alinement at the end of last year, the interest in the company was unprecedented. 'We're now in talks with various parties regarding the financing of the initial phase of our company, being the cell and module manufacture with a capacity of eighty megawatts', says Hanssen. 'The parties with whom we're talking have also expressed their interest in the second phase of the project, in which the factory is to be prepared for manufacturing 500 megawatts per annum.' Koerselman adds: 'The banks have formed a consortium and are prepared to absorb part of the financing themselves. So we can't presume otherwise than that the finances are all on track.'

**Pilot machine**

'Above all, the WABO permit (construction and environmental permit) has been issued by the municipality of Heerlen and European Science & Business Park Avantis', continues Koerselman. 'DHV has already been selected as the contractor. Considerable steps have been made for the construction of the factory as evidenced by the issue of the permits.'

Alinement has also made progress with regards to the technology. Hanssen: 'With Day4 Energy, we're at such an advanced stage that the layout for the factory has been completely frozen. Prior to the financial close taking place, we intend to place our signatures on the purchase contract. The same applies for Roth & Rau. The selected Neuchatel technology has been transferred to a pilot machine. One of the last things that has to be improved is machine availability for realising production. Any wafer breakage shouldn't be at the expense of the machine's up-time. We're passionately involved in the testing of a suitable solution with Roth & Rau. Here, too, the purchase contract will be signed before the financial close.'

**Material suppliers**

The latest technological developments concerning Alinement will mean that the production line will not be completed turnkey. The company first wanted to entrust this to Roth & Rau, but they changed their strategy through which Alinement has entered negotiations with third party equipment suppliers. 'We're currently immersed in the specification of the machines. To complete the picture, the PAs and JDAs with three Asian material suppliers who are to supply the full square mono N-type wafers are close to completion.' On the marketing side of things, Koerselman and Hanssen of Alinement are working intensively with Day4 Energy. 'Through this, we'll be able to enter a sales contract with Day4Energy. All in all, everything is right on track and in the second half of this year the first ground can be broken, so that in the second quarter of 2012 the factory can be completed. The commercial manufacture will then commence in the third quarter of 2012.'

## Key competences Alinement

- Alinement will construct an integrated manufacturing line for PV cells and modules;
- this line is based on Roth & Rau's PV cell and hetero-junction technology and Day4 Energy's module technology;
- altogether, Alinement will produce a highly efficient (>20%) and low-cost solar module;
- the production will start in Q3-2012 with a capacity of 80 MWp/a and expansion to 500 MWp/a.

*Henk Koerselman and Jac Hanssen*

# Smit Ovens ready for definitive breakthrough in thin film technology

**Over the last few years, the solar industry has welcomed countless start-ups involved in thin film solar cells. Although the market share for thin film solar cells lags behind that of silicon solar cells, this does not discourage the scientists' conviction that thin film solar cells are the future. '2012 has to be the year of the definitive breakthrough in thin film technology', says Wiro Zijlmans, CEO of Smit Ovens.**

Smit Ovens designs and manufactures thermal process solutions. The company does this for three solar thin film technologies: Transparent Conductive Oxide (TCO), Copper Indium Gallium Selenide (CIGS) and Cadmium Telluride (CdTe). At the beginning of this calendar year, Smit Ovens found the investment company Active Capital Company (ACC) prepared to make a capital injection. This investment supports Smit Ovens' aggressive plans for growth. The company wants to see its annual sales grow by fifty percent in the next five years. 'This financial reinforcement has made it possible for us to benefit from the recovery of the solar market in the first part of 2011. We've returned to the level before the crisis', says Zijlmans.

**Crystallization**

The majority of the customers for Smit Ovens machines are located in Europe and the United States. Zijlmans: 'Thin film technology will demand extra efforts in the coming years. The Asians will only get on board at the next stages, as better economy of scale has been achieved.' During the last few years of the three thin film technologies that Smit Ovens is working on, CIGS has been earmarked as the one with the most potential. Zijlmans: 'With CIGS, crystallization is a crucial process step. This is the point at which the increase in solar cell efficiency can be achieved. We have mastered this step. 2012 has to be an important milestone for getting CIGS off the ground once and for all.' 'There are still high hopes for thin film technology', continues Zijlmans. 'As it becomes more widely known and the economy of scale increases, the manufacturing costs make it a real competitor for silicon solar cells. The expectation is that this will happen anytime within the next three years. It should be mentioned that we're one of the few who are able to take the most critical step in thin film technology for various customers and different technologies, being the crystallization.'

**Efficiency**

Smit Ovens is really keeping the R&D efforts up there. During the last year, significant steps have been made with regard to innovation. 'A machine has been developed for CIGS technologies that offers a better basis for the crystallization process', explains Zijlmans. 'We've already sold two of this type. One of them is destined for the Netherlands R&D cooperative Solliance in which the Energieonderzoek Centrum Nederland (ECN), the Eindhoven University of Technology, TNO and the Holst Centre are participating. It's a machine for conducting research and manufacture. Above all, we've also sold a roll-to-roll CIGS machine. Although solar cells can be manufactured with this machine, the cost price doesn't yet fare well against the competition. Even so, there is a market for these premium cells, because they are lighter and more flexible. Finally, we're working on a new generation of our cadmium telluride (CdTe) manufacturing machine that utilizes a modified technology for the application of the active layer.'
'In the coming period, we hope to be able to supply customers with various machines to allow them to manufacture with success', says Zijlmans. 'It's extremely important that this is cost-effective. For the moment, it appears that we're supplying what the market requires. A new trend here is the demand for R&D tools. We'll be increasingly supplying these tools – that can facilitate the step to manufacture – in the coming years.'

### Key competences Smit Ovens

Thermal process solutions for high-volume manufacturing

Thin film solar solutions:
- Crystallization for CIGS
- Selenium deposition for CIGS
- Activation and deposition for CdTe
- Contact firing

Glass for solar:
- TCO for CdTe and thin film silicon
- Strengthening and toughening

*Wiro Zijlmans*

# Mastervolt drafts an ambitious plan for further growth

**'We want to double our sales every three years.' These ambitious words were spoken by Bouke Siebenga, Solar director with Mastervolt. The company designs, develops and manufactures reliable solar inverters. At the end of 2010, Mastervolt was acquired by the stocklisted industry partner Actuant in order to realise its plans for the future.**

'Everyone understands that the solar-power market will continue to grow in the coming years', explains Bouke Siebenga. 'Because the growth, we decided to join forces with Actuant at the end of last year. During the last decade, Mastervolt has enjoyed tremendous growth. As a result of this growth, a need arose for a new kind of shareholder. This was because we were no longer able to fund the current growth from our own capital and reserves. With Actuant as a new shareholder, our bankability has been seriously bolstered.'


**Doubling**

According to Siebenga, with the new shareholder, Mastervolt wants to continue the current growth in the coming years. 'This basically comes down to a doubling of the sales every three years', says Siebenga. 'Up until now, we have been chiefly active in the European market. With an American shareholder, we will also be entering the US market properly. What really will not change is our target group. We focus on residential and small commercial applications and not on large-scale industrial solar-power systems. The business model for those types of projects is completely different and it is difficult to compete in that market long term.' Mastervolt is currently hard at work on the development of new technologies for the following generations of its products. 'The coming years will be filled with the completion of our range of products for inverters up to thirty kilowatt hours', explains Siebenga. 'We're in the worldwide top ten with regard to inverter yield. We want to maintain this position through continuous innovation and, where possible, improvements. On top of this, in the coming years, we will focus more on control of the entire energy system and the management and monitoring of the entire underlying infrastructure. As Mastervolt, we want to provide optimum control of the interaction between the national grid and the arrival of great numbers of decentral energy generators in the form of solar energy systems. Part of this is the recently introduced 'reactive power' capability. Inverters – and consequently a company like ours– could play a crucial role in the successful roll-out of a smart grid.'

**Energy storage**

Unlike a great many competitors, Mastervolt is consciously focusing on a limited number of countries. 'In addition, we have opted to extract as many kilowatt hours as is possible from the solar-energy systems with our inverters', according to Siebenga. 'We do this with a relatively small range of products that can be deployed flexibly. We have carved a niche through a small selection of inverters for multiple applications. In the coming years – in which worldwide solar energy will be increasingly deployed – our products will play an increasingly important part and fulfil a multitude of roles. In the future, an inverter will not just supply the national grid with power, but it will regulate and optimise the grid and add certain qualities to the so-called smart grid. Furthermore, inverters may in fact play a role in the energy storage issue. Not in the form of a battery, but possibly through energy management.' Siebenga foresees tremendous opportunities in the intelligent national grid not solely for Mastervolt, but in fact for the entire Dutch industry. 'Overburdening the electricity grid may now appear to be a threat to the densely populated Netherlands, but as a country we could transform this into an opportunity. Similarly to the way in which after the 1953 flood disaster we transformed the Delta works into an export product, the Netherlands could become an international superpower in the area of renewable and the implementation into smart grids.'

### Key competences Mastervolt

Mastervolt delivers grid connected solar solutions around the world, comprising:

- solar inverters 0-1 kWp;
- solar inverters 1-10 kWp;
- solar inverters 10-100 kWp;
- solar monitoring.

# Solliance introduces focus to the research world of thin film

**'We want to officially move into the new building on the High Tech Campus in 2012, but we actually commenced work last autumn. The first results of this are already visible in the field, the focus has been locked down and cooperation with industry has begun. As part of this, eight innovation projects are well underway and the industry board has been assembled', says Hein Willems, managing director of Solliance.**

During the transition from spring to summer in 2010, the arrival of Solliance was widely publicised. Energieonderzoek Centrum Nederland (ECN), the Eindhoven University of Technology (TU/e), TNO and the Holst Centre announced that they are joining forces in Solliance. Recently Imec has expressed its interest to join Solliance as a research partner. 'During the period that followed, we were promised financial support from the Province of Noord-Brabant. With this funding, it was possible to move the PV activities thin film from ECN to the High-Tech Campus', explains Willems. 'This move – that is completed by the end of this year – has strengthened the already present solar cluster in this knowledge-intensive industrial area. Solliance can now be found at the centre of this industry. The funding from the Province of Noord-Brabant will be employed further for investment in our accommodation and a valorisation programme for small and medium-sized companies.'

**Linchpin**

With the first activities off to a good start under the Solliance flag, the Solliance industry board was recently set up and completed. Willems: 'The board, chaired by Wiro Zijlmans from Smit Ovens, comprises Nuon Helianthos, NV BOM, OM&T, OTB Solar, Philips Innovation Services, Scheuten Solar and VDL ETG. Together with all these companies, Solliance attempts to transform fundamental knowledge of thin film PV from the entire chain into products. This makes Solliance the linchpin for entrepreneurs who need rapid and central access to the underlying knowledge infrastructure. We want to be a world player, which is why we collaborate with other world players.'

'In the coming years, Solliance will be confronted with the impact', continues Willems. 'This is why Solliance is focusing on areas where the greatest impact can be achieved. The most effective way to do this is through entering partnerships. Not solely with knowledge institutes, but actually with the industry. This is the only way to reach world level. Acquiring fame with world records for solar cell yield achieved in laboratories is actually not the goal. We are striving for an increase in the efficiency of the process steps for manufacturing processes. We derive Solliance's impact and correspondingly its success from the creation of new jobs in the industry.'

**Parcels of work**

According to Willems, Solliance is already in 'full swing', despite the fact that the new building will only be taken into use in 2012. 'The number of entrepreneurs working with us has increased since the announcement of the initiative and the temporary laboratory with the first machines are soon up and running. Eight new innovation projects have started under our flag. These are in line with our research programme that is focused on five business cases within the 'thin film' domain. In consecutive order, these are the cases thin film silicon solar cells; thin film CIGS solar cells; thin film organic solar cells; tests, analyses and characterisation and, finally, generic technologies which are used in all the different thin film solar cells. Based on a scientific approach, we will generate technological solutions for the various parcels of work that are practical for the industry.'

## Key competences Solliance

Solliance offers participation in its research and will open up its lab facilities to new entrants, either from industry or in research. On the basis of clear Intellectual Property (IP) agreements, each industrial partner can participate in this research effort, or alternatively, hire equipment and experts to further develop its own technology.

Solliance can help you to find partners, on the basis of its network. Solliance would like to assist you in the design of joint projects and, if necessary, act as a broker between prospective partners. Projects may be (co)funded by the EU or through national programs , and Solliance can offer help and expertise in drawing up applications.

*Hein Willems, managing director of Solliance*

# Solland Solar continues its search for new partners

**'We want to officially move into the new building on the High Tech Campus in 2012, but we actually commenced work last autumn. The first results of this are already visible in the field, the focus has been locked down and cooperation with industry has begun. As part of this, eight innovation projects are well underway and the industry board has been assembled', says Hein Willems, managing director of Solliance.**

Under the banner 'if you can't beat them, join them', Solland Solar rolled out a new strategy last year. The company decided, using the Sunweb technology, to manufacture cells and modules with a number of partners. In the meantime, the company is, as the result of a management buy-out, no longer part of the power company DELTA and the first Sunweb modules are to be delivered at the beginning of October.

