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Laser Community

THE LASER MAGAZINE FROM TRUMPF

WWW.TRUMPF.COM

Jump!

New generation of scanner optics releases remote welding from the working plane

Hard edge

Before you send parts into the lion's den – send them first to Hayden

High time

The era of taking days or even weeks to build car sides for railroad cars is over

WELL FOUNDED

JÖRG JETTER'S RECIPE FOR SUCCESS FOR 4JET → Page 26

PUBLISHER TRUMPF GmbH + Co. KG, Johann-Maus-Strasse 2, 71254 Ditzingen, Germany, www.trumpf.com
RESPONSIBLE FOR THE CONTENT Dr.-Ing. E.h. Peter Leibinger *EDITOR-IN-CHIEF* Verena Buttler,
Phone +49 (0) 7156 303–31559, verena.buttler@de.trumpf.com *DISTRIBUTION* Phone +49 (0) 7156 303–30121,
Fax +49 (0) 7156 303–930121, laser-community@trumpf-laser.com *CONSULTING* Helmut Ortner
EDITED BY pr+co GmbH, Stuttgart, Norbert Hiller, Martin Reinhardt *CONTRIBUTORS* Prof. Armin Aberle,
Dr. Dieter Fischer, Catherine Flynn, Miriam Hoffmeyer, Olaf Meier, Martin Reinhardt, Julia Schmidt, Dr. Franz Trieb, Anton Tsuji
PHOTOGRAPHY Steve Adams, KD Busch, Oliver Graf, Ralf Kreuels, Bernd Liebl, Jana Madzigon, Peter Oppenländer
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IMPRINT

Nice One Productions / Corbis

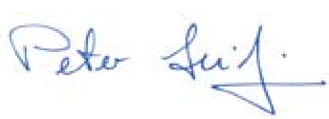
Companies in high-wage countries need to focus on resource-efficient production if they want to be fit for the future, according to Hans-Jörg Bullinger, President of the Fraunhofer Gesellschaft. Only by making careful use of scarce raw materials in order to protect the environment do companies stand a chance of overcoming tough global competition. The laser is almost perfectly adapted to this situation — and it is a tool that embodies resource conservation in its broadest sense. The photonic industry's innovations and the research work conducted at TRUMPF are also very much in tune with current global processes involving social and technological change. Thanks to the laser's close affinity to megatrends such as energy efficiency, flexibility, networking, mobility, individualization and lightweight construction, this is a tool that is destined to play a decisive role in all the markets of the future.

Laser systems help conserve resources, make parts last longer, encourage maximum precision, and optimize processes. Lasers play a key role in the production of components for electric cars, making an important contribution towards the goal of zero-emission driving. Ultrashort pulse lasers make cell phones and tablet computers lighter and more robust and support people in their pursuit of individuality. Laser cutting machines will soon be capable of processing new, lightweight construction materials such as CFRP, ceramics, and fiber composites. And the laser is the tool of choice among many manufacturers of solar cells.

Always one step ahead

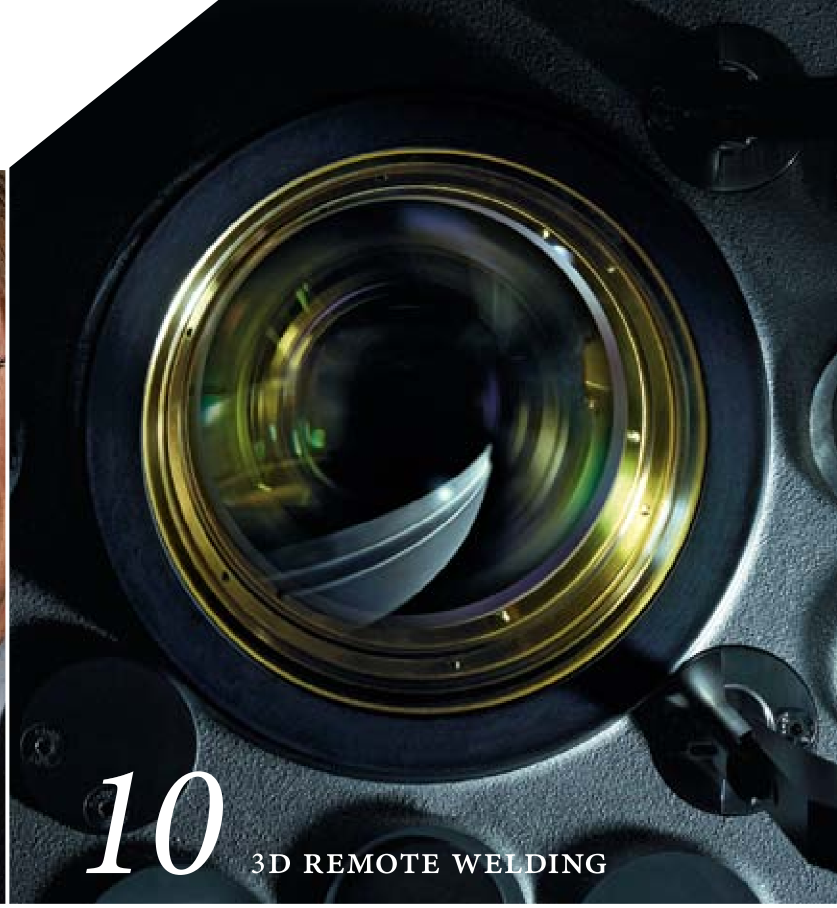
Yet, however widely accepted the laser has become in many industries, it would be a fatal mistake to sit back and take this success for granted. Increasingly rapid cycles of volatility and sustained phases of heightened uncertainty require enormous flexibility and a tremendous pace of innovation. Only by appreciating that fact can we help our customers to respond even more skillfully to the demands of their markets. And this explains why we must systematically encourage, guide and actively support the creativity of our best minds in research and development.

Every good idea needs a promoter, someone capable of making the time-to-market as fast as possible. But there is no magic formula that covers every scenario, so forward thinking and quick reactions are essential. In the memorable and pertinent words of Hans Heinrich Driftmann, President of the Association of German Chambers of Industry and Commerce: "A good captain always looks forward, but constantly keeps his eye on his ship."



PETER LEIBINGER, D.ENG. H.C.

Vice-Chairman of the Managing Board
Head of the Laser Technology / Electronics Division
peter.leibinger@de.trumpf.com



02:

COMMUNITY

Lasers and people at a glance PAGE 06

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COVER STORY

Dance of the photons

STATEMENT

Give visions a chance

2011

REPORT

“It helps me sleep better”

Dan Hayden prepares parts for the harshest environments. **PAGE 16**

All aboard

The laser has arrived in railroad car manufacturing – and car manufacturers are jumping on board. **PAGE 19**

A beautiful story

Customers expect a solar inverter to look stylish — but what else do they want? **PAGE 22**

SCIENCE

DR. DIETER FISCHER

Mix it !

Femtosecond lasers mix and deposit complex coating systems in a single pass. **PAGE 24**

PEOPLE

“It’s a great playing field”

Are you a high-tech entrepreneur who is not particularly interested in physics? That could be the perfect combination, says Jörg Jetter. **PAGE 26**

SPOT

--- CLAIM
The European research project CLAiM got off to a successful start in the summer. Two research institutes and four companies will be working together through September 2012 to improve sheet welding processes.
www.lzh.de

--- MACHINE TOOLS
There has been a significant increase in demand for German machine tools. The German Machine Tool Builders' Association reported growth of 83 percent in the second quarter of 2011. *www.vdw.de*

--- LASER INVISIBILITY CLOAK
Scientists at the Karlsruhe Institute of Technology have successfully used a special laser-structured surface to make a micrometer-sized object invisible to the human eye.
www.kit.edu

--- VIBRATION TEST
A laser has been subjected to an unusual test at the U.S. National Institute of Standards and Technology (NIST): physicists tested its stability on a bumpy journey in a minibus!
www.nist.org

--- LASER SINTERING
Exeter University has inaugurated its 'Centre for Additive Layer Manufacturing'. This is the first institute in England to specialize in processes such as laser sintering.
www.x-at.co.uk

--- CALCULATING COSTS
The Italian company SIAD has developed the first software program capable of precisely calculating the cost of a laser cutting process by taking all the relevant factors into account.
www.siad.com

--- TRACTOR BEAM
The U.S. space agency, NASA, has challenged scientists to develop a laser-based tractor beam. NASA hopes the tractor beam will allow space probes to scoop up tiny particles such as cosmic dust. *www.nasa.gov*

Optimizing processes

What companies need to do to remain competitive

Resource-efficient production is one of the megatrends of our times, according to to Prof. Hans-Jörg Bullinger, President of the Fraunhofer Gesellschaft. Noting that this issue has long been about more then 'just' environmental protection, he argues that it also has a major impact on profitability. He says that this is especially true for companies in high-wage countries, arguing that they need to focus more on optimized production processes if they want to remain competitive. "Ultimately, companies are primarily concerned with how they can best tackle the challenges of fast-changing markets and products," said Bullinger in an interview he gave shortly before EMO 2011. "To meet those challenges, they need production systems that are extremely flexible and adaptable." One example he cited was the solid-state laser, which offers significant benefits in speed, productivity and profitability across a broad range of jobs, such as processing stainless steel up to 4 millimeters thick. *www.fraunhofer.de*

In September 2011 the TRUMPF Laser Truck visited 19 cities.