Early July, it became known that Delta had sold Solland Solar to the current management under the supervision of the managing director Henk Roelofs. 'As a result of this sale, we can accelerate the transition initiated last year from a manufacturer of multi-crystalline solar cells to a supplier of Sunweb modules', says Roelofs. 'It's easier for us to enter cooperative ventures and attract finance now. As is already known, our strategy has two other spearheads. The first is to perfect the technology of the back-contact solar modules that we manufacture. The modules have metal wrap through cell's inside. We are now at a very advanced stage of the perfectioning of a high yield cell's and back-contact solar modules.
The other spearhead is entering contracts with partners for licensing, financing and manufacturing purposes. Through these cooperative ventures we intend to achieve economies of scale and spread our latest cells combined with module technology across the market through working with foil and equipment suppliers and OEMs. In all probability, manufacture will also take place in the Far East. We are currently in talks with several parties.'

**End-customer**
Many parties that show interest in working with or financing Solland are keen to see the commercial market results of the Sunweb technology. To demonstrate this success, Roelofs wants to shift Solland modules to the customer as quickly as possible: 'The closer we are to the end-customer, the greater and more certain the chances of sales. We're currently opening all the sales channels especially to the rooftop segment. Through continuing to distinguish ourselves at product level – the Sunweb technology is currently resulting in modules with a 250 Wp capacity and a 16% efficiency – we are creating a firm footing. The Sunweb modules are currently being certified and can be supplied commercially from the start of Q4. Our technology roadmap anticipates an efficiency increase in the coming years and the addition of extra functionalities. We will not only cooperate solely with partners for the manufacture of the panels, but also realise manufacturing facilities in the Netherlands. In the coming years, we want to grow to become a serious West-European contender in solar systems and integrated power systems.'
Although, according to Roelofs, the Sunweb modules that Solland supplies are the eye-catchers as tangible products, the core competence remains technology development. It is partly because of this that the company wants to realise a so-called Technology Development Centre in the heart of its own building on the Avantis industrial estate. 'We'll be shaping this initiative in the near future. The intention of the centre is the development of new cell and module concepts for manufacturers. On the other hand, it provides companies with the opportunity to test cell and module equipment in the field. Our centre will facilitate the testing and development of materials, equipment and products. This Technology Development Centre should be followed up by the introduction of a Application Centre. The centre is the next step in the chain – and as such it is closer to the customer – and will, for example, be active for installation and building companies who want to integrate solar components and market solar products.'

### Key competences Solland Solar

- Development innovative solar technology
- Marketing of the Sunweb module, benefits to partners:
  - 10% Higher output / m2
  - Higher product quality
  - Striking appearance
  - Following the same roadmap towards continued efficiency improvements and lower product cost

# ECP Solar strengthens its position as a green utility provider

**In recent years, ECP Solar (ECP Holland brand name) has supplied the utilities for PV factories worldwide to the likes of Solland Solar, Solar Cells Hellas and Photovoltech. 'Now that the solar industry is on the up again, we intend - in the coming period - to win several large European projects and, in doing so, further strengthen our market position', says managing director Paul Raeven.**

The utilities that ECP Solar supplies – from IBC handlers to pipes, waste water processing systems and other process equipment – form the proverbial 'factory under the factory'. 'Without these utilities, a factory simply can't function', continues Raeven. 'Together with the Dutch company DHV (advice and engineering firm) and a supplier of installations and control systems for high-purity gases, we have formed a proverbial trinity. The three of us together can construct a PV factory completely from the foundations up.'

According to Raeven, ECP Solar has created a unique market proposition through bundling knowledge with more specialised parties. 'We're one of the first worldwide to intertwine construction, utilities and process equipment. We've also expanded our product portfolio at ECP Solar with a water reclamation system. This product allows us to recycle 65 percent of the industrial water. For an average PV factory that uses ten cubic metres of demiwater per hour, this means an annual cost reduction of about 300,000 euro.'
'Sustainability in the PV factories is actually winning ground', continues Raeven. 'The basic assumption – partly due to the pressure on cost prices – is therefore that you need to supply utilities that consume as little energy as possible. Thirty percent of the cost of cell manufacture still results from utilities and energy. This knowledge drives the increasing importance of the Total Cost of Ownership (TCO) of a factory. More and more often, people opt for a factory that isn't just more sustainable, but also cheaper in the longer term. It's our aim to cater to the worldwide solar industry's need in this area.'

# Ferro intensifies R&D efforts in efficiency improving pastes

**For as long as anyone can remember, materials manufacturer Ferro has supplied pastes for the manufacture of silicon solar cells. The company supplies pastes for solar cell front (emitter) and rear side contact. 'In the coming years, we will link up with the industry to reduce the amount of material required and to increase efficiency still further', says Andre Noppe, European Sales Manager Electronics with Ferro.**

'Through continued and more recent innovation, we've been able to make considerable improvements to all three pastes', continues Noppe. 'For example, at the end of last year, we launched a new front side contact paste and aluminium rear side contact paste on the market.'

**Expansion**
Many new developments are taking place especially with regard to paste for rear side contact cells', says Noppe. 'On the one hand, wafers are becoming increasingly thinner and this places innovation demands on the aluminium pastes. On the other hand, there is a demand for lead-free pastes in which the use of silver has to be dramatically reduced.'
'In the knowledge that many competitors are developing alternatives for the use of silver in the manufacture of solar cells, we're also intensifying our R&D efforts', continues Noppe. 'Partly due to the price development, we expect to see silver used less and less. Three quarters of the cost of the process of contacting solar cells is actually formed by the raw material silver. Logically enough, in the long-term, silver is going to become very expensive for cell manufacturers. On the other hand, there aren't many alternatives available. Above all, various cell manufacturers have been able to reduce the amount of silver required by twenty to thirty percent. We aim to maintain and possibly even expand our market share in the coming year. As far as the innovation processes for our pastes is concerned, a further reduction of the necessary quantities of materials and the continued improvements in efficiency are our chief objectives.'

# SoLayTec starts completion of Ultrafast ALD High Volume Tool

**Last year, it became clear that the high-speed spatial ALD was going to make its mark in the solar industry and already the first market successes can be chalked up. The Eindhoven based company SoLayTec is specialised in ALD technology and has already sold the first Process Development Tool to the Belgian knowledge institute IMEC. With the delivery of this tool, SoLayTec also started the development of the High Volume Tool (HVT) that is to be marketed in the summer of 2012.**

The limited company SoLayTec officially saw the light of day at the end of 2010. As a spin-off from the knowledge institute TNO, SoLayTec has marketed the spatial separation ALD (Atomic Layer Deposition) technology. 'Since the official start of our company, everything has really taken off', relates managing director Huib Heezen. 'The developments followed each other at such a rate from the beginning of this calendar year that we needed to arrange extra work capital.'

**Milestones**

SoLayTec sourced the extra necessary financial funds in part from Rena GmbH. This German machinery manufacturer injected capital together with the North-Brabant Development Agency (BOM). 'Thanks in part to these financial funds, we've already been able to sell our first three Process Development Tools (PDT) that can handle a speed of 100 wafers per hour. One of them is to be supplied to IMEC.' 'This is a crucial step that facilitates the next phase for our company', adds manager marketing and sales Roger Görtzen. 'SoLayTec has a Joint Development Program together with IMEC. IMEC is going to do research with our machine and they will not only give us the essential feedback of the performance of the tool itself. But also target to get the AlOx layer integrated in the cell processes, with the aim of reaching higher efficient solar cells. In the summer of 2012, we want to supply our High Volume Tool with a speed of 3,600 wafers per hour.' With the High Volume Tool, an immediate and important milestone has been laid down for the calendar year 2012. In the coming period, SoLayTec will reduce both the cost price and lead-time for this tool as far as is possible. 'The lead time must ultimately be reduced to thirteen weeks', explains Heezen. 'The set-up of the necessary supply chain is well underway. In addition, in the coming six months, we want to promote the Unique Selling Points (USP) of our technology and machine.'

**Cleaning**

According to Görtzen, almost nothing still stands in the way of the promotion of the most important USP, the lowest Total Cost of Ownership for deposition of aluminium oxide ($Al_2O_3$). 'In the reduction of the TMA consumption, the breakage of wafers and the uptime of the machine the most important technological risks have been resolved. For these matters it is only a question of scaling up. In parallel to this, we are working with Rena on the development of the cleaning process, which takes place prior to the deposition of the aluminium oxide. Rena is the market leader in wet chemical processing and we believe that we can develop the necessary process with them. Rena's vested interest offers us and our customers serious advantages in this specific field.'

Now that the industry believes in ultrafast ALD, the demand from the market has really come alive, according to Heezen and Görtzen. 'The demand for the Process Development Tools is great. All the customers are employing this tool one by one to optimise their cell concepts, after which they can take the decision to purchase a High Volume Tool. We expect that the first customers will be ready for this in the summer of 2012. If ALD is a success in the coming period, every new solar factory will have an ALD line in five to ten years' time. SoLayTec's market potential is consequently still unbelievably large.'

### Key competences SoLayTec

*High-speed spatial Atomic Layer Deposition, benefits:*

- Efficient precursor usage, < 2 €ct per wafer
- Atmospheric pressure
- No contamination
- No deposition on other side of the wafer
- Simple to ramp up from lab (100wph) to fab (3,600wph) Movement through double floating wafers, no carriers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# Ubbink launches BIPV portfolio and enters the African market

**Exciting times in the solar business lie ahead for Ubbink. This calendar year, the company opened a new branch in Kenya and, in doing so, it has got a foothold on the African continent. Above all, Ubbink Solar is currently involved in the launch of three Building Integrated PV (BIPV) applications: the Ubbink Energiedak, the Systaic design roof and, finally, a facade solution.**

The Ubbink Group is a subsidiary of the stock-listed Centrotec Sustainable AG. Ubbink's time-honoured mission is the improvement of the energy efficiency and interior climate of buildings. 'We've been active with our solar business in the world of solar power for about twenty years', relates managing director Jacko van der Stege. 'We have a module factory in the Netherlands with an annual capacity of forty megawatts. We've recently opened a factory in Kenya, too. This is already up-and-running and, as the first foreign company, we have acquired a product certificate for our modules: European quality, made in Kenya! In the near future, we aren't just going to serve the local market from Kenya, but the rest of the East African market, too.'

**Design**

Ubbink also completed two takeovers this calendar year that are interesting for many reasons. 'First of all, we acquired a majority interest in the German company Solar23. This company has a sales network in more than twenty African countries. This acquisition, together with our own factory, makes us confident that we'll be able to become a leading player in Africa.' Ubbink has integrated another BIPV solution in the form of a design roof through the acquisition of (assets belonging to) Systaic. Van der Stege: 'We even launched the Ubbink Energiedak at the beginning of this year. This product combines solar power with solar heat and it's currently being introduced in a large number of European countries. The Systaic design roof is a more exclusive solution, a so-called premium. This roof, too, generates electricity and heat from sunlight. In the third quarter, Ubbink will launch the Systaic design roof and, this year, we expect to deliver the first units. In addition, in 2011, we want to launch a third product – a facade integrated solution – on the market.'

**Ambitions**

Ven der Stege believes that Ubbink's greatest advantage is the company's background in building technology. As a result, it is one of the first European companies with multiple – as already mentioned no less than three– building-integrated products on the market, in addition to 'ordinary' modules and mounting systems that the company has supplied for many years. Van der Stege: 'Experience has taught us how to integrate applications in roofs and facades. This makes our products very simple to integrate in existing buildings and, as such, they're suitable for the renovation market.'
The roll-out of three new BIPV products in a single year makes the ambitions for the coming period patently clear. According to Van der Stege, Ubbink can reflect on a successful introduction if, by next summer, dozens of projects have been completed with its power-generating roofs. 'And in Europe, this has to be several hundred', according to the top man. 'In addition, the first projects with facade applications should have been completed. In the course of time, this variant will be available in various materials, colours and such like. Whatever happens, the basis for our BIPV portfolio has been established and we're going to serve the market with them. After that, it is just a question of continuing the product optimisation.'

### Key solar competences Ubbink

Ubbink is a developer and manufacturer of the following products:

- PV modules, both regular size for Europe and small size for solar home systems in Africa;
- solar mounting systems;
- Building Integrated PV applications, for roofs as well as facades.

Ubbink is also a solution provider for projects both in Europe and in Africa. Projects ranging from midsized on-roof installations to telco repeaters, mini grids, solar power plants and solar pumping.

As a configurator and distributor, Ubbink supplies its solar systems in many countries throughout Europe and Africa.