On the road

TRUMPF sends its Laser Truck on tour

In September, the TRUMPF Laser Truck visited 19 locations across Germany, giving people all around the country the opportunity to see laser technology in action. The truck features several laser workstations which can tackle a range of applications including welding and marking. The 45-square-meter mobile showroom is designed to get new users interested in laser technology and to showcase cutting-edge applications for existing customers. The demonstrations were accompanied by a comprehensive series of lectures. *www.trumpf.com*

"Laser technology can help produce more efficient solar cells at lower cost."

Dr. Malte Schulz-Ruhtenberg

Together with his team, Dr. Malte Schulz-Ruhtenberg develops new manufacturing methods for solar cells at the Fraunhofer Institute for Laser Technology. One example is the use of high-speed laser drilling to quickly drill holes in precisely the right spot — an essential prerequisite if you want to put all the contacts on the back of the cell. Up to now, solar cells have also featured contacts on the front side, facing the sun, but the shadows of these reduce the effective photosensitive area. *www.ilt.fraunhofer.de*

"Imagine a tiny supercapacitor capable of storing and releasing energy over thousands of cycles."

Wei Gao

Scientists have long known that the heat of a laser beam can turn oxidized graphite into an electrical conductor. A research group at Rice University in the USA, led by Prof. Pulickel Ajayan and Wei Gao, decided to take advantage of this fact to transform thin films of graphite oxide into self-contained, long-life supercapacitor by writing patterns into them with a laser. These supercapacitors have the ability to store and release energy over thousands of cycles. *www.rice.edu*

"We have the laser to thank for our company's success."

Prof. Berthold Leibinger

At the end of October, the Laser Institute of America presented Professor Leibinger with the 2011 Schawlow Award — one of the most prestigious prize in the field of laser technology — in honor of his life's work. The Chairman of TRUMPF's Supervisory Board was praised in particular for his achievements in expanding the company and developing the field of laser technology. The Prize is named after the Nobel Prize winner and laser pioneer Arthur Leonard Schawlow. *www.trumpf.com*

Fraunhofer-Gesellschaft, Jeff Fitlow / Rice University

PHOTONICS WEST
January 21 – 26, San Francisco, CA, USA
Conference and exhibition for photonics, piophotonics and the laser industry
www.spie.org/photonicswest

SEMICON KOREA
February 7 – 9, Seoul, South Korea
Largest technology trade show in that region
www.semiconkorea.org

LASER WORLD OF PHOTONICS CHINA
March 20 – 22, Shanghai, China
World's leading trade show for optical technologies
www.world-of-photonics.net

TUBE
March 26 – 30, Düsseldorf, Germany
International trade fair for tube and pipe
www.tube.de

JAPAN INTERNATIONAL WELDING SHOW
April 11 – 14, Osaka, Japan
Welding devices and materials
www.weldingshow.jp

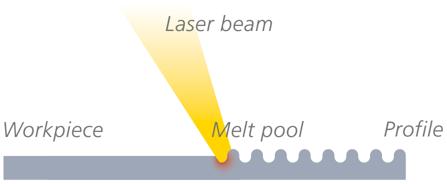
SIMTOS
April 17 – 22, Seoul, South Korea
Manufacturing technology show
www.simtos.org

LAMIERA
May 8 – 11, Bologna, Italy
Trade show for metal and sheet metal machining
www.lamiera.net

SIAMS
May 8 – 11, Moutier, Switzerland
Meeting point for micro-technologies
www.siams.ch

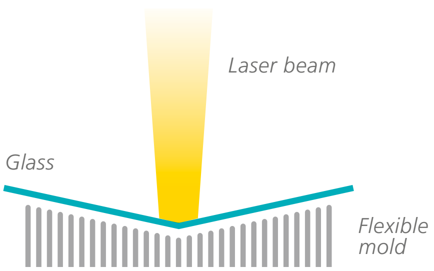
AKL
May 9 – 11, Aachen, Germany
International laser technology convention
www.lasercongress.org

LASYS
June 12 – 14, Stuttgart, Germany
International trade fair for material processing with lasers
www.lasys-messe.de



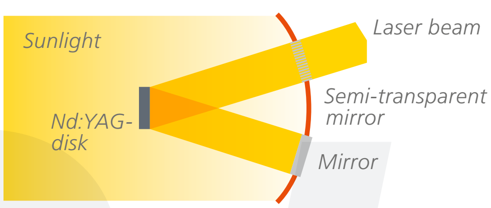
-- LASER TEXTURING

Fraunhofer ILT has developed a process to produce textured metal surfaces using laser remelting. To lend structure to the surface, the scientists modulate the laser output power in order to continuously change the size of the melt pool at defined points. *www.ilt.fraunhofer.de*



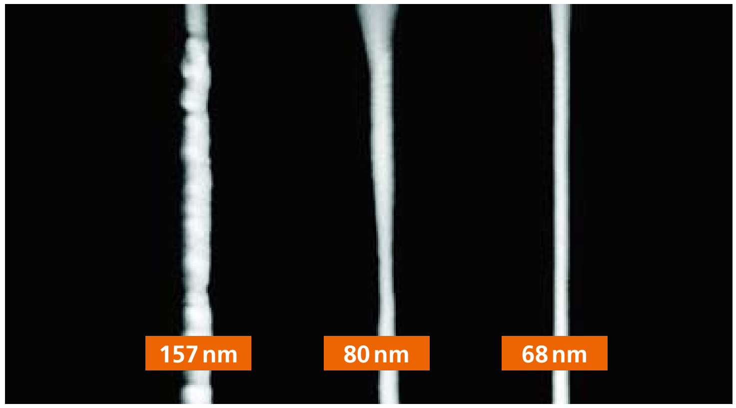
-- GLASS BENDING

A new method developed by Fraunhofer IWM makes it possible to shape glass faster and more cost-effectively. The laser is used to heat specific points on a glass panel, which is then molded into the required shape by a specially developed mold which resembles a pinscreen toy. *www.iwm.fraunhofer.de*



-- SOLAR LASER

Researchers in Uzbekistan have developed an efficient solar-pumped laser which converts 35 percent of the sun's energy into laser light. A parabolic mirror focuses the sunlight in an Nd:YAG slab. Several focal mirrors amplify the resulting laser. *www.aip.org.*



Comparing the new nanowire (far right) to previous wires in terms of size.

The holy grail

A nanowire could pave the way to a new Internet

A nanowire 68 nanometers thick could pave the way to a faster and more sustainable Internet. Scientists at Swinburne University of Technology in Australia have channeled this new development into their attempts to create a photonic chip, the holy grail of computer technology. Photonic chips could enable scientists to construct an efficient telecommunications network that would transport data at the speed of light. They could also significantly improve the Internet's energy efficiency and hence its ecological footprint — an important aspect since it is already one of the world's largest power consumers. The catch is that building a photonic chip requires miniscule components, and scientists previously had no way of manufacturing them on such a small scale. But, thanks to the optimized laser process researchers used to fabricate the tiny new nanowire in chalcogenide glass, that could be about to change. *www.swinburne.edu.au*

Benefits stacking up

MCFC stacks can at last be affordably manufactured, using a laser

A MCFC bipolar plate

Korean developers have succeeded in developing a cost-effective, automated manufacturing process for molten carbonate fuel cell (MCFC) stacks. The laser plays a key role in this new process by welding together the bipolar plates, the components that separate individual cells in a fuel cell stack and provide channels for the reactant gases (air and hydrogen). The hope is this new method, the result of collaboration between the Research Institute of Industrial Science & Technology (RIST) and the automation specialists AUTOEN, will help MCFC stacks overcome the one obstacle currently holding them back, their high manufacturing costs. With their comparatively high efficiency, stationary MCFC systems are an excellent choice for use in power plants and large-scale industrial applications. *www.rist.re.kr*

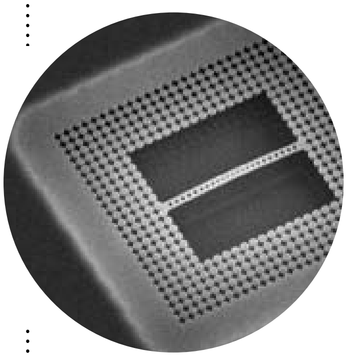
Gernot Walter; Swinburne University of Technology, AUTOEN

“Really cool”

An international team of researchers has managed to cool an object to its lowest possible energy state – using laser light. Jasper Chan from the California Institute of Technology explains why this is such a huge leap forward for quantum mechanics.



Jasper Chan is the lead author of the paper on laser cooling which resulted from cooperation between the California Institute of Technology and the Vienna Center for Quantum Science and Technology.



Measuring just a micron across, this nanobeam is designed to produce a strong interaction between photons and phonons.

Jana Madzigon, Caltech / Painter et al.

Why is cooling solids down towards their quantum ground state so important?

Quantum mechanics describes very different behavior than classical mechanics at atomic and sub-atomic scales. We are trying to demonstrate these phenomena in larger objects composed of billions of atoms. But for quantum mechanical effects to be visible, these objects have to be in or close to their lowest possible energy state. That means you have to remove all the phonons — in other words the thermal vibrations, or heat — from the object you are investigating.

How do you cool an object down to this lowest possible energy state?

One possibility is to use conventional refrigeration techniques, which another team of researchers managed to do recently. However, that method requires powerful and costly cryogenic cooling systems. So we decided to focus on laser cooling, which is also based on long-familiar principles. The limitation for this process is that it requires a large optical-mechanical interaction that is sufficiently isolated from the hot environment. We designed a special resonator from a tiny beam of silicon to satisfy this requirement.

How does laser cooling work in that context?