# Levitech's Atomic Layer Deposition System to Ramp HVM for Solar Cell Makers

**Levitech's CEO Jaap Beijersbergen and Levitech's Account Manager Robin Schiermann spoke with Solar Magazine's Edwin Gelissen-Van Gastel about the Dutch company's breakthrough ALD tools for the solar industry that are about to enter the HVM market.**

Leading-edge technology company Levitech has been investing heavily the past two years in the development of its Levitrack Atomic Layer Deposition (ALD) system for the solar market. The Levitrack system is based on the novel concept of precursor separation in space, instead of time, thus capable of extremely high throughput -- up to four thousand wafers per hour. The company delivered its first Levitrack earlier this year to an innovative solar cell manufacturer in Europe, and now is preparing to ramp the Levitrack system for capacity production.

'We are currently in contact with several potential customers that include some of the top twenty solar cell manufacturers in the world. The solar industry is slowly but surely embracing Atomic Layer Deposition as an enabling solution for maximizing production values', noted CEO Jaap Beijersbergen.
Established in 2009, Levitech is a spin-off of semiconductor equipment manufacturer ASM International. Based in Almere, the Company markets two leading edge products: the Levitrack and the Levitor. The Levitor is a Rapid Thermal Processing system (RTP) used in semiconductor manufacturing with a unique patented technology for rapid heating via conduction that 'floats' the wafer on gas between solid heating blocks. The Levitrack, its ALD system for the manufacture of solar cells, is based on the same floating wafer technology used in the Levitor.
Last spring Levitech had the option of selecting the site of its Levitrack pilot program from a shortlist of five companies. Robin Schiermann, account manager at Levitech, talked about their selection.
'We consciously opted for a European solar cell maker whose location would facilitate our quick response in supporting the customer during installation of the pilot machine. The result was a faster execution of the pilot program. The machine was successfully installed in the field, and our support crew remains on site to monitor the Levitrack's early performance.'

**Leveraging Reliability**

'Our goal with this pilot system is to increase the machine's reliability to the optimum level for High Volume Manufacturing (HVM),' Schiermann continued. 'Our Levitor RTP system has been in the field for many years, achieving uptimes of 97 percent during HVM. By leveraging the knowledge and skills from our core Levitor systems over the years, we believe we can achieve similar production reliability with the Levitrack.'
In addition to reliability, Beijersbergen points out another built-in advantage of the Levitrack's design. 'Generally, the process of developing a new product from pilot system to HVM, takes as much time as the pilot design. With the Levitrack, however, the HVM philosophy has been incorporated into the system design. As a result, customers can ramp to high production volumes more easily.'
To secure funding for their developmental roadmap and time-to-market, Levitech approached the financial markets earlier this year. The positive response from investors included a capital injection from existing shareholder ASMI, and supplied the necessary funding. Beijersbergen is confident the investments will pay off.
'Our sales for the 2011 first half are above expectations and, as a result, we expect to have a neutral cash flow by the end of the calendar year. We are currently achieving tremendous growth, and expect continued annual growth of twenty to thirty percent for 2012.'

**Serving the Solar Market**

With the capital secure for Levitrack's HVM phase, all that remains, noted Schiermann, are a few technological challenges. 'The biggest challenge is always getting the system ready for HVM on schedule. But with the significant technological risks resolved, the design optimization phase had already begun.'
Beijersbergen adds: 'We're currently ramping production capacity to be able to supply the Levitrack for High Volume Manufacturing spring 2012. The complete supply chain is already prepared for this next step, so we are ready to serve the market.'

### Key competences Levitech

Levitech provides unique production solutions for the semiconductor and solar markets, addressing advanced processing challenges with enabling technologies:

- Rapid Thermal Processing for Integrated Circuits and III-V
- Rapid Thermal Anneal for LED
- Atomic Layer Deposition for Solar Cells

# Femtogrid wants to become 'King of the Power Optimizers'

**Femtogrid Energy Solutions in Amsterdam increases the energy yield of PV modules by adding smart electronics to each PV module. 'We're working hard to engineer a direct current optimized network for the production and transport of solar produced energy, the so-called Femtogrid Solar System', says CEO Tom Engbers.**

On the one hand, this Femtogrid Solar System increases the energy yield of PV modules, while on the other hand, it reduces the costs of PV systems. Our aim is to shorten the ROI period for a PV system by at least one year. The heart of the Femtogrid Solar System is the combination of Power Optimizers mounted behind every PV module and a parallel system approach. 'This increases the energy yield for PV systems up to 30% depending on the type of PV module used, its quality and the location of the installation. Moreover, the safety of the PV system is improved considerably and due to the simplicity everything becomes 'plug & play', explains Engbers. 'The Femtogrid Solar System consists of 4 components: Power Optimizers per PV module, an inverter, DC cables, and monitoring. It's first version, a 2200 watt peak version, was launched on the market on the 1st of June. On the 1st of January 2013, we want to introduce a completely new Femtogrid Solar System with a new Power Optimizer and an inverter of 4400 watt peak'.

**Integration**

With these two systems, Femtogrid can then serve 50% of the residential market. It is Femtogrid's aim to equip at least 50 MW of PV installations with the Femtogrid Solar System within the next years. 'To achieve this in the coming years, we will have to increase the capacity of our inverters, develop a new generation Power Optimizers and integrate them in the junction box of the PV module. Finally, our smart electronics must be integrated in the back of the PV module'. Engbers concludes: 'We're developing this concept together with module manufacturers like Solar Modules Nederland and Solland Solar Cells. It's our ambition to become the king of the Power Optimizers'.

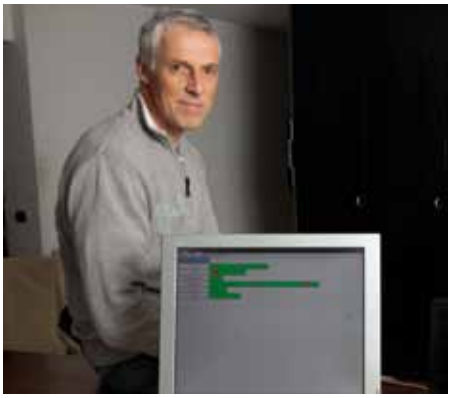
# DataLyzer acquires dominant market position with SPC software

**The demand for Statistical Process Control (SPC) software from within the solar industry is increasing rapidly. The software is intended for statistical process management, which boils down to improving processes by detecting, understanding and controlling the sources of variation. The Eindhoven-based DataLyzer International is one of the leading suppliers of SPC software.**

As a result of the tremendous demand for SPC software, the selection has increased dramatically in the last few years. DataLyzer is one of the most popular SPC programs. The software from the Eindhoven-based DataLyzer International is used by more than 3000 companies worldwide. DataLyzer is the standard program for AMD, STMicroelectronics and Coca Cola, but companies like Bosch, GM, Philips, Photovoltech, Solland Solar and Scheuten Solar also use it. DataLyzer works closely with the Dutch supplier of solar module lines, Rimas. DataLyzer's most recent achievement was the opening of a branch in India to serve the growing market in the subcontinent.

**Mass production**

'Traditionally, we are the largest supplier of this type of software within the semi-conductor industry', says managing director Marc Schaeffers. 'There isn't a single factory anywhere in the world in this industry that can produce without applying SPC. The step from the semi-conductor to the solar industry was a logical one for us. As a consequence of the pressure on prices and the necessity for strict quality control, the importance of statistical process control in this sector is increasing. On top of this, throughout the chain, there is a demand for improved quality control through the application of SPC, from the raw materials producer to the cell and module manufacturer. The solar industry is a classic example of mass production and, as a result, is perfectly suited for the application of SPC. Logistics within the solar industry are relatively simple so a major investment in MES systems is unnecessary. A good SPC system is perfectly adequate and far better value for money.' In the coming years, DataLyzer international wants to grow to market leadership in niche markets, and Schaeffers believes that continual innovation is one of the essential factors for success. 'It's based on this vision that we fostered, the ambition to participate in innovation with the solar industry. Thanks to more than twenty-five years of experience and development, our SPC software is perfectly suited to rapidly providing improved results in various projects.'



# Bundling strengths

**Where the Club of Rome lacked support in the seventies, everyone has now realised that fossil fuel is becoming increasingly expensive. The price that has to be paid for power is increasing rapidly. With the increasing costs of mining and the fact that the stocks are finite, alternatives are becoming all the more relevant. The alternatives have to be clean, safe and inexhaustible. The European Union has taken up its responsibilities and develops policy to encourage industry to introduce technological solutions that utilize inexhaustible sources. Solar power is an excellent example of this.**

Together with the government, the FME-CWM association - as the representative for the Dutch technology industry - established Cleantech Holland in 2008. The objective is to provide companies with an export platform from which technological and scientific products and services can be offered. Cooperation at this front considerably increases the opportunities for an integrated approach in foreign projects.

The use of solar power has enormous potential and a number of Dutch companies focus on the development of products that stimulate the use of solar power.

The Dutch government, industry, knowledge institutes, trade associations and regional development organisations bundle their strengths in the Cleantech Holland pavilion with the objective of raising the profile of Dutch industry as a strong cluster abroad. Companies and knowledge institutes present themselves under a single roof to help others with energy efficiency and the manufacture of sustainable energy.

Collaboration is also the key in R&D. So it is perhaps not surprising that companies are quicker to seek each other out. In regions like Twente, Groningen and Eindhoven, there are concentrations of companies that, each with their own specialisation, settle close to each other. FME, too, encourages companies to work together on developing solutions through its policies and opening regional offices at these locations.

The technology industry in the Netherlands also works closely with Germany. In April, this was reinforced when Her Royal Highness Queen Beatrix attended a seminar in Dresden where German and Dutch companies involved in energy innovations met.

FME also hopes that the Cleantech Holland pavilion at this PV-SEC fair forms a stimulus for further international collaboration. The necessary support now exists!

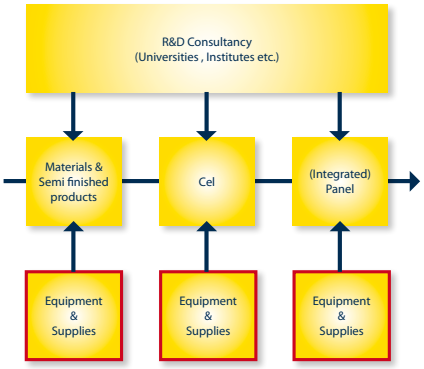
*Ruben Dubelaar*
*Business Development Manager Energy Sector, Cleantech Holland*

# SOLAR INDUSTRY REGISTER

September 2011,
PV SEC Hamburg

The following pages give an overview of organisations and companies active in the PV-solar value chain. In view of fast developments in the PV-solar industry, it was impossible to make a suitable specific model in which all possible PV-solar technologies are mentioned. For this reason a three-step model has been chosen, with each step coupled to equipment and knowledge center. An indication (the red lines) is given per company in which part of the value chain they are active.

## AAE BV - Prototype and Serial Machine manufacturing




As a first-tier supplier and partner to Original Equipment Manufacturers, we not only value technically sophisticated solutions, but also discipline and character. Our knowledgebase is continuously updated and applied to the development, production and testing of our customers' OEM products. Experience gained by AAE in the Solar industry, positions us ideally as a partner for development projects, value-engineering and all your manufacturing needs. For dust-free assembly of modules we have a sophisticated Cleanroom available, including a cleaning line for components (class 7, 950 m2). Our engineers and technicians are trained and skilled in the fields of clean and high vacuum related manufacturing.

AAE The Art of Mechatronics

**AAE BV**
*R.B.J.M. Alink & R.J.M. Janssen*

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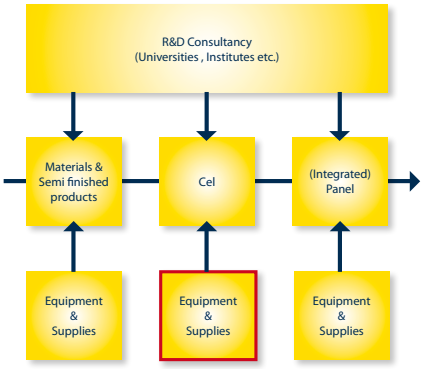
## A-B-T bv




A-B-T bv is a flow specialist with a broad portfolio of flowmeters, based on different measuring principles, and therefore in the position to provide a solution for any flow application. For PV-technology both high end and low cost MFC's are offered, as well as VA-meters, electromagnetic, turbine, ultrasonic, vortex, coriolis and laser based flowmeters for low flow applications. Customised products with special materials, process connection, construction, etc. are also possible.

A.B.T
WITH SENSE OF FLOW

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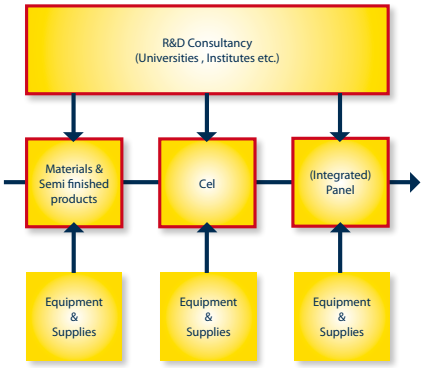
## Alinement




Alinement (Netherlands) plans an integrated manufacturing line for PV cells and modules based on Roth & Rau's PV cell and hetero-junction technology and Day4Energy's PV cell and module technology. With this combination of new technologies and manufacturing equipment, Alinement will produce highly efficient (>20%), low-cost solar modules. Alinement will start production with a capacity of 80-100 MWp/a and expand to 500 MWp/a at industrial park Avantis, Heerlen, Netherlands.