To explain it in the simplest terms possible, we first drill holes at precise points in the silicon beam, forming a cavity in the center for both photon and phonons. We then introduce photons into the solid at a frequency slightly lower than the structure’s optical frequency. The photons have to absorb a phonon in order to enter the cavity, thereby removing phonons from the system and achieving a cooling effect.

Will this successful research have any tangible impact on our everyday lives?

Not for many years; it’s all still far too theoretical for that. But, we have opened the door for many new experiments and I am sure that people will eventually come up with practical applications. One important point is that the light which escapes from the cavities in the silicon strip also carries with it information about the object itself, for example about the temperature of the beam. This could open up new horizons in sensor technology and aid the development of the quantum computer. Before that happens, there is still one obstacle we have to overcome: even with our method, we have to cool the object to fairly low temperatures using conventional means before we can proceed. Our dream is to take objects at room temperature and put them into their quantum ground state.

Dance of

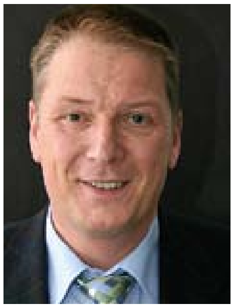
3D scanner optics add the Z motion of a focusing lens to the X-Y motion of the mirror. This allows the focus spot to move freely and smoothly over the part.

Fotostudio Loster, Faurecia

the photons

The next generation of scanner optics will release the focus spot from the working plane. Here's how users will benefit from this three-dimensional dance.

Conventional wisdom states that a gap width of 0.2 millimeters is the upper limit for remote laser welding. However, Volkswagen has now developed a solution that makes this rule of thumb a thing of the past. Remote welding works by using two mirrors inside the scan head to rapidly focus the laser beam on the workpiece with a high degree of precision. The automaker has taken this method one step further by making the laser beam oscillate, or 'dance', along the gap. This new technique is called laser stir welding, and Volkswagen has already integrated the process into its production lines. Thorge Hammer, who is responsible for technology planning and development, body shop planning, and tool and die operations at Volkswagen, explains that the mirrors in this process manipulate the beam in a circular motion as they guide it along the gap: "We call this the 'wobble effect', and it causes the laser to stir the melt pool, which increases the volume of molten material. As a result, we can now bridge larger gaps than we could before." It also means that the laser is even capable of processing components designed for MIG and MAG welding, without need for modifications. "We weld mounting blocks with gaps of up to 0.5 millimeters," says Hammer.



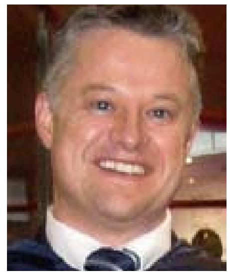
"The third dimension enables constant power distribution over three axes."

Uwe Viehmann, Faurecia

There is no doubt that scanner welding using robot-guided optics has become firmly established in car body manufacturing and is increasingly pushing production engineers towards ever more exciting innovations, but there has always been one major limitation — the Z axis. The scanner mirrors could make the focus spot dance and jump across the workpiece

"We want to use the PFO 3D to enlarge the working area for welding on the fly."

Geert Verhaeghe, Faurecia



along the X and Y axes. To bring the Z axis into the equation, the only option was to move either the entire scan head or the lens inside the scanner optics. Now, however, new 3D scanner optics have given the focus spot a whole new freedom of movement. Equipped with a highly dynamic drive unit, the movable lens quickly positions the spot in a precise location on the Z axis without moving the optics. This allows the laser to move around in a third dimension, eliminating the problem of working in different planes and enabling the beam to quickly reach small weld spots in previously inaccessible locations. Returning to the example at Volkswagen, the company has incorporated this technology in the laser stir welding process it uses to join sub-assemblies for the Golf VII, which are subsequently integrated in a platform. The front seats are held in place on the four seat supports, while the two mounting blocks referred to by Hammer are used to secure the engine and the power train. The seat supports are made from deep-drawn, medium-strength sheet steel, 0.7 mm thick. To fix the mounting blocks, Volkswagen welds a 3 mm flow-formed sheet into a shell 3 mm thick. "The ability to move in a third dimension allows us to laser weld components with undercuts," says Hammer.

Volkswagen uses six remote welding systems equipped with 4,000-watt disk lasers to process the Golf VII sub-assemblies, including the laser welding system for welding on the fly. This is the minimum setup to achieve the cycle time required to turn out 4,500 pieces a day. "The laser has 7.5 seconds to carry out a total of 19 weld seams per part," says Hammer. "But at a laser power of 4,000 watts, the robot should not take more then 1.2 seconds to move between two welding spots." A newly developed robot-based control system re-calculates the position of the scanner every millisecond and corrects the position as necessary to create the welding structures specified.

This new-found freedom of movement means the laser system can also be employed in the passenger compartment. OEM supplier Faurecia uses this process to manufacture its seating products. Remote welding already plays a key role in the company's production operations — the technique is used to weld the frames for the seat backs of the front and rear seats, the recliners and seat tracks. The laser beam is used to process the materials in packages 0.7 to 6 mm thick and comprising multiple layers. For materials up to four millimeters thick, the laser uses remote welding technology. Each year, Faurecia uses this technique to manufacture 18 million frames for front and rear seats and 115 million seat recliners and tracks. Geert Verhaeghe, senior expert for welding, adds: "There is a clear trend toward lightweight construction — materials that are thin yet stable — and consequently toward high-strength steels." This material can only be welded using a laser. Faurecia now has more than 20 systems in operation worldwide, equipped with robot-guided and fixed scanner optics, and the third dimension gives them more freedom of movement: "The PFO 3D from TRUMPF enlarges the working area without requiring us to move the optics over the workpiece," says Uwe Viehmann, joining technology manager. "The seat backs come in different heights. The PFO 3D programmable focussing optics do a better job with them because we can now position the laser beam in the Z axis using the same dynamic system we use for the X and Y directions." Verhaeghe already has one eye on the next technological innovation — he wants to use the PFO 3D for welding on the fly. "Some of the components we process are very large, and the combination of robots and 3D optics would give us an even bigger working area," he says.

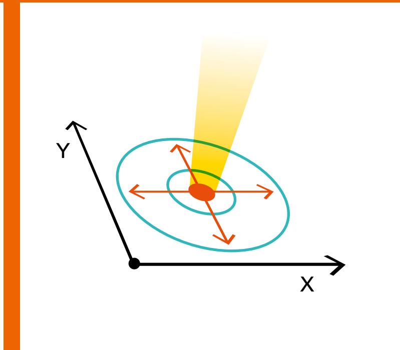
By gradually making a transition from CO_2 to solid-state lasers, the company is gaining important benefits: "Disk lasers are far more efficient — which has helped us significantly reduce our costs," says Verhaeghe. Optimizing the design of the joints and connections improved the situation for the laser and led to a positive side-effect: laser-welded joints are up to 30 times smaller and thinner than their MAG-welded counterparts. That saves resources and cuts down weight: the laser-welded spots take up just 0.6 millimeters

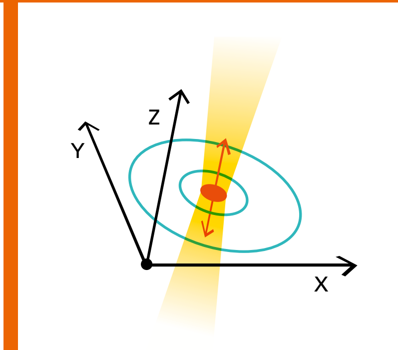
"The laser stirs the melt pool and spreads it further, which allows us to weld across larger gaps." Thorge Hammer, Volkswagen AG

Faurecia, Volkswagen AG, Fraunhofer IPM, Gernot Walter

TODAY

KNOWING WHERE THE FOCUS LIES: CalibrationLine calibrates the laser beam with a sensor. The control unit can then calculate the spatial coordinates of the beam focus at any given time.



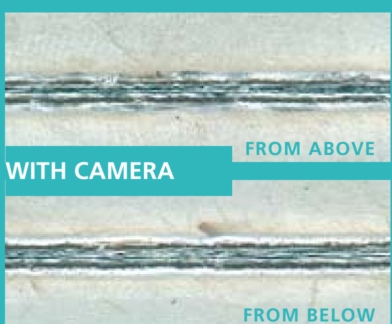


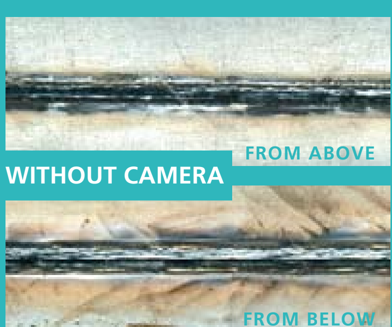
X-Y AXIS: The PFO unit scans the area around the tiny central hole in the sensor. The photodiode detects the maximum power level when the light is beamed precisely into the hole.

Z AXIS: The PFO 3D focuses on the hole and displaces the focus spot along the Z axis. The Z coordinate is determined by measuring the change in laser power.

QUALITY ASSURANCE

TOMORROW



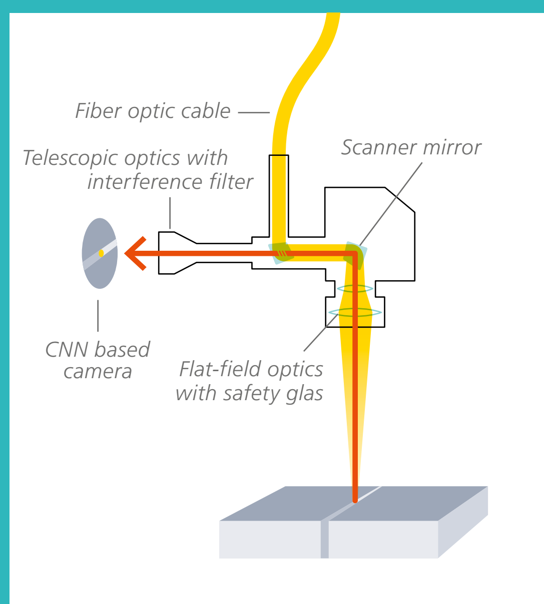


KNOWING WHAT'S HAPPENING: A CNN-based camera follows the focus spot from a distance and analyzes up to 10,000 images per second.

THE SINGLE-LENS REFLEX PRINCIPLE: The camera constantly "looks through" the scanner mirrors to the exact point at which the laser is aimed.

EVALUATION: The system monitors the penetration hole and adjusts the laser power if the hole deviates from the specifications.

STATE OF THE ART: It may sound simple, but this is a highly sophisticated concept. It is currently being developed by Fraunhofer IPM in Freiburg, the IFSW at Stuttgart University, and the IEE at TU Dresden (see illustrations on the left).

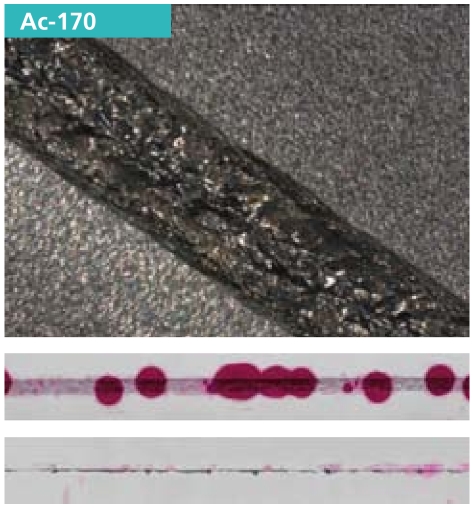


of space compared to the 10 millimeters required in resistance spot welding.

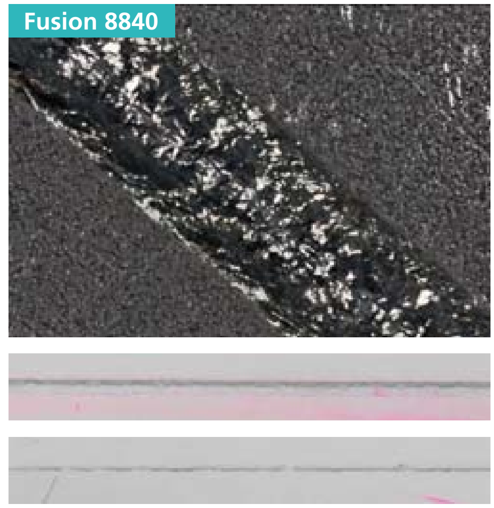
Lasers are making their mark deep inside the cars of today and tomorrow, with the vast flexibility of the third dimension finally making it possible to weld housings for high-voltage batteries. Each battery module consists of individual cells in rectangular aluminum enclosures. By the time it reaches the laser processing stage, the battery is already inside the housing and fully charged. That means a laser can only be used if heat input is kept to a minimum and if welding depth is precisely controlled — penetration would damage the battery, which could have fatal consequences with a battery that is already charged. Spatter is unacceptable and the seam must be fully sealed. Welding performed using TruDisk disk lasers with an output power of between one and five kilowatts, on battery housings ranging in thickness from 0.8 to 1.5 millimeters, has confirmed that the laser lives up to its promises: the weld seams were fully sealed and the battery sustained no damage.

In addition to welding housings, lasers are finding other novel applications in batteries, including welding thin battery contacts and joining individual battery cells into complete modules. Since at the moment battery cells to be changed, the current practice is to screw the modules together. But once these teething problems have been ironed out, the laser could become the preferred solution for holding the modules firmly together. At the moment, these new applications are at an early stage, and manufacturers are only just starting to consider what form of automation would work best in each case. Nowadays, lasers supported by modern scanner optics play a crucial role in the production of car body parts and seating components. The laser is already playing a key part in the development of electro-mobility, and it will continue to help light the way toward ever more cost-effective vehicle production. ■

Contact: TRUMPF Laser GmbH + Co. KG,
Dr. Rüdiger Brockmann, Phone +49 7156 303–30115,
ruediger.brockmann@de.trumpf.com



A dye penetrant inspection reveals flaws in the weld seam of the monolithic Ac-170 alloy, which was welded without filler wire.



Weldability confirmed! The new fusion 8840 alloy does not require filler wire; the seam is tight and no hot cracking has occurred.

New basis

Aluminum is the car body material of the future, but it will only achieve its full potential if it can be processed using remote welding techniques.

The aluminum alloys used in automotive engineering are difficult to weld without filler wire because they form hot cracks which reduce the strength of the weld seams. Currently, a filler wire is used to keep micro-fissures from forming during the welding process. This seemed to rule out the possibility of using remote laser welding for car body parts, since the nature of remote welding means you cannot incorporate filler wire. Yet aluminum would offer some real advantages, helping to reduce weight by up to 45 percent compared to steel.

No cracking Now, the company Novelis has solved this problem with its new fusion 8840 aluminum silicon alloy. The material can be welded without cracking thanks to its special design: the aluminum material consists of two alloys, one of which forms the core and the other the outer layer. It is the smooth alloy in the outer layer that makes the sheets weldable. These new aluminum sheets can be used as normal in automotive engineering — they can be bent, glued and cut — and TRUMPF has also carried out extensive testing showing that they can be welded by laser. The TRUMPF experts also tested other factors such as different gap widths and edge spacing and susceptibility to hot cracking. Subsequent dye penetrant inspections showed that the seams were tight and that no hot cracking had occurred.

Future mix The idea of combining two materials has long enjoyed priority in the work of scientists worldwide. In particular, components combining steel and aluminum are the focus of intense research. Augmented with a laser capable of performing reliable remote welding, these blended materials would offer enormous potential for a wide variety of future applications — especially in the automotive industry, where costs, weight savings, and efficient joining technology are becoming ever more important. ■

Contact: Novelis Switzerland SA, Corrado Bassi,
Phone + 41 27 457 7100, corrado.bassi@novelis.com

Dr. Franz Trieb works for the German aerospace center DLR

Give visions a chance

"That won't work" is a phrase that has no place in scientific research, says Dr. Franz Trieb.

Big ideas nearly always come across as one step removed from reality. That's why I was understandably skeptical when I was first introduced to the Desertec concept — especially since the idea behind it is over 100 years old. In 1912, Frank Shuman built a 55-horsepower power plant in the Egyptian desert to pump groundwater. He also planned to use the energy of the steam produced in the plant to generate electricity, some of which he hoped to export to Europe. However, the First World War and the development of the oil economy stopped his idea in its tracks. Fast forward to 2003, the year when the German section of the Club of Rome and the Hamburg Climate Protection Foundation set up the 'Trans-Mediterranean Renewable Energy Cooperation' to finally put the idea into practice. The German Aerospace Center came on board in 2004 when the German Federal Ministry of the Environment charged us with assessing the feasibility of Desertec. We evaluated the concept on the basis of extremely rigorous sustainability criteria — it had to be safe, cost-effective, environmentally friendly, and socially acceptable.

The hardest thing was mapping out the energy requirements of 50 countries in North Africa and Europe between 2000 and 2050. The transition to renewable energy involves all sorts of paradigm shifts, and initially that made it difficult for us to form a clear picture. For example, in 2005 people assumed that the price of oil, which then stood at 25 US dollars a barrel, would rise only gradually to 80 US dollars a barrel by 2050 — and that obviously had a major impact on assessing whether it was possible to compete with cheap fuels. In the end we took the energy prices from the year 2000 as a yardstick for our scenario, reasoning that the primary goal is a cost-effective energy supply rather than the ability to compete with resources that are becoming steadily more expensive. Our investigations came to the conclusion that a sustainable energy future requires a balanced mix of most of the energy sources that are available today, with the exception of nuclear energy. I regularly came across people who were convinced that renewables do not work and who simply refused to change their minds. But you can't just dismiss ideas out of hand; you have to constantly question your stance and clarify whether a new concept might actually be capable of standing up to scrutiny and satisfying the requirements.

Ultimately, many important ideas from the past would never have seen the light of day if they had not been given a proper chance. Even experts get things wrong, as shown by famous statements such as "Everything that can be invented has already been invented", "Anything heavier than air cannot fly", and "There is no reason anyone would want a computer in their home". I think people understand that without visionaries and ideas, our world would come to a standstill.

The idea spread to industry when the Desertec Foundation was set up in 2009, and now companies are pushing ahead with their own work on it. The concept quickly gathered momentum, and even the skeptics jumped on board eventually. Sometimes it takes a little time for people to realize that an idea is viable. That's why you need people who believe in the idea and who are willing to invest their time to take it to the next level. ■

E-mail to the author: franz.trieb@dlr.de

"Some of our first pieces have come back for work on different areas and, despite heavy use, the original tungsten carbide looks like it did when we put it on the piece." *Dan Hayden*

"It helps me sleep better"

If the founding family of Hayden had a motto it would most likely be: "Get tough." Dan Hayden, the fourth generation to lead the family firm, explains why laser technology is one of the best ways to achive this.