ALINEMENT

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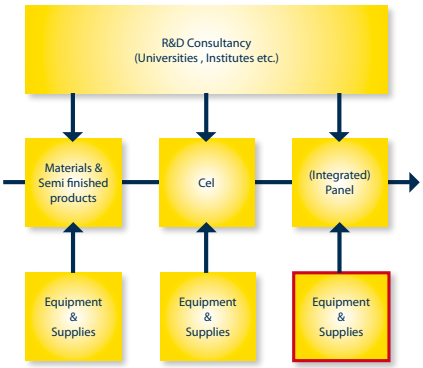
## Alrack BV




Partner in Solar mechatronics. Alrack is the ultimate solution provider for module manufacturers and installers of PV systems. We develop, produce and represent components for PV modules. Solexus junction boxes, junction boxes with various electronic functions, PET backsheet, back-contact backsheet to tinplated and special black ribbons are in our broad product range. Monitoring and fire protection are hot topics now. Alrack is taking the lead in the introduction of advanced, integrated electronics into solar modules. We are experts in junction boxes, connection technology, power conversion and communications. The perfect combination for success. Alrack components make you successful in solar!

Alrack

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**Avantis European Science & Business Park**

Avantis Science and Business Park is the first cross-border German-Dutch business park. Its location, in the Meuse-Rhine Euroregion between the cities of Aachen and Heerlen, offers businesses and investors excellent market opportunities.

The purpose of Avantis – which has a special focus on the photovoltaic industry – is to give new technologies the space they need to develop and to facilitate synergies between research, development and international management. At the Avantis business park, you can take advantage of the benefits offered by the labour markets in either Germany or the Netherlands.

AVANTIS
european science & business park

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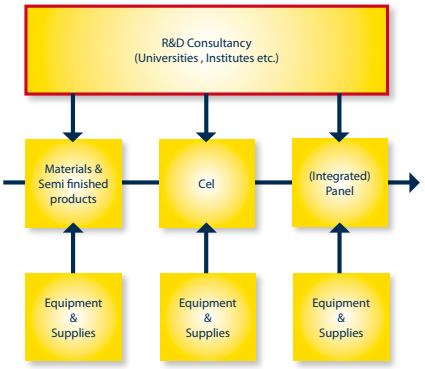
**New Solar Business Development The Netherlands**




The Brabant Development Agency (BOM) joins relevant parties in the solar value chain to develop initiatives and projects to build a strong international PV cluster. Partners include companies such as Fujifilm, Philips, NTS Group and academia such as Imec and Eindhoven University of Technology. BOM has helped hundreds of foreign companies initiate or expand operations in Brabant. We provide high quality services free of charge to any organisation interested in establishing solar activities in Brabant. Please feel free to contact us.

BOM FOREIGN INVESTMENTS
Brabant, Europe's heart of smart solutions

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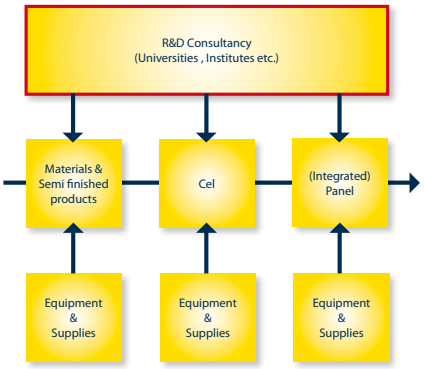
**Brainport Development N.V.**




Brainport Development is a new-style development company, working with representatives from industry, knowledge institutions and government to strengthen top technology region Brainport. Along with Rotterdam (seaport) and Amsterdam (airport), Brainport is a cornerstone of the Dutch economy. The five focal sectors are High Tech Systems & Materials, Food, Automotive, Lifetec and Design. Brainport Development encourages and develops regional and (inter)national projects and programmes, promotes Brainport at home and abroad, and facilitates regional industry through business advice and funding, incubator facilities, business premises and business centres. Brainport is a top location for the development and production of photovoltaic systems, crystalline silicon solar cell technology and thin film (see page 4).

Brainport
Eindhoven

**Brainport Development N.V.**
*Pieter Noordzij, Manager Business Development*

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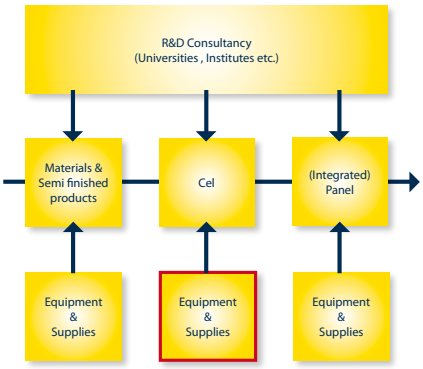
**Bronkhorst High-Tech BV**




Bronkhorst High-Tech BV has 30 years experience in designing and manufacturing precise and reliable mass flow and pressure meters and controllers. In solar cell fabrication Bronkhorst mass flow controllers are applied for highly accurate, repeatable and fast control of process gases and liquids. Our 'CEM'-System (Controlled-Evaporation-Mixing) is an accurate and efficient vapor flow control system that can be applied for atmospheric or vacuum processes, e.g. for coating on polymer films or thin metal foils for flexible PV cells or depositing silicon nitride passivation layers for multi crystalline solar cells.

Bronkhorst®
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*Wout van 't Wel*

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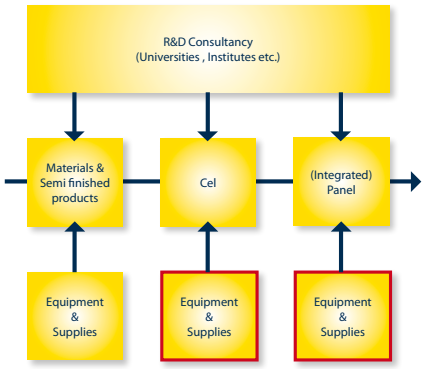
## Brooks Instrument B.V.




Brooks Instrument provides the broadest array of flow products in the market in industries as diverse as solar, bio pharmaceuticals, oil and gas, fuel cell, chemicals, medical devices, analytical instrumentation, and semiconductors. Our award-winning meters and controllers consistently rank at the top of their category for accuracy, reliability, and user preference. With our experience on the needs for solar panel production we address the right balance of accuracy and cost of ownership for your flow equipment. Our latest product targeted for this market, GF040, will help you reduce inventory cost and simplify logistics by it's multi-gas and multi-range functionality.

**Brooks Instrument B.V.**
*Ryan Kromhout*

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E. ryan.kromhout@brooksinstrument.com
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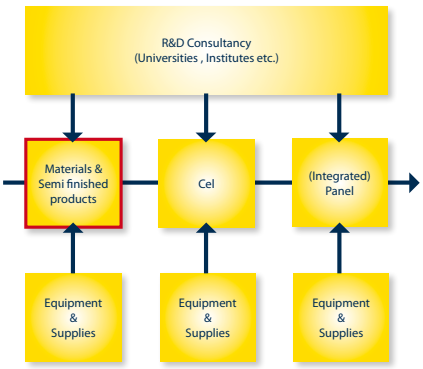
## Ceratec Technical Ceramics BV




Ceratec has specialized in industrial components constructed from technical ceramics since 1983. Ceratec`s strength lies in the total formula of problem analysis, development, prototyping and production. ***Material Properties:*** the special properties of technical ceramic materials make them highly suitable for industrial components. ***Engineering:*** Ceratec provides professional support in the area of material selection, economical design and backup for incorporation of ceramic components. ***Production:*** Ceratec has modern production facilities for processing technical ceramics. ***Custom made Products:*** Ceratec develops and manufactures technical ceramic products for customer-specified applications.

**Ceratec Technical Ceramics BV**
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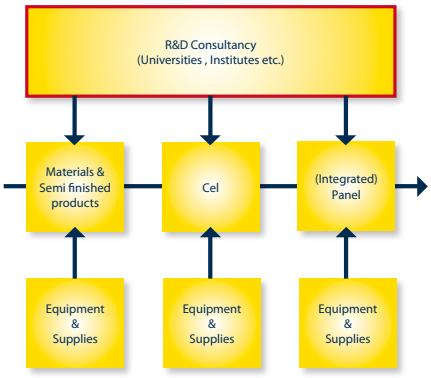
## Cleantech Holland




Cleantech Holland is the export organization and platform for Dutch clean-tech companies. Holland has an outstanding reputation in the field of energy efficiency and renewable energy. Dutch companies are known for their high-quality energy efficient solutions in the build environment, industry and greenhouse sector. When it comes to renewables the Dutch are particularly strong in solar, offshore wind, biomass and waste to energy. Cleantech Holland is an initiative of Association FME-CWM, the Dutch Ministry of Economic Affairs and the Dutch Ministry of the Environment.

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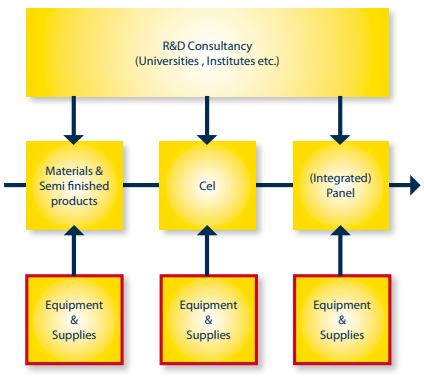
## Cortexon




Electronic enclosures are subject to strict requirements regarding form, functionality, cooling and EMC-protection. Based on many years of experience and knowledge Cortexon develops and produces the best solution for customer's needs. Besides innovative, customer specific electronic enclosures Cortexon offers added value, such as assembly of electronic components, logistic services and lifecycle control of integrated products.

**Cortexon**
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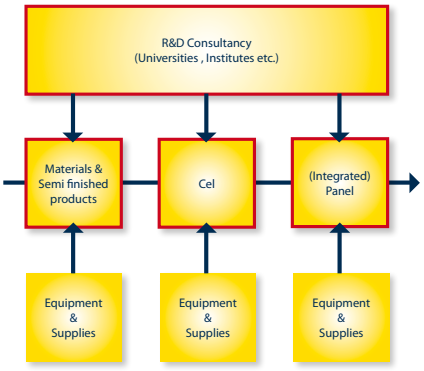
## DataLyzer International




Statistical Process Control (SPC) is a well known technique in industry to improve quality and productivity. For example in semiconductor industry SPC it is mandatory to achieve the required efficiency. DataLyzer Spectrum has a proven track record of 20 years in semiconductor industry and is implemented in both cell and module manufacturing. DataLyzer Spectrum can be used in combination with MES systems but is also used both in cell (> 150 MW) and module manufacturing as stand-alone MES system. Available in 14 languages including Chinese.

**DataLyzer International**
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## DHV

DHV is an international consultancy, architect and engineering company. We provide multidisciplinary services to realize the best sustainable cost-effective photovoltaic production facilities.The added value of DHV in photovoltaic solutions is based on our extensive experience of over 25 years in realizing a variety of industrial sites worldwide, in particular in the electronics industry. As a customer, you will benefit in particular from the fact that DHV was involved in the realization of several photovoltaic sites in Germany, Belgium, Lithuania, Spain, India and the Netherlands. We are convinced that this, together with a strong commitment to our customers and our ability to manage the different participants in the project, is our key to success.

**DHV B.V.**
*Mr. Ad Schrijvers*

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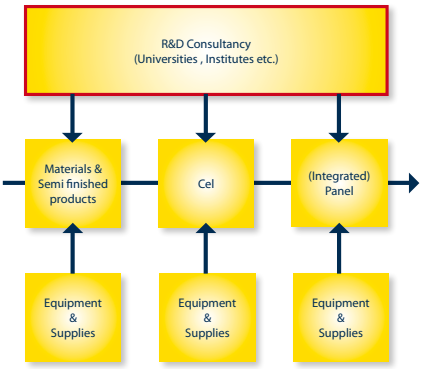
## ECN Solar Energy




ECN Solar Energy, with an international staff of 85 employees, offers a wide range of R&D activities on PV materials, solar cells and modules. Our mission is to contribute to the worldwide implementation of solar energy. We develop cutting edge processes & technologies that will drastically reduce manufacturing costs of photovoltaics and improve its environmental profile. Our expertise and facilities optimally fit current and future needs from the industry and the research community. We have a proven track record in co-development and technology transfer to the PV industry. ECN is an independent R&D organization and can work on a non-disclosure and exclusivity basis worldwide.

**ECN Solar Energy**
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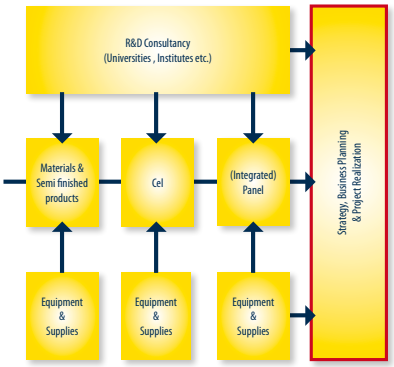
## Ecofys




Ecofys is a consultancy company dedicated to renewable energy, energy saving and climate change challenges. We bring 25 years of expertise in solar consultancy.

***For national governments and EU:***
Strategies for market development, innovation and economic development.
***For technology suppliers, project developers and investors:***
Business planning, due diligence services, feasibility studies and project services.
***For building sector, local authorities and (industrial) electricity users:***
Sustainable energy programs, planning schemes for Energy Performance norms.

Ecofys has offices in Utrecht, Köln, Berlin, London, China and USA.

**Ecofys**
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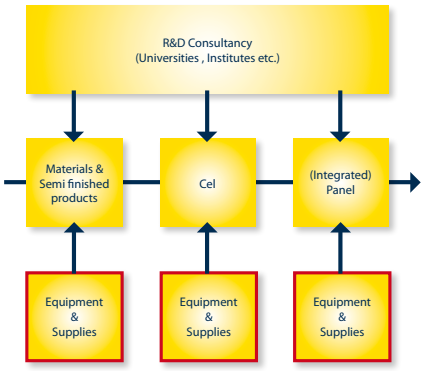
## ECP Holland




ECP Holland is a contractor for all utility and process piping. Through many years of experience and working closely with our customers in the industry, ECP Holland has developed a number of features in this area. Our strength is complete project management of utility and process piping, from design, manufacturing, installation till commissioning and training. ECP Holland has also developed a whole new concept of handling the dangerous chemicals of the PV industry, resulting in a patented system for handling IBC bulk containers, which is environmental law, BImSchG certified. Further reclaiming and re-using process water and chemicals are innovations of ECP Holland.

ECP Solar™
Trademark of ECP Holland

**ECP Holland**
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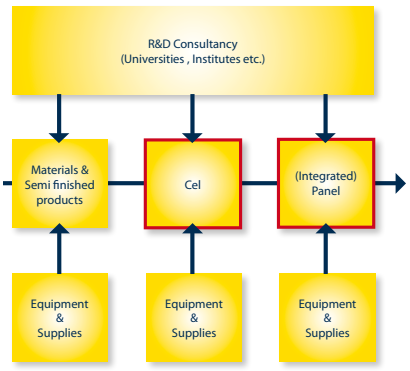
## Enthone Inc.




Enthone Inc. is a business of Cookson Electronics (www.cooksonelectronics.com). The company is a global and leading supplier of high performance specialty chemicals and coatings. Enthone manufactures, markets and distributes its functional, decorative and electronic processes that are used in printed wiring board, semiconductor, photovoltaic, automotive, energy, aerospace, jewelry, and plumbing applications. For photovoltaic applications Enthone's technology development is focused on reducing cost and improving performance through specifically designed electroplating processes for Silicon and thin film cell manufacturing, as well as back-sheet production. For more information, please visit www.enthone.com.

enthone Cookson Electronics

**Enthone**
*Frando van der Pas, Director of Marketing*

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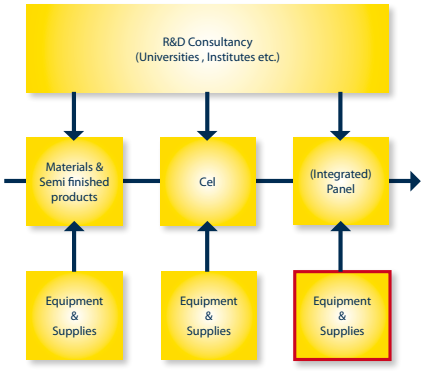
## Eurotron B.V.




Eurotron offers a complete solution for the photovoltaic module manufacturing process, based upon backside contact cells. Our equipment is engineered to maximize our clients manufacturing efficiency and offers a wide range of possibilities, matching clients requirements. Eurotron's flexible equipment enables the solar industry to produce solar modules at the lowest cost per Watt and is based on the most recent backside contact technology.

EUROTRON
POWERFUL INSTRUMENTS

**Eurotron B.V.**
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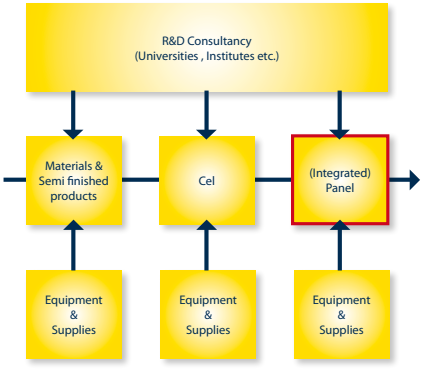
## Femtogrid Energy Solutions BV




Femtogrid provides smart solutions for renewable energy systems that improve the system's performance, reliability and safety. Our distinguishing trademark is the combination of smart electronics, so-called Power Optimizers, per energy source with a parallel instead of the traditional serial system approach. This generates up to 30% more energy harvest per installation. Firstly, we focus on PV installations up to 25kW, and secondly on the combination of PV and Urban Wind energy over one inverter. Our product is the Femtogrid Solar System and consists of Power Optimizers per module, cabling, inverter, and monitoring. It is now available via our dealers.

femtogrid
energy solutions

**Femtogrid Energy Solutions BV**
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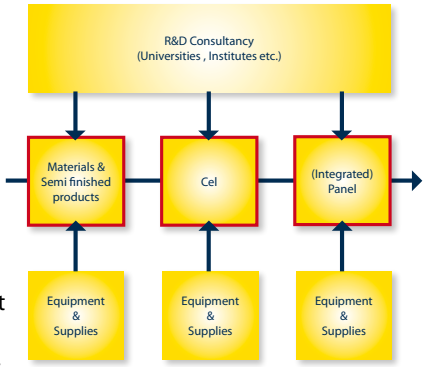
## Ferro Electronic Materials

Ferro Electronic Materials develops, manufactures and markets high-purity powders, pastes, and tapes for many electronic applications, including photovoltaic materials.




Ferro is leading supplier of all major PV pastes and next generation solar materials. Ferro is first-to-market with:

- Screen printable Ag & Al pastes
- Pb-free Ag paster
- Low Bow Al pastes
- Seminal research in front contact information
- Patented Hot Melt ink technology

**Ferro Electronic Materials**
*André Noppe*

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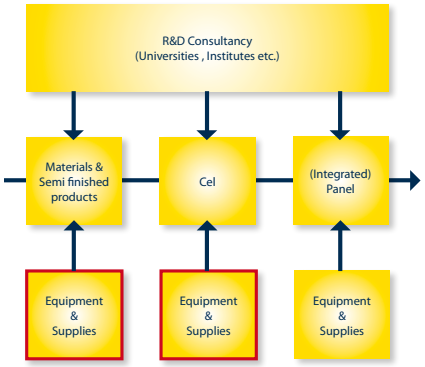
## Frencken Europe B.V.

For almost 65 years, Frencken Europe has been serving an international client base in the medical, semiconductor, analytical and industrial automation markets. We enable our customers to speed up their innovation, simplify their processes and focus on their core activities, by offering design, development, and complete production of complex and advanced modules and products, based on precision mechanics, electronics and software.Frencken Europe directs all business development, marketing, sales, development and engineering activities worldwide and acts as a linking pin between our customers and our global production sites, creating competitive advantage in both products and services.

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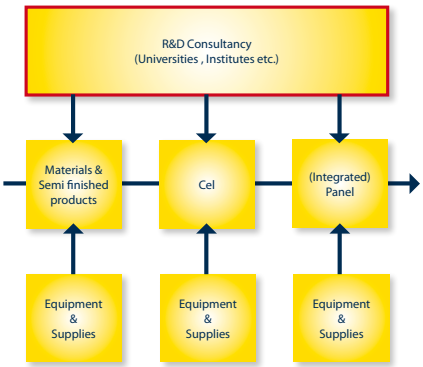
## GBO DESIGN

GBO DESIGN is an experienced partner in product development. Founded by Jacques Gramser, Erwin Boes and Jeroen op ten Berg in 1989 it has evolved from a small-scale industrial design consulting agency to a full-grown and modern company. With locations in Helmond (NL), Antwerp (BE) and Hong-Kong (CN) we have more than 20 employees specialized in design and engineering.
During the years we've built up successful, long term relationships with both small companies as well as large multinationals. Our knowledge of different materials, production methods and markets creates added value for current and future clients.




**GBO DESIGN**
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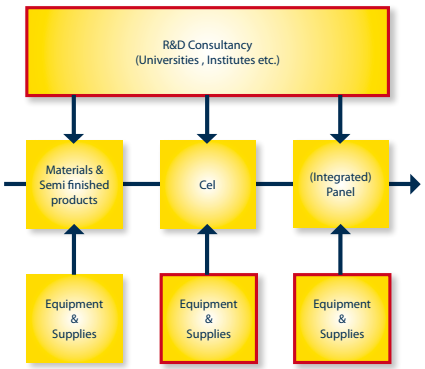
## GreenTech Engineering

To implement the customers' business strategy, GreenTech Engineering is offering integral engineering services, project realization, specific equipment and turnkey commissioned production solutions. From consultancy into project results and from spe-cification into realization. Delivering tailor made solutions including project management and capacity. Our focus is industrialization of new technology by 6 sigma methodology and reliability engineering. Bridging the gap between 1st time right and never a failure again. Acces to experience will accelerate your Business. Driving Innovation into Operation.

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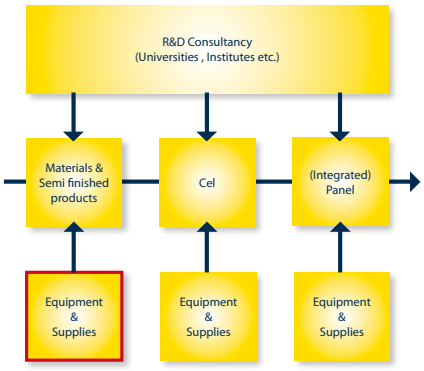
## Hauzer Techno Coating




x Hauzer Techno Coating has 28 years of expertise in the supply of vacuum plasma coating technology, design and building of equipment. Open cooperation characterizes the company, combined with technology sharing, inventive engineering and robustness of equipment. Hauzer offers industrial platforms of PVD/ PACVD batch systems, granting you flexibility in terms of deposition technology, industrial reliability and reproducibility of the coating. Due to open cooperation and experience in building special equipment, Hauzer is also an excellent partner for companies that require special inline types of equipment. In short, Hauzer will provide the optimum solution for your specific requirements.

Hauzer TECHNO COATING
PVD / PACVD TECHNOLOGY

**Hauzer Techno Coating**
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## High Tech Campus Eindhoven | Hotspot for Human Focused Innovation

High Tech Campus Eindhoven belongs to the 17 percent largest science parks worldwide and has been designated by the Dutch Ministry of Economic Affairs as 'campus of national significance'. High Tech Campus Eindhoven is an R&D ecosystem of more than 90 companies and institutes, and some 8,000 researchers, developers and entrepreneurs, who together are working on developing the technologies and products of tomorrow. The preferred work approach at the Campus is Open Innovation. This means that Campus companies share knowledge, skills and R&D facilities, creating innovative solutions that make human life healthier, more pleasant, easier, more interesting and which contribute to a sustainable world.

High Tech Campus Eindhoven

**High Tech Campus Eindhoven**
*Cees Admiraal*

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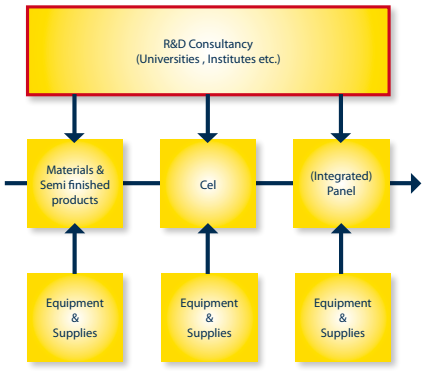
## Holland Innovative BV




Holland Innovative is market leader in supporting organizations in product, process en project management. In Solar we actively participate in and reinforce project teams in process development as well as running-in of solar production facilities on a global scale. A multidisciplinary team of experienced professionals develops and implements adequate and sustainable solutions. According the ‹voice of the customer› and the ‹voice of the business›, with clear targets and results.