Laser cladding is a rather expensive process. What is the added value for your customers?
Dan Hayden: The parts we process are often worth hundreds of thousands of dollars and need to function reliably for a long time. For example, we laser clad large cylindrical tubes carrying electronic monitoring equipment into harsh oilfield environments. The laser deposits tungsten carbide bands onto the pipes to keep the tools centered and away from the wall of the bore, which could grind down the tool. Laser cladding extends the piece's lifetime substantially. Some of our first pieces have come back for work on different areas and, despite heavy use, the original tungsten carbide looks like it did when we put it on the piece.

Coated turbine blades: customers are often skeptical at first – but they change their mind once they see and hold the laser clad part, says CEO Dan Hayden.

When it gets down to coating processes, Hayden knows them all — and even invented some. Why did you invest so heavily in laser cladding?
As a business owner, I can sleep better at night when I see a laser coating leave the shop. For us, the primary advantage over thermal spray is the bonding strength. We can apply many of the same materials using thermal spray, but if the coating is misused, it can peel or flake off. The laser-clad overlay physically becomes part of the substrate. You can't chip or crack it off. Still, it was a big step for us. At the time, the investment to get into laser cladding was equivalent to half our annual sales — not revenue — from the year before.

How did you get into laser cladding?
One of our thermal spray customers had asked us to start laser cladding. They wanted us to use a CO_2 laser (due to their experience and familiarity with the technology) and be able to process shafts up to 40 feet long and 12 inches in diameter. We investigated our options and considered piecing together our own system, but I'm glad we didn't go that route. I flew to Europe on a two-day trip and had two samples processed at providers in France and Germany. The samples done in France varied widely one from another in terms of their physical properties, while the samples done at TRUMPF were practically identical.

The option of making your own system instead of buying it was out of the question then?
Many of our competitors worked with third-party integrators or assembled their own systems, but they are often limited to doing cylinders with the nozzle in a vertical orientation. Thanks to our laser's nozzle design and the ability to operate in any orientation, we can practically weld upside down. Also, the consistency of the powder delivery system and accuracy of the positioning system make programming challenging surfaces easy. We're able to tackle more delicate work and finished pieces, too. I can throw any project — no matter how geometrically complex — into the laser cell and our talented team will figure out how to do it.

What's a typical job?
We apply protective coatings to machine parts used in harsh environments. We've been doing this since the 1940s and we still employ a range of technologies. We do lots of laser work for the oil and gas industry. Cylinders and wearing surfaces are a pretty common geometry and application for us, but there's a lot of variety in our work. We just finished some very large parts — 60-by-60-inch hydroelectric turbines to be used in a dam — but we've also done small, half-inch parts for the energy industry.

Have you reengineered any part designs for more efficient processing?
Customers often give us specifications based on older welding technologies that require more material for the necessary hardness. For example, one customer requested 0.060 to 0.100-inch thick hardfacing based on old specs. Since the laser gives us un-

diluted hardness on the first pass, we reduced the hardfacing to 0.030 to 0.040 inches while providing greater protection, extending part life, and saving materials, time and costs, too.

When you say you often get old specifications, does that mean that many customers don't see laser cladding as an alternative process?
Laser cladding is a great technology for solving wear and corrosion challenges, but some industries seem hesitant to trust it. Until they actually see and hold a laser clad part, they're concerned the material will vary in density or will crack. Often they just don't understand how the technology works. We invite customers to see the process in action. Usually watching the bead go down and checking the actual weld is enough to convince them.

What direction do you see future business going?
I anticipate the growing number of light rail train systems will encounter wear and corrosion problems that haven't been addressed yet. We've also discussed ways to serve the wind and solar power markets. Generally, I see us investigating new materials and techniques to expand wear protection technologies and further reduce cost.

Where does laser technology fit into your future?
We're happy to see the demand for both thermal spray and laser cladding growing. We purchased a TruLaser Robot with TruDisk laser to increase capacity and serve other industries. The smaller cell meant we could evaluate disk lasers without investing tons of capital. Disk laser technology has allowed us to increase efficiency, reduce power usage, and avoid some reflection issues encountered with the CO_2 laser. Our next laser system will definitely have a disk laser.

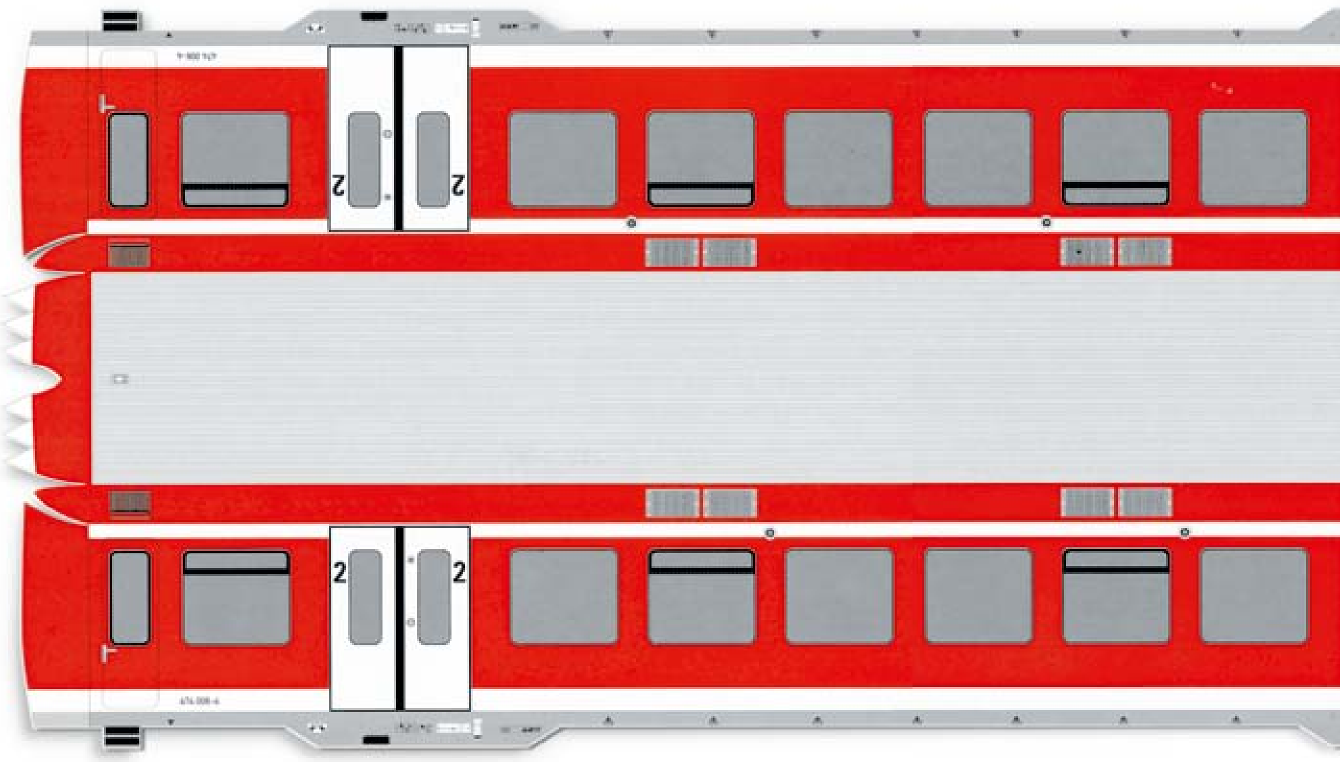
Sounds like you are a true laser fan…?
Yes, I am. We also use it for cutting. I decided to start with that application in case laser cladding didn't work out, though it's not a big business for us. In off-hours we manufacture tooling for our thermal spray business with the laser as well. Then we invested in a TruMark which supports our thermal spray business, too, with part traceability. Thermal spray parts commonly return for resurfacing over the years. We can permanently laser mark parts with a serial number and date to track how frequently they come to our facility. If there's a customer complaint about a coating, we can determine whether we applied the coating. Once again, the laser helps us sleep better at night. ■

Contact:
Hayden Corporation, Dan Hayden, Phone+1 413 734 4981,
daniel.hayden@haydencorp.com, www.haydencorp.com

TOP 'Make or buy?' was the choice when the company entered the field of laser deposition welding. Hayden Corp. had successfully developed its own protective coating processes in the past – but Dan Hayden chose 'buy'.

CENTER "Does it work?" is a question Dan Hayden often hears. "Take a look," is his reply.

BOTTOM "What does the future hold?" Hayden Corp. started out in 1919 as a supplier to the paper industry before the family business shifted its focus to protective coatings for metal parts in the 1940s. The founder's great-grandson Dan Hayden thinks their future lies in lasers.



Producing car sides may not yet be quite as simple as this cut-out sheet layout implies, but laser techniques have certainly made the process a lot faster.

All aboard!

Laser welding is advancing into railroad car manufacturing on a wide front – a 16-meter-wide front to be exact.

Most people take a step back when they first enter the Photon Laser Manufacturing GmbH production hall, mainly because that is the only way to grasp the scale of what the company is building: entire sides of railroad passenger cars, each up to 16 meters long, laser welded on an automated production line. The methods employed here are very different from those used by other companies in the industry. Many of them continue to see railroad car manufacturing as an essentially down-to-earth affair involving manual operations.