**Holland Innovative BV**
*Hans Meeske*

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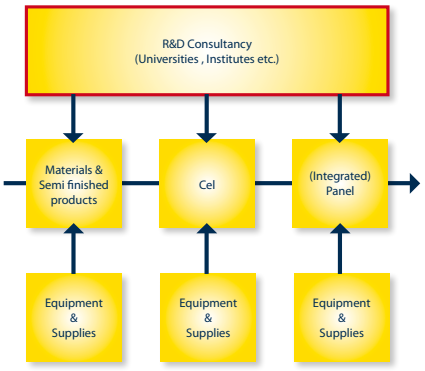
## Holland Solar




Holland Solar is the association for the solar energy industry in the Netherlands. It aims at stimulating the use of solar thermal and photovoltaic energy in the Netherlands. In addition, Holland Solar represents the Dutch solar industry on regulatory matters with local and national governments. The association has over 65 members, including manufacturers, suppliers, installers, consultants, architects, and research organizations. Holland Solar is a partner of the Dutch sustainable energy association (DE Koepel) and the Cleantech Holland platform. Internationally, it is a member of the European industry associations ESTIF and EPIA.

**Holland Solar**
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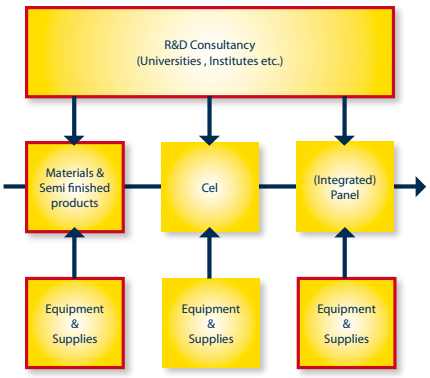
## HTR BV Rubber and Foam

HTR BV Rubber and Foam is an almost 60 years old manufacturer and supplier of rubber and foam parts. Profiles, mouldings, hoses, thermoformed foam and converted parts (die cutting, kiss cutting, lamination, self adhesives etc.) are our product groups. We supply products made out of all rubber qualities like EPDM, Cr, Nbr, NR, silicone, Viton etc. HTR does already supply many products in the solar industry and has developed several special designed profiles. HTR does also offer product design on rubber/foam parts as well as the complete engineering and production. HTR is based in The Netherlands, Germany, Turkey and India.




**HTR BV Rubber and Foam**
*Ferry van de Pasch*

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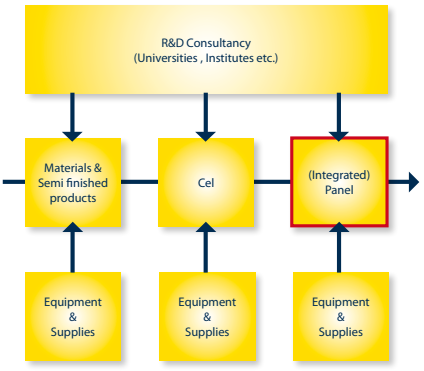
## Inteqnion Solar BV

Inteqnion Solar BV develops and markets commercial PV solar systems. As a part of the PV solar system, Inteqnion Solar BV develops and markets innovative roof elements, in which PV and PV/thermal solar modules are integrated. Inteqnion Solar BV is part of the 102 years old Dutch Ottevanger Group of companies, an international operating group active in de milling machinery industry (see: www.ottevanger.com).

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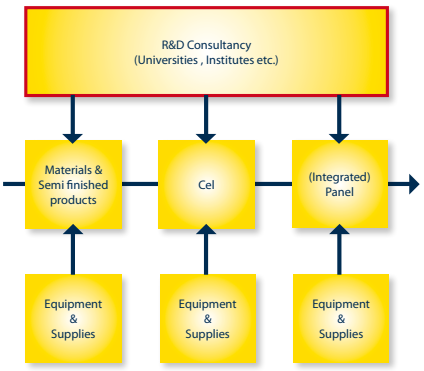
## KIWA

Kiwa is a world wide accepted and recognized Testing and Certification Body with laboratories and highly skilled inspection facilities in Italy, China, the Netherlands and the United Kingdom. With only one stop you can have your modules and other products certified for a world wide market. Testing, Certification and Inspection of PV Modules, Installation kits, Inverters and other materials and components. Including EN/IEC, North America, MCS (UK) and other regions. Testing and certification of Solar Collectors and systems for Solar Keymark. Fast, flexible and to the point! Get your products certified the friendly way!




**Kiwa Nederland BV**
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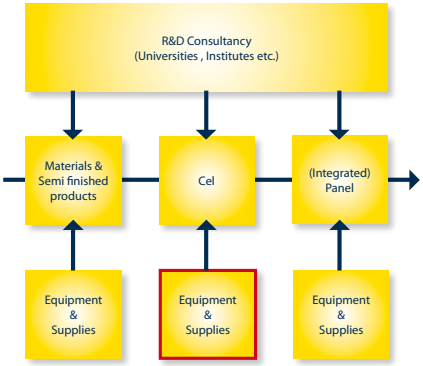
## KMWE Precision Systems & Precision Components

KMWE offers total solutions in precision handling and motion systems and the assembly of modules for the high tech industry including the solar industry. With over 300 employees in the Netherlands, Malaysia and Turkey, KMWE carries out engineering, prototyping, fully robotized 24/7 machining, systemassembly and testing, all under its own roof. Lean Manufacturing, smart manufacturing technologies and process control for low/medium volume - high mix applications are deeply integrated. KMWE is your source for repeated quality and security in production and assembly by combining an international sourcing network (including LCR) with a sharp eye on market developments and dedicated accountteams. KMWE offers solutions on:

- Positioning-, and Handling systems of fragile materials (wafers);
- Sources;
- Load locks;
- Cost reduction by value engineering.




**KMWE Precision Systems & Precision Components** - *Geert van Bergen*

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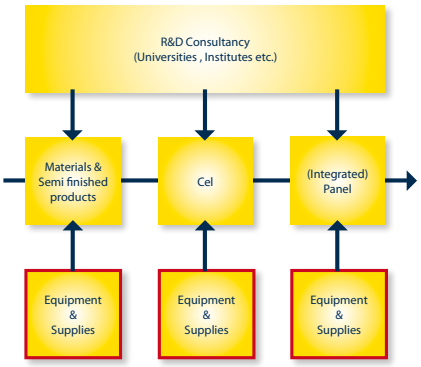
## Lamers High Tech Systems




Lamers High Tech Systems is a leading supplier to technology driven markets for over 25 years. Main activities in the solar market are:
*Turn key installation consisting of:* Gas & chemical infrastructures (SS or Plastics; Gascabinets and Bulk Chemical systems; Hook up of production equipment incl. vacuum; Hot commissioning, qualification & validation.
*Subassemblies for OEM's:* R&D&E of custom & standard products and assemblies; Purification and assembly under clean room conditions (>1000 m2); Bulk Chemical systems for POCL3/BBr3; Stand alone Evaporator Systems for DEZ, TMA, TTC; High Purity vacuum & process piping; Contamination (RGA,TOC,etc), particle and moisture analysis.

**Lamers High Tech Systems BV**
*Age Leijenaar*

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## Levitech


Levitech is a global player providing production solutions for the IC and Solar Industries. The company maintains a strong technological base, state-of-the-art manufacturing facility, a competent and qualified workforce, and a highly trained, strategically located support network.
Over the past years Levitech developed its Levitrack® Atomic Layer Deposition (ALD) system to deposit Al2O3 films for surface passivation of Solar Cells. The system is based on the novel concept of spatial precursor separation, instead of precursor separation in time, in combination with the unique floating wafer and conductive heating technology used in the Levitech's Levitor® RTP products. The unique design of the Levitrack® allows for single side ALD deposition. Because each ALD deposition cell is optimized for throughputs that exceed 3600wph, a high productivity and low cost-of-ownership is guaranteed.

**Levitech BV**

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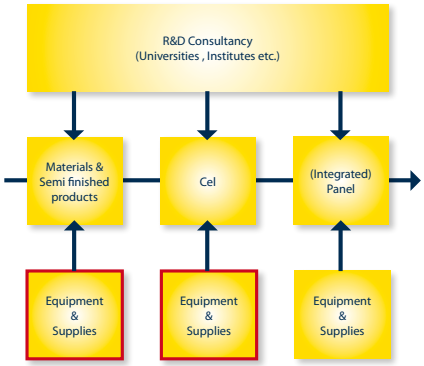
I. www.levitech.nl

## Masévon Technology BV




Masévon Technology is a high tech system supplier, with decades of experience in the solar-, display- and semiconductor market.

Within the Triumph Group and together with group member Vernooy Vacuüm Engineering, we are specialized in realizing handling- and vacuum equipment , and are ready to support in design, engineering and manufacturing, within our own facilities, to meet PV requirements.

**Masévon Technology bv**
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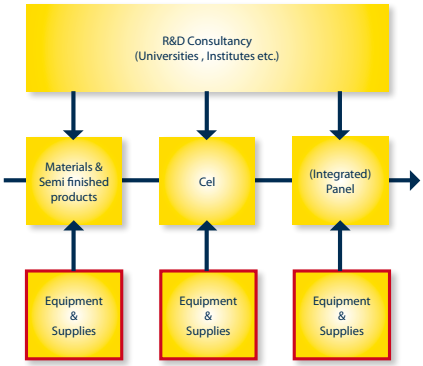
## Mevi Group BV




Mevi can offer engineering, manufacturing and assembly of parts, modules and machines. We are a creative and skilled team and realize tools and machines for various purposes, from concept up to installation. We are a vertical integrated organization and control the complete supply chain which benefits the customer in quality, manufacturability and lead time. High precision milling (0,3 um) repeatability and clean room facilities help to get the requirements you need.

**Mevi Finemechanical Industries BV**
*J. Colen / B. Hoogers*

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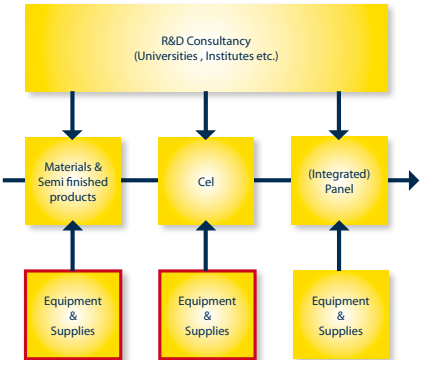
## Mogema BV




Mogema is a supplier of mechatronical systems, with over 50 years of experience. With over 150 employees, an advanced machine shop, specific know-how in accurate machine operations , welding and (cleanroom) assembly. Herewith Mogema is the right partner for development and production of high level components, accurate machine frames and integrated modules like vacuum systems. Mogema is a division of Aalberts Industries NV, a Dutch stock listed company. Within Aalberts Industries Mogema has a large network of specialists for production- and surface treatment. Herewith Mogema always has the right partners to manage you complex projects.

**Mogema BV**
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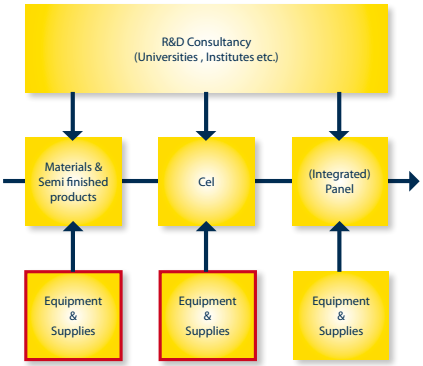
## NTS-Group B.V.




The NTS-Group is system supplier in high tech industry. The company assumes responsibility for the development, creation and optimization of opto-mechatronic systems and modules for leading original equipment manufacturers (OEMs). The NTS-Group is a chain of specialised companies in the Netherlands, the Czech Republic, Israel and China.
This unique concentration of strength on an international level means that customers can deliver high-quality machines to their market in a shorter turnaround time and at competitive prices.
NTS-Group: accelerating your business!

**NTS-Group**
*Marc Hendrikse CEO*

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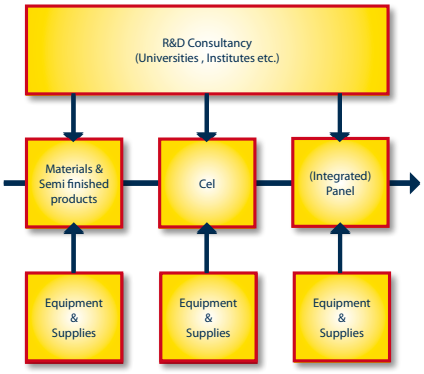
## Ocean Optics




Ocean Optics offers several products for the solar industry for research and development as well as for production line challenges through our modular and turnkey spectrometers and accessories. Our offerings include:

- Transmission measurement of materials used in solar cell production
- Quality control of photovoltaic panels
- Rapid analysis of test flashes in solar simulations
- Characterization of dye-sensitive and organic solar cells
- OEM systems for plasma and thin film monitoring

**Ocean Optics BV**
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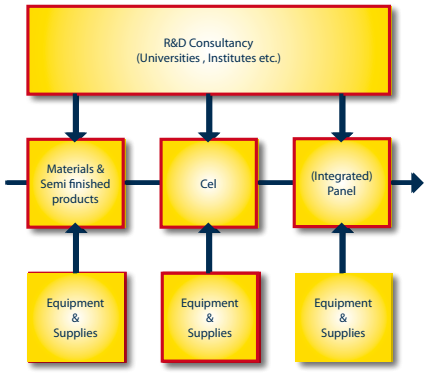
## OM&T B.V. | Moser Baer Technologies Europe




OM&T is the European R&D centre of Moser Baer India Ltd. (MBI). OM&T's main focus is in the field of energy-efficient devices, such as photovoltaic and OLED lighting modules. Its specialist knowledge of lithography, electro-plating, replication, thin-film technology and system integration is used to develop new concepts and production processes for products with improved energy-efficiency and lifetime at reduced manufacturing costs. Located at the High Tech Campus in Eindhoven, the Netherlands, OM&T has access to world class R&D facilities on site next to an own dedicated cleanroom and separate analysis labs. OM&T has strong partnerships (both regional and international) with leading knowledge institutes and companies.