When it comes to the car superstructure — the coach body — little has changed over the past four decades: the outer shell consists of thin sheet steel, welded onto a framework of metal profiles serving as a support structure. This step is generally performed in an automated process using traditional welding techniques such as arc welding and resistance spot welding. This exposes the thin metal of the outer shell to considerable amounts of heat, which can cause the large pieces to warp. To eliminate the warping, workers use an oxy-acetylene torch to manually tackle one heat-affected zone after the other. Thomas Fittkau, Sales Manager at Photon, explains how this lengthens the time it takes to build the railroad cars: “You have to work on thousands of points distributed over the entire side of the car — the job often takes several days”. Depending on the type of surface required, this is often followed by the appli-

cation of a filler material designed to smooth out the smaller dents. That takes up even more time — and can occasionally lead to an undesirable increase in weight.

Is it worth it? "Laser welding long ago demonstrated its ability to overcome these obstacles for smaller components," says Fittkau. "But laser systems for workpieces on this scale require a huge investment, and the preparations and jigs and fixtures for this kind of welding are far more complex than their counterparts in conventional welding processes. It seems financially infeasible — at least until you step back and look at the process as a whole." This is exactly what Photon did, and they soon realized that an automated laser welding facility would quite simply result in a more efficient process and a better product: "The new process pays for itself, and by taking greater care at the beginning of the process, we provide clear benefits for the customers at the end."

Fittkau explains that many of these customers are facing significant challenges of their own: "The big railroad car manufacturers are actively seeking ways to produce cars more efficiently so they can offer world-class products at prices that the world markets can sustain." In addition to cost, aspects such as energy-saving aerodynamics and design also play a key role, as illustrated by the rail transport operators' continuing preference for high-gloss finishes. The problem with these high-gloss paints is that they reveal every dent in the metal, including those caused by warping. That is prompting a surge of interest in automated laser welding thanks to its speed, the fact that the weld seams require minimal reworking, and the reduced warpage you get, even across large components.

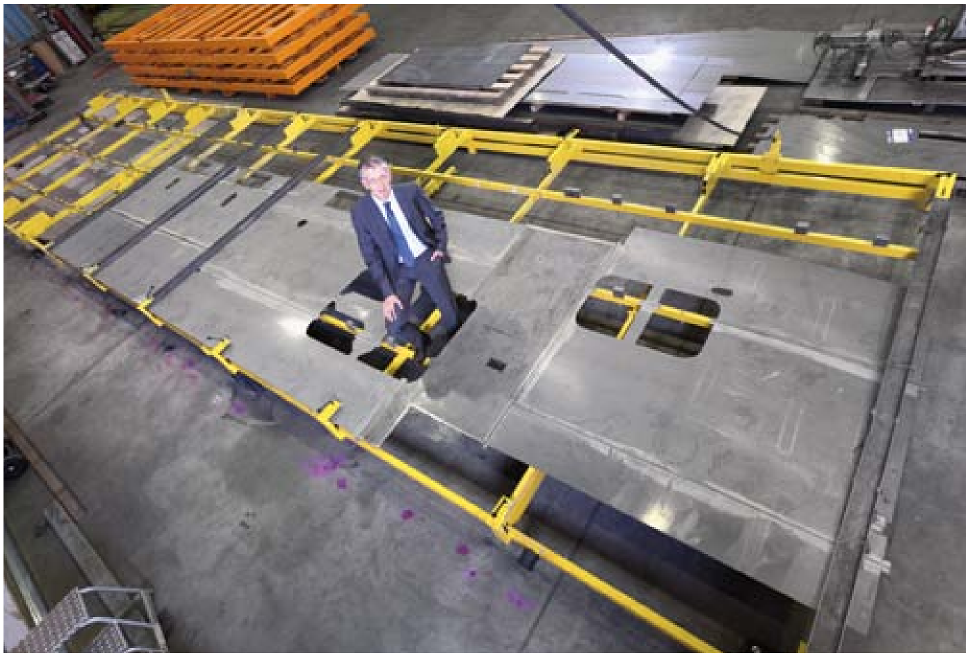
> "Many people suspected that laser welding offered huge potential for car sides. We decided to try it out."
>
> *Thomas Fittkau*

A wall in one, please In 2008, Photon was approached by one of the leading manufacturers of modern rail vehicle technologies: The company was hoping to build car sides using laser welding techniques. To achieve this, the two firms went back to the very beginning of the production process, working together to optimize the design and the calculations on which the design was based. "There are currently no real guidelines on how to handle a laser weld seam in terms of design calculations. So a lot of the figures had to be verified by performing fatigue tests," says Fittkau. The task was complicated by the fact that the rolling stock manufacturer intended to produce the car sides in a total of ten different versions. It was clear to the Photon design engineers that the process would be efficient only if all the variants could be handled by a single piece of equipment — so the decision was made to characterize the jigs and fixtures technology right from the design phase. "The fact that we were producing the laser system meant that it was a good idea to get us involved in the process early on," says Fittkau. "Laser welding has the potential to provide enor-

Left: The first station is a large portal system that welds the sheets that have been clamped in place.

Center: The second station features two welding robots that weld the support structure to the back of the outer shell.

Right: Sales Manager Thomas Fittkau and the welded outer shell.



mous benefits, but very often it involves making a fresh start. It is only by participating in the design process that you can develop a feeling for the laser system, the required levels of precision, and the tight tolerances."

The car sides are built in a multi-stage production process. The first station is a portal system which joins the individual metal sheets to form the complete 16-meter outer shell. Photon utilizes the 'tailored blank' method originally used in automotive engineering; sheets of varying thicknesses and grades are used, depending on the load to which each section will be subjected. "The tailored blank method works much better with laser material processing than with conventional techniques," notes Fittkau. The clamping mechanism holds the sheets in place magnetically to ensure that they remain locked in position until they exit the laser welding portal. In the second station, two articulated-arm robots move across the huge metal surfaces and weld the struts — pre-aligned and mechanically clamped to the outer shell. "Ninety percent of the car sides manufactured here exhibit deviations from planarity of considerably less than two millimeters per meter," says Fittkau. That means that subsequent work to flatten out the metal can be kept to a minimum. A 4-kilowatt TruDisk disk laser feeds the portal and the articulated-arm robots on an alternating basis using waveguides approximately 50 meters long. While one station is being loaded, the other station receives maximum laser power.

The final proof At the third station, the structural joints in the framework are connected using arc welding. This is because it is only possible to control the tolerances up to a certain point in a component this long, as Fittkau explains: "Theoretically we could modify the construction of the sides to create gaps that the laser could cope with. But, in this case it is better for our customers if we leave gaps of two to three millimeters and then use a conventional welding method to join them together."

Between February and June 2011, Photon produced more than one hundred car sides in the facility, thereby demonstrating that it is perfectly feasible to process large quantities of these outsized components using laser welding — without sacrificing quality. And Fittkau has noticed that word is already getting around in the industry: "The rail vehicle manufacturers have been waiting for someone to show that this is possible. Laser welding has long offered the potential to improve their processes, but until now it was far from clear that it was a sensible choice for workpieces on this scale." ■

Contact:
Photon Laser Manufacturing GmbH, Thomas Fittkau, Phone +49 33231 705–17, t.fittkau@photonag.com, www.photonag.com

PHOTON LASER MANUFACTURING
Part of the Photon Group, the company cuts and welds complex assemblies made from steel, stainless steel, aluminum and composites. Along with large-scale assemblies for the rail, commercial vehicle, and automotive industries, the company also produces components for aviation, facility construction and the mechanical engineering sector.

A beautiful story

Whatever method you use, aluminum is very difficult to weld. So Thomas Schnekenburger decided the laser was his best option.

Protruding weld seams are almost impossible to avoid when you weld aluminum — the only question is how visible they are to the eye. This is a problem Thomas Schnekenburger knows all too well. His employees have long been used MIG torches to weld the material, and they had learned to accept weld seams that were several millimeters thick. Schnekenburger is the Managing Director of the sheet metal contractor SMB Schnekenburger based in Bad Dürrheim, Germany, whose products include casings for solar inverters. These devices convert direct current from photovoltaic systems into alternating current and are generally installed out of sight in a corner — yet their appearance still matters: "If a device contains cutting-edge technology, that should be reflected in the casing," says Schnekenburger. But this means extra work for SMB: three employees spend their days polishing hundreds of meters of weld seams, with all the risks that involves for the process: "The casings need to stay watertight whatever the weather," says Schnekenburger. "But there is always the risk with grinding that you could open up microfissures or pores, or that you could grind too deep."

Aluminum is still the best choice.

That's because aluminum is an excellent material for this type of enclosure: lightweight, corrosion-resistant, and yet robust enough to use outdoors. Aluminum is also a modern material that customers like. Design and physical appearance are important, and SMB has built a superb reputation as a company that knows how to make parts look good — from solar inverters to medical equipment and industrial computers. That's why Schnekenburger and his team have spent many hours discussing the issue of aluminum weld seams and debating the use of a laser, though they initially felt it was unrealistic: "For a long time we believed that our parts did not have the level of precision you need for laser welding," he says. "We also saw laser welding as something more suited to mass-produced parts such as those in the automotive industry." Nevertheless, he started looking around for a suitable laser machine — and a surprise was in store for him when he took his aluminum casing to the Applications Center at TRUMPF: "It only took a handful of tests and we got a perfect, tight, robust weld seam that no longer required any grinding or finishing work." By introducing a more accurate clamping device, the production process also turned out to be easier to adapt to the laser than they had thought. Schnekenburger was impressed enough to invest in a TruLaser Robot 5020 in early 2010, with a 3.5 kW disk laser as a beam source. Much of their subsequent success has been based on this disk laser, which offers beam quality sufficient to cleanly couple the laser into the highly reflective material.

Thomas Schnekenburger with the part that led him to use lasers.