**OM&T B.V. | Moser Baer Technologies**
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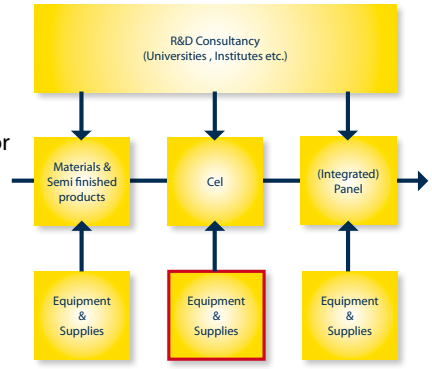
## OTB Solar – Member of the Roth & Rau Group




Roth & Rau AG has been one of the world's leading suppliers of production equipment and innovative production technologies for the photovoltaics industry for more than 10 years. In its photovoltaics segment, Roth & Rau focuses on providing production systems for crystalline silicon solar cells as well as thin film solar modules. OTB Solar – Roth & Rau, a subsidiary of Roth & Rau AG, is a leading manufacturer of integrated process modules, automated wafer handling systems, and industrial ink jet printing tools. With headquarters in Eindhoven, The Netherlands, and a worldwide sales and service network OTB SOLAR – Roth & Rau provides local, fast, and reliable support for customers' production sites.

**OTB Solar – Roth & Rau**
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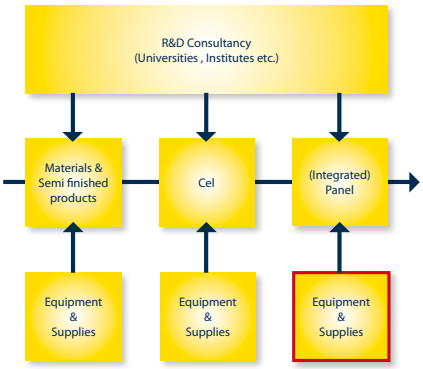
## Phoenix Contact bv




Phoenix Contact is a worldwide manufacturer of components, systems and solutions in the area of electrical engineering, electronics and automation. Phoenix Contact produces with a high vertical range of manufacture all over the world; not only screws, plastic and metal parts, but also highly automated assembly machines are build inhouse. Product innovations and specific solutions for individual customer requests are developed at the locations in Germany, China and the USA. Numerous patents underline the fact that many developments from Phoenix Contact are unique in their own. In close cooperation with universities and science, future technologies like e-mobility and environmental technologies are explored and integrated into products, systems and solutions for markets.

**Phoenix Contact bv**
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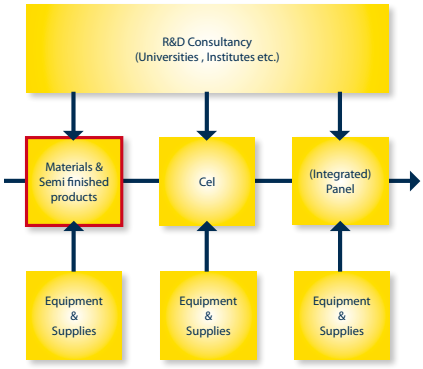
## Profilplast




Profilplast is an industrial supplier of high end semi finished plastic products such as piping systems, valves as well as sheets, rods and tailor made parts. As a dedicated distributor of first-class international producers, Profilplast delivers worldwide with a specialization in the Semiconductor and Photovoltaic industry. The exceptional extensive stock of all kind of High Purity, ESD and FM approved materials, makes Profilplast an all over partner for your ambitious projects. For specific solutions, projects and technical matters, Profilplast can assist and support you with their own technical and chemical department, regarding materials, components, design and installation possibilities.

**Profilplast BV**
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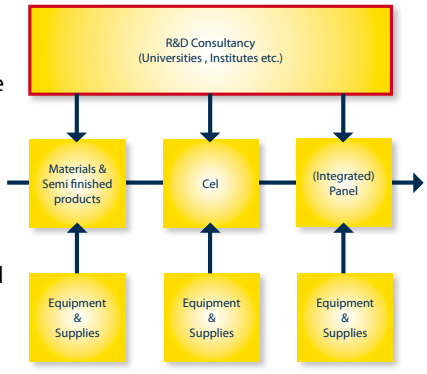
## ReRa Systems




ReRa has built up many years of experience in the development of complete pv measurement systems (IV-curves, Quantum Efficiency). Besides complete systems, ReRa offers consultancy, software and measurement equipment design. This unique combination resulted in excellent measurement systems which will facilitate the further research on solar cells. The knowledge of solar cell measurement interpretation is what makes ReRa unique. ReRa products:

- Tracer: all-in-one software solution for IV curve measurements;
- SpeQuest: State of the art Quantum Efficiency measurement system for all types of Spectral Response measurements incl. Multijunction;
- LumiQuest: Complete turnkey solution for Electroluminescence;
- (Customized) Probestations and reference Cells.

**ReRa B.V. / ReRa Solutions B.V.**
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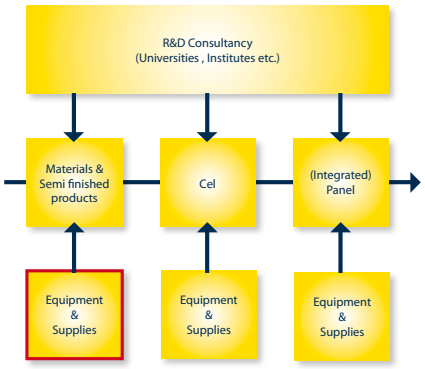
## RGS Development B.V.




The ribbon-growth-on substrate (RGS) silicon wafer technology is a unique silicon casting technology for the next generation of photovoltaic wafers. Compared to today's crystal growth and cutting wafer technology, the silicon yield is increased from about 40% to more than 90%. This allows a strong decrease in wafer manufacturing costs. Due to the high productivity, RGS is a key technology for enabling the high growth rates of the PV sector in the future. The development of this technology into a commercial wafer manufacturing technology is the mission of RGS Development BV.

RGS development B.V.
Photovoltaic Silicon Wafer Technology

**RGS Development B.V.**
*A. Schönecker & M. den Heijer*

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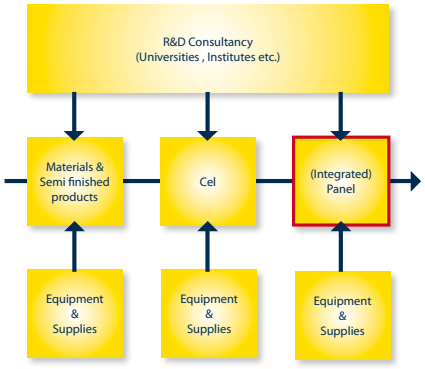
## Scheuten Solar




Scheuten Solar specializes in the manufacture of solar panels and building-integrated (BIPV) solutions. In addition, we have all the know-how required for the development and implementation of turnkey PV projects. Our specialists work throughout the world on high-quality total solutions. Our production lines are located in Germany and the Netherlands. Besides these we have sales offices in Europe and the United States. Scheuten Solar forms part of the Scheuten group, an international firm with in excess of 2,000 employees working on total solutions in glass and solar energy systems. Scheuten stands for energy, sustainability, growth and life. In 2010 the Scheuten group achieved a turnover of more than € 500 million.

solar | glass Scheuten

**Scheuten Solar**
*Lilian Geurtjens (Marketing & Communication Manager)*

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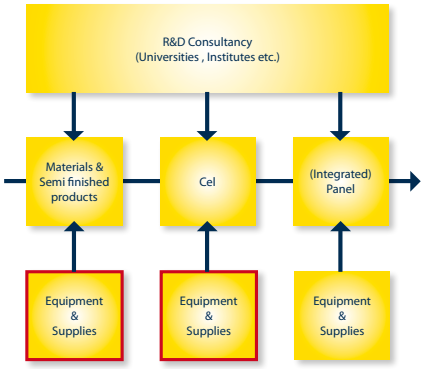
## Sierra Instruments bv




Founded by Dr. John G. Olin in 1971, Sierra Instruments is a global leader in fluid flow measurement and control instrumentation for gas, liquid and steam applications. Industries include semiconductor, environmental, scientific research, biotech, petrochemical, energy, aerospace, manufacturing process control and many more.

SIERRA®
EXPERIENCE OUR PASSION FOR FLOW!

**Sierra Instruments bv**
*Paul de Waal*

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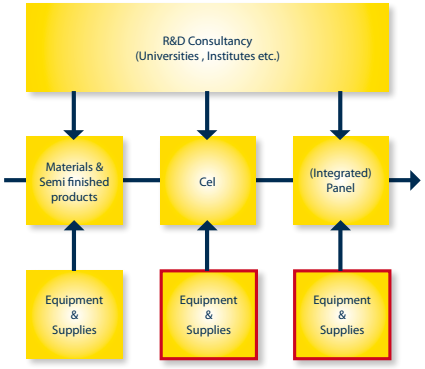
## Sioux – Increase solar cell efficiency




For more than 15 years Sioux is an important partner and supplier for R&D, Sioux has a work-force of 300 engineers experienced in technical software, remote solu-tions, industrial math-ematics and electronics. We are also specialized in embedded in-pro-duct software develop-ment for manufacturing, semi conductor an solar related industries. Sioux capabilities range from motion control, image processing, machine connectivity for the semi conductor front end production equipment (wafer scanners) to back end equipment (wafer inspec-tion, laser dicing, PCB production and SMT, application of inkjet). Solar is an important part of Sioux's project portfolio, e.g. centered around atomic layer deposition to increase solar cell efficiency. Source of your development!

SIOUX

**Sioux**
*Monique Klooster*

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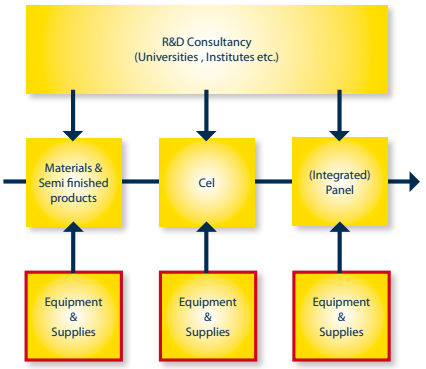
## SMC Worldwide leading experts in automation




With more than 26 percent market share SMC is providing the global automation industry pneumatics and related products, keeping them at the leading edge of technology. A global supply of 11,000 standard products in 630,000 variations cover most thin-film and c-Si Solar-Cell manufacturing processes. We understand important issues such as the fast and safe handling of cells, the need for a uniform deposition layer and other technical requirements unique to the Photovoltaic Industry. Our competence includes non-contact handling, transfer, high-vacuum, temperature control, high-purity products and static control. SMC is your reliable partner for developing customized solutions.

**SMC Pneumatics B.V.**

De Ruyterkade 120
NL-1011AB Amsterdam
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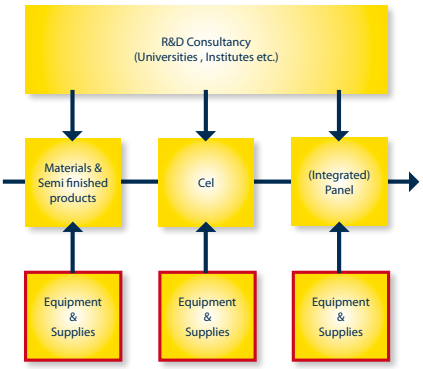
## Smit Ovens




Cost-effective thermal processes for thin-film photovoltaic production. Smit Ovens is a leader in thermal processes for high-volume thin-film solar cell production. We deliver innovative, high throughput solutions based on smart designs and processes. These cover:

**CIGS:** Deposition of elemental selenium; selenization; crystallization; RTP (Rapid thermal processing); activation; conditioning.
**CdTe:** Deposition; activation; conditioning.
**a-Si/µ-Si** : Conditioning; Pre-heating.
**TCO:** FTO - atmospheric pressure CVD; ZnO - atmospheric pressure CVD.

**Smit Ovens BV**
*Wiro Zijlmans*

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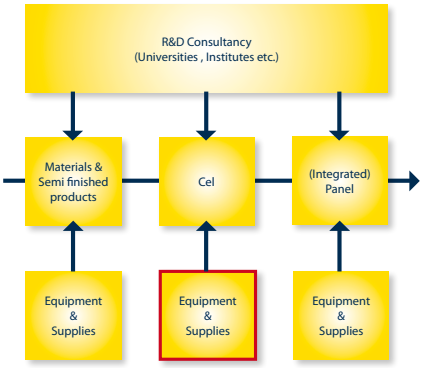
## SoLayTec




SoLayTec – 'A total solution for Al2O3'. Our mission is to enable our worldwide customers to reduce the cost per watt peak of c-Si cells modules by developing and supplying Ultrafast ALD equipment as OEM. This equipment incorporates the latest technologies: spatial ALD and motion of the solar cells by applying the floating principle. Because of the modular concept, the SoLayTec equipment is easily scalable from development tool for your process development requirements into a fully integrated Al2O3 ALD deposition tool for high volume production (from Lab to Fab 3,600 wph). Please visit us at the RENA booth A1/A1.

**SoLayTec**
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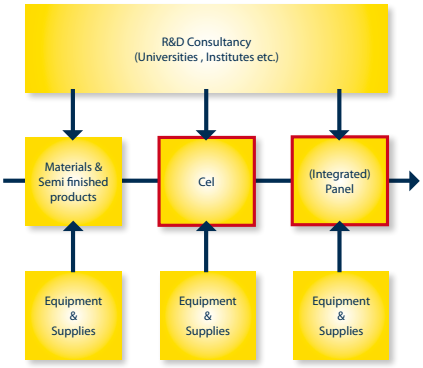
## Solland Solar




Sunweb®: the world's most beautiful solar technology. Solland Solar is a worldwide leading technology company in the solar photovoltaic industry. Solland is the inventor of Sunweb®: the ase module technology to fully utilize the advantages of back-contact (Sunweb®) cells making use of Solland's patented In-Laminated Soldering technology (ILS). The Sunweb® cell is ase don 'Metal Wrap Through' (MWT) concept and has a unique metallization pattern on the front side. The advantages of Sunweb® technology result in a stunning 10 percent higher power output per m2 on module level. With Sunweb® inside you will always be one step ahead!

**Solland Solar**
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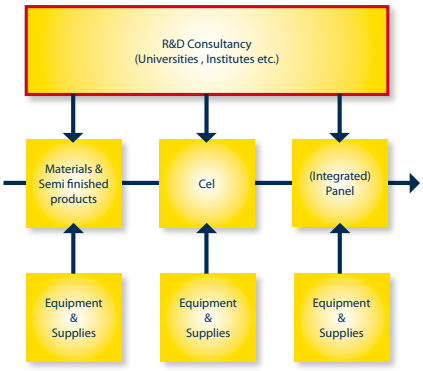
## Solliance




Solliance offers participation in its research and will open up its lab facilities to new entrants, either from industry or in research. On the basis of clear Intellectual Property (IP) agreements, each industrial partner can participate in this research effort, or alternatively, hire equipment and experts to further develop its own technology. Solliance can help you to find partners, on the basis of its network. Solliance would like to assist you in the design of joint projects and, if necessary, act as a broker between prospective partners. Projects may be (co)funded by the EU or through national programs , and Solliance can offer help and expertise in drawing up applications.

SOLAR RESEARCH
SOLLIANCE

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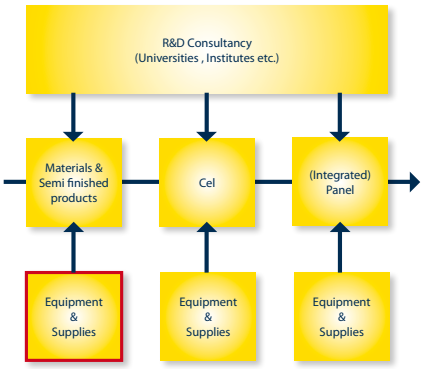
## Technobis Mechatronics BV




Technobis Mechatronics is specialized in carrying out complete development trajectories to come from an idea to a successful turnkey special product, prototype or series product. Technobis Mechatronics successfully operates in the solar market for several years now. Technobis Mechatronics is a supplier of handling systems for silicon solar cells and is specialized in handling silicon solar cell wafers at high speeds (one wafer per second) in harsh environments as high temperature (1000 ºC) and vacuum environments. Also systems used to handle peripherals for the manufacturing of silicon wafers at high temperatures have been developed and delivered by Technobis Mechatronics.

Technobis Mechatronics
Passion for precision technology

**Technobis Mechatronics BV**
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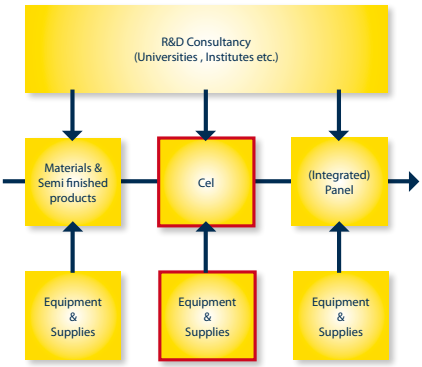
## Tempress Systems




Tempress Systems: the expert source in Solar solutions. We are a supplier of: • POCl3/BBr3 Diffusion & CVD furnaces. Ranging from small batch laboratory equipment to full size production equipment; • Cassette to cassette automatic wafer handling; • PSGR-S Dry Etch PSG Removal equipment; • Inline PECVD deposition equipment.

All equipments are being installed and serviced through our worldwide network in the industry. Proces improvements, system integration optimalization, reducing down time and the cost of ownership are key activities within our company and on your equipment manufacturing line.

TEMPRESS®

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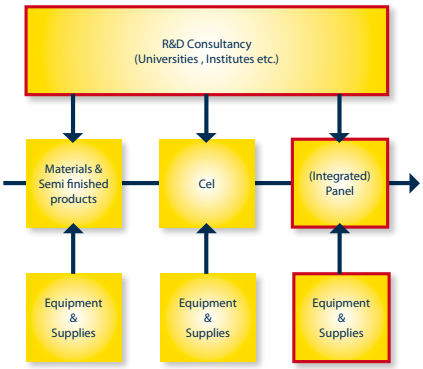
## Tendens Solar Industries BV




Tendens is a Dutch PV module company selling high quality mono and multi crystalline PV modules. Tendens is currently working with an experienced European OEM to manufacture its products, but early 2012 Tendens will operate its own factory in the Netherlands.

The Tendens products will allow customers to improve the esthetics of a PV system on a building and can be used in various building specific applications. We work together several R&D organisations to develop new products and applications for PV solar.

TENDENS
solar industries

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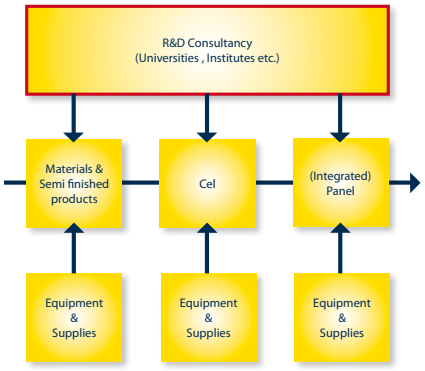
## TNO




TNO is an independent innovation organisation. TNO connects people and knowledge to create innovations that sustainably boost the competitive strength of industry and the welfare of society. TNO's more than 4000 professionals work on practicable knowledge and solutions for the problems of global scarcity. TNO focuses its efforts on seven themes: Healthy Living, Industrial Innovation, Energy/Geological Survey of the Netherlands, Mobility, Built Environment, Information Society, and Defence, Safety and Security (www.tno.nl/themes). TNO is a partner of Solliance. Solliance is a R&D cluster bringing thin film solar energy technology to excellence.

TNO innovation for life

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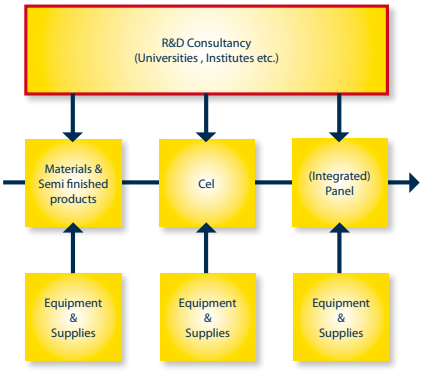
## TUD – Delft University of Technology




Research in the Photovoltaic Materials and Devices group at TUD is aimed at the development of low-cost and high-efficient silicon-based solar cells. The group has unique expertise in: (i) nanostructure engineering of thin silicon films, (ii) degradation of thin-film solar cells, (iii) light management in thin solar cells, (iv) integrated optical and electrical modeling of solar cells, (v) processing thin-film materials with various PV-related functionalities. This expertise is supported by an advanced technological infrastructure including deposition machines and measurement set-ups that allow synthesis of thin films, surface and bulk nanostructures, and fabrication and characterization of complete state-of-the-art silicon-based solar cells. The broad interdisciplinary research in the group combines material science, technology development, process engineering, and design of devices with a strong valorization value of prototype devices.

TU Delft Delft University of Technology

**Delft University of Technology -** *Photovoltaics Materials and Devices group - Department of Electrical Sustainable Energy - Prof. dr. Ir. Miro Zeman*

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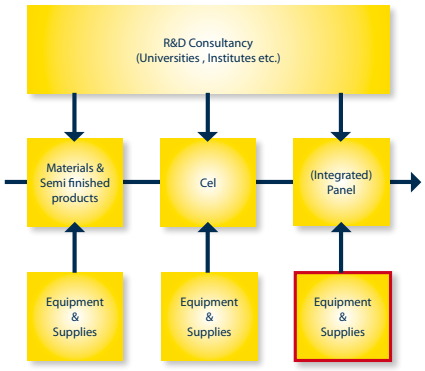
## TULiPPS™ Solar B.V.




TULiPPS™ Solar B.V. has invented a new technology for building lightweight glass PV modules. This unique, lightweight solar PV module technology and installation method (COSMOS™) harnesses the benefits of tough, long-lasting automotive-grade composites with the design flexibility and manufacturing efficiency of plastics to solve challenges common to conventional roof-mounted PV modules such as high cost, heavy weight, and installation time associated with traditional PV modules. The COSMOS™ module technology can be used for both silicon and thin film modules and allows efficient installation on flat and pitched roofs. Especially interesting is the possibility to manufacture exceptionally large and lightweight PV modules.

TULiPPS Solar System Solutions

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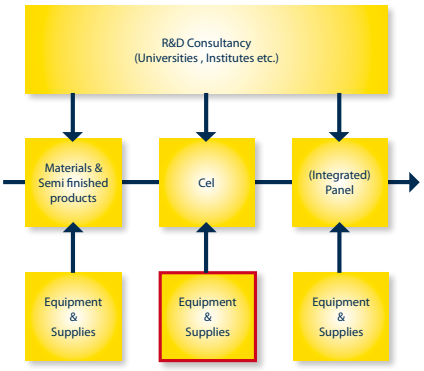
## Wilro Advanced Technologies BV (Glaesun Group)




Wilro, member of the Glaesum Group, is active in the solar industry, providing clients with tailor made solutions for thermal processes. The focus is on the development and production of diffusion furnaces for the manufacturing of CIGS thin film solar cells. The solutions are dedicated for Selenization and Sulfurization processes and based on proven technology. Wilro is the perfect partner to rapidly and effectively get from a R&D environment to a mass production process. The product portfolio includes lab furnaces, mass production furnaces, loading/unloading equipment and waste gas treatment solutions.

wilro advanced technologies bv
solar furnace systems

**Wilro Advanced Technologies BV**
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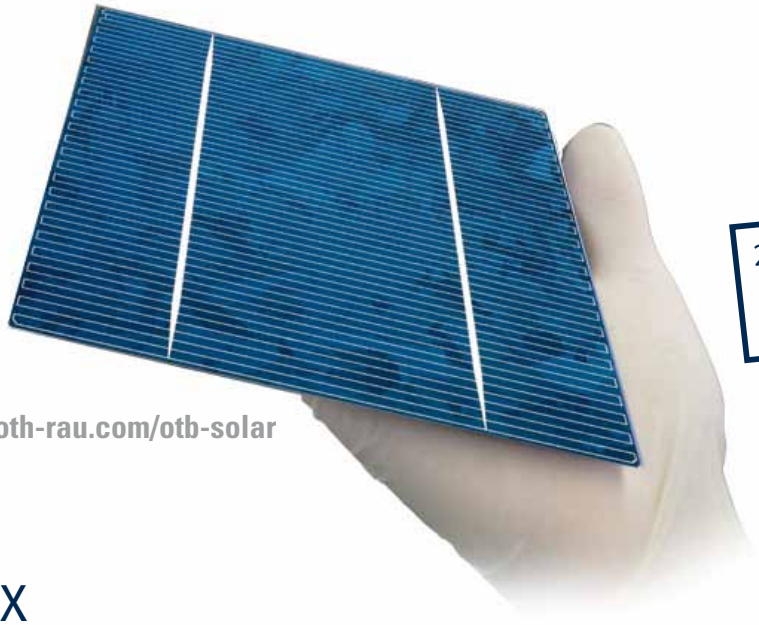

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