The laser welding cell is now an integral part of the production process and its range has been extended beyond the solar inverter casings: "Not everyone has a machine like this and we have learned to make the most of it!" says Schnekenburger, who has been aggressively marketing his company's new capabilities. "It shows our customers what we can do." Several potential customers have been intrigued and impressed by the advantages the laser offers, especially for stainless steel parts, which the company can now work without discoloration. Schnekenburger has also shifted some of his older processes over to laser welding, pushing the machine to full capacity over two shifts. His satisfaction with this investment is hardly surprising: the thick weld seams on SMB's high-tech casings are a thing of the past, and his full order books tell a story of solid success based on beautifully finished products. ■

Contact: SMB Schnekenburger GmbH,
Thomas Schnekenburger, info@smb-blechtechnik.de

Meticulous preparation and a high-brilliance laser source make it easy to work with aluminum.

THE MATERIAL: Aluminum is highly reflective and very quickly conducts heat away within a workpiece. Coupling with the laser under these conditions requires a finely focused, high energy, short-wave beam – something that can only be provided by high-brilliance solid-state lasers.

THE PROCESS: In order to work with such a fine focus, the metal sheets are cut, punched and bent to very exacting tolerances, enabling them to be clamped with minimal gap dimensions and welded together with an airtight fillet weld.

THE COMPANY: SMB Schnekenburger GmbH is a systems supplier for casing and thin sheet technology. The company covers the entire production chain from toolmaking and in-house development to sheet metal processing, assemblyand surface finishing.

Mix it!

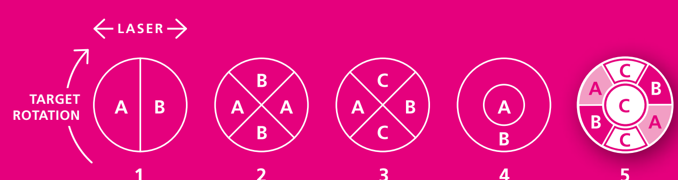
Dr. Dieter Fischer
Prof. Martin Jansen

Femtosecond lasers mix and deposit the ingredients of complex coating systems on flat panel displays and solar cells in a single step.

Pulsed laser deposition (PLD) is nothing new. A laser source — generally an excimer laser — fires at what is known as a 'target'. The laser pulses vaporize material from the target and this material then accumulates as a thin film on the workpiece. The major advantage of PLD is that neither the 'substrate' (the workpiece) nor the target need to be magnetic or electrically conductive. Scanner systems are also nothing new in industrial applications: the small, lightweight mirrors incorporated in these systems are used to move the focus spot over the surface of workpieces at extremely high speed. But now scientists at the Max Planck Institute for Solid State Research have created something that really is new: a successful technique that combines the PLD concept with scanner technology. Their 'Combining Laser Deposition (CLD)' method substitutes scanner optics for the fixed focus of the PLD technique.

In the PLD process, the usable area on the target is very small, and it gets rougher each time a laser pulse hits it, forming a pico-scale lunar landscape from which the laser blasts out increasingly uneven 'chunks'. Larger particles begin to be deposited on the substrate as droplets. Since the target can only supply the material for a single coating layer, multilayered coatings are produced in multiple process steps. Alternatively, the laser can be focused on alternating targets in a single process step, though each change of target is reflected as an unevenness in the coating. Coatings combining multiple elements can either be produced using a 'pre-mixed' target or by quickly alternating between individual targets consisting of the pure elements. However, in both these cases the elements often accumulate in a slightly different ratio to that at which they are ablated from the targets.

In the CLD process, one target supplies all the components for all the layers of a coating system. In addition, the technique generates composite layers during the process. This is achieved by arranging the elements for the coating system in a suitable geometry. In the CLD process, the scanner directs the laser pulses over the target line-by-line. This lets the process use the entire target surface while simultaneously coating large areas of the substrate with a continuous and complete coating system. It is even possible to form gradients with evenly increasing or decreasing concentrations of the coating components within a single layer.



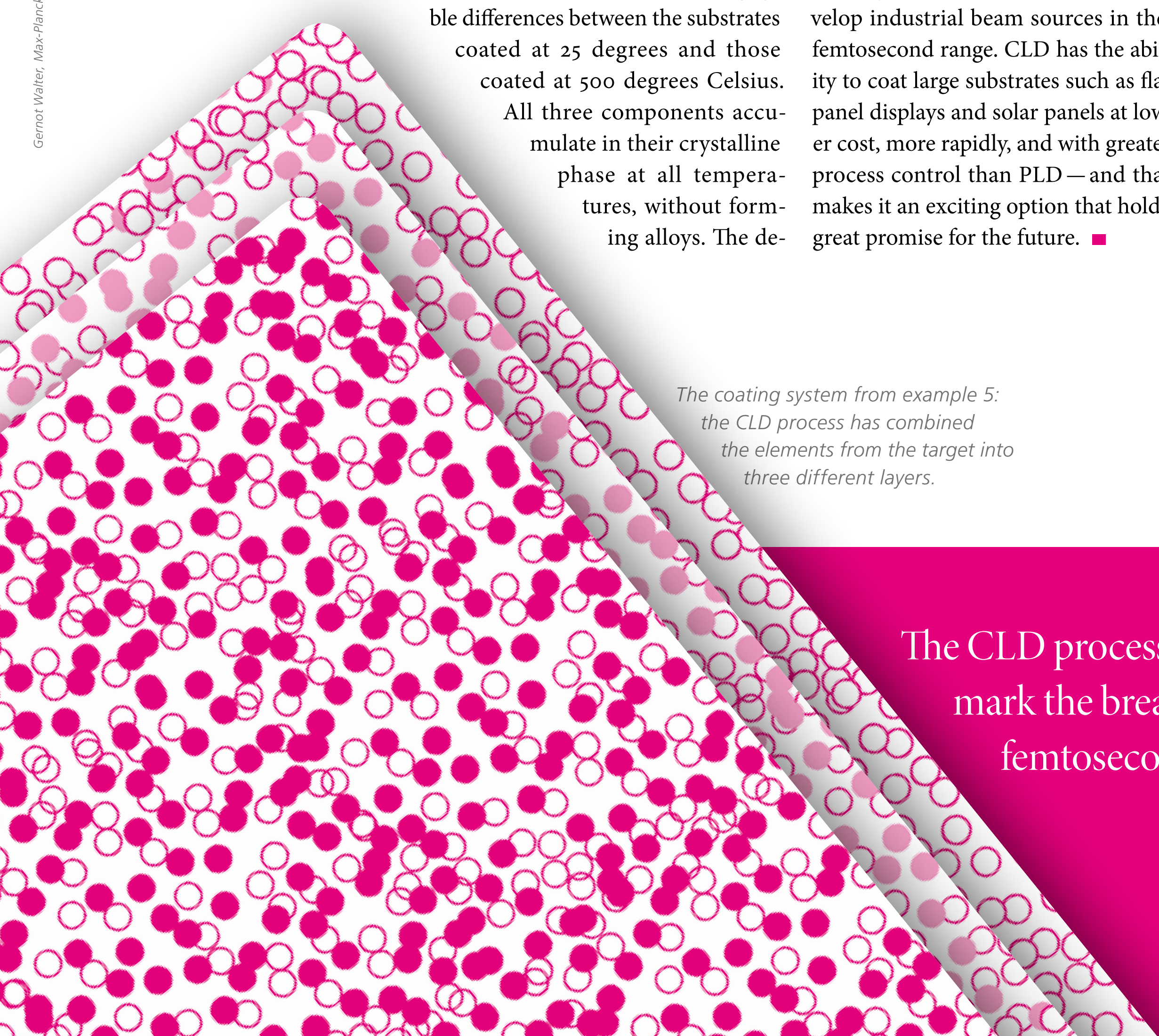
Different coating systems can be obtained by arranging the components on the target in different ways: Target 1 results in an A:B layer, Target 2 produces alternating A and B layers. Target 3 creates A and B layers interleaved between C layers, while Target 4 produces a variable A:B ratio. Target 5 first deposite a pure C layer, followed by alternating A:C and B:C layers.

The Max Planck Institute investigated and developed this new technique as part of a project to coat sapphire substrates with an aluminum-titanium-niobium coating system. The target they used consisted of a titanium disk into which wedge-shaped segments had been inserted and a niobium disk in the center. The experiments were performed at target temperatures of between 25 and 500 degrees Celsius. A femtosecond laser struck the target at a wavelength of 516 nanometers, pulse energy of between 0.3 and 0.6 millijoules, and pulse frequency of one kilohertz. The researchers subsequently examined the ablation of the target and the deposition and composition of the coating layers on the substrate samples.

This series of experiments showed that one of the biggest difficulties of PLD — droplet formation — does not even occur. Overall, the new CLD technique transfers more material, thanks to the higher pulse frequency of the femtosecond laser. Yet the ultrashort pulses ablate smaller quantities of material more evenly with each pulse. In addition, the focus spot migrates across the target instead of constantly firing at the same point, which results in the surface actually being smoothed by the laser.
The substrates used in the experiments featured evenly mixed Al-Ti-Nb coatings with particle sizes of between 20 and 200 nanometers. There were negligible differences between the substrates coated at 25 degrees and those coated at 500 degrees Celsius. All three components accumulate in their crystalline phase at all temperatures, without forming alloys. The desired component ratio of 1:1:1 was achieved across the entire coating. The researchers also discovered that the ratio of the components in the deposited coating changes immediately and in exactly the same proportion whenever the target ablation ratio is changed. In addition, the scientists found that the ablation of the components can be directly controlled by the position of the scan lines, and an examination of the deposited coatings showed that ablation and deposition also change in proportion to the laser power employed — a change that is immediate and 'drag-free'. As a result, the laser output power, the position of the scan line on the target, and the movement of the target can all be harnessed as precisely controllable process parameters.

The joker in the pack in this process is the laser: experiments performed at TRUMPF with a TruMicro have shown that a productive and stable coating process can even be achieved with an industrial picosecond laser. And everything suggests that the process could be accelerated even further by using more powerful lasers, shorter pulses, and higher repetition rates, while still retaining full control over the process. Thus, interest in the CLD technique looks likely to increase steadily as scientists continue to develop industrial beam sources in the femtosecond range. CLD has the ability to coat large substrates such as flat panel displays and solar panels at lower cost, more rapidly, and with greater process control than PLD — and that makes it an exciting option that holds great promise for the future. ■

Dr. Dieter Fischer has worked at the Max Planck Institute for Solid State Research since 1998, conducting research into solid state synthesis from atoms. This research work eventually lead to the development of the CLD process in Prof. Martin Jansen's department.
d.fischer@fkf.mpg.de



The coating system from example 5: the CLD process has combined the elements from the target into three different layers.

Gernot Walter, Max-Planck-Gesellschaft, Dr. Dieter Fischer

The CLD process could mark the breakthrough of the femtosecond laser.

“It’s a fantastic playing field”

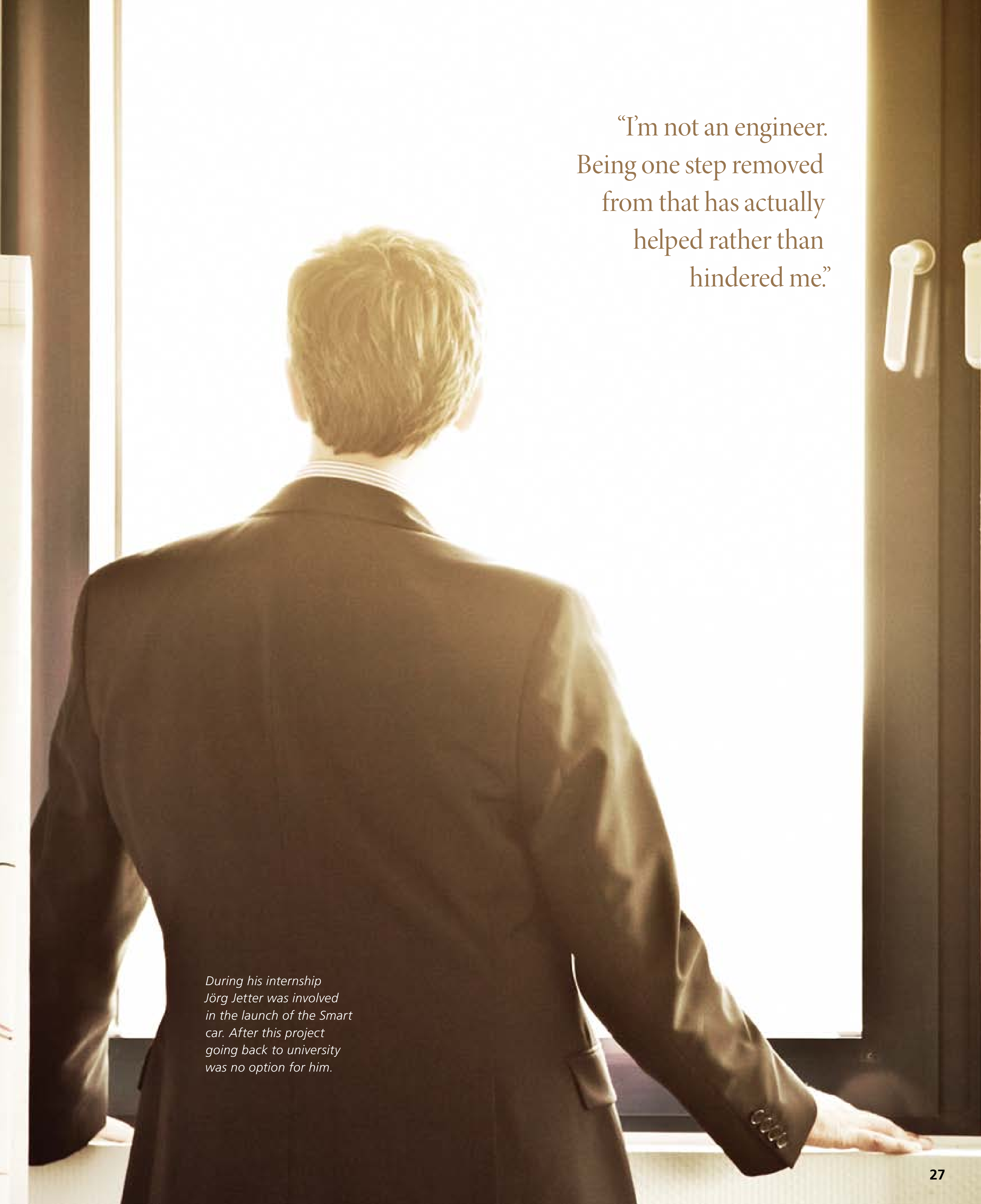
How do you get a high-tech company off the ground? We asked someone who should know — the German Founder of the Year 2011.

Mr. Jetter, you are neither a scientist nor an engineer, yet you still managed to set up a hugely successful laser company. How did you do it?

Sometimes things work out in ways we don’t expect! It’s true that lasers were a familiar concept to me from a young age, because my father, who is a physicist, has worked on laser technology all his life. But the fact is that I never liked physics when I was at school, and I had no idea what direction I wanted to take when I left school. In the end I decided on a combination of business administration, law and communication design at the University of Göttingen. But it wasn’t until I did some internships that I finally discovered what really stirred my interest and my passions.

And that was…?

Business management, because it offers so much variety. I was working as an intern at Daimler in 1997 when they were preparing to launch the Smart car and they got me heavily involved in the marketing and sales aspects. The internship turned into a full-time position. Two years later I decided I wasn’t interested in returning to college, so I started working on a freelance basis selling laser systems to the tire industry in the USA, primarily machines produced at my father’s company. When I returned to Germany in 2006 I had already made up my mind to set up my own company. My father gave me lots of support and my first employees were two highly-skilled mechanical engineers who had worked with him. The fact that I’m not an engineer has probably helped rather than hindered me because I am always focused on what customers want and what they can afford. There are plenty of technology-obsessed engineers out there who like nothing more than developing highly specialized, one-off machines — but I was determined right from the beginning to make products that would be used in larger quantities. →



“I’m not an engineer. Being one step removed from that has actually helped rather than hindered me.”

During his internship Jörg Jetter was involved in the launch of the Smart car. After this project going back to university was no option for him.

You started out with one customer order and three employees. Today, 4Jet has more than 50 employees and sales revenues well in excess of 10 million euros. Did you expect to be so successful?

I was certainly optimistic, but I admit I was surprised at how fast the business developed. The truth is that we had several strokes of good luck. We got into the photovoltaic industry in 2007 more by chance than by design; a customer actually came to us, asking whether we could develop a laser system to remove coatings from thin-film solar cells. That was just when the boom was really picking up steam in that industry, and 4Jet was the first company to build that type of laser system. Before long we had attracted lots of new customers, mostly companies that had only just been set up. Basically we stumbled into a niche and immediately became the market leader!

You are also the market leader in laser systems for tire marking. How can you produce machines for such diverse industries?

Actually, the first machine we ever marketed was a tire marking system. And we managed to find a niche in that industry, too. The challenge was to come up with a fully automated solution, in other words a machine that could find the right spot to mark, on a wide range of different tires. We still offer that model, but we have also moved forward with the development of new solutions for tire manufacturers and other auto suppliers. It's certainly true that the photovoltaic and tire industries are two completely different worlds: on one side you have a very young industry made up of lots of small companies, and on the other side global corporations steeped in tradition. That obviously produces two entirely different kinds of corporate cultures, so we run completely separate sales and marketing operations for the two different segments.

Why didn't you simply set up a second company to provide services specifically tailored to customers from the solar technology industry?

The basic technologies we rely on in both markets are in fact quite similar. Regardless of whether we are removing rubber from tire molds or semiconductor layers from glass, we use the same basic process of laser ablation — applying the light to the surface and finding the best way to vacuum up the residue. We use similar modules in both these markets — for the optics, the drive units, and the process visualization systems for control and programming purposes. So basically we benefit from all sorts of technical synergies while simultaneously spreading our market risk by not putting all our eggs in one basket!

Where do you get your ideas for new products?

They always come from our customers, particularly from the fledgling solar tech companies; they turn out lots of ideas for which we need to develop new solutions. We started out with edge chamfering systems but since then we have also developed laser systems to drill solar glass and integrate solar modules. We would never build a system that another company is already producing — we are not interested in standard off-the-shelf applications. Each year we develop two or three new product lines.

"We focus on replacing existing production processes with laser techniques. Nowadays we can even devise substitutes for inexpensive techniques like sandblasting."

LASER Jörg Jetter grew up with laser technology. His father is a physicist who founded his own laser company. Jetter junior was never particularly interested in physics or mechanical engineering – but he did inherit his father's belief in the potential of light as an industrial tool.

LIFE Jetter studied business administration, law and communication science, but turned his back on academia after an internship at Daimler. The experience of selling his father's laser systems to the American tire industry encouraged him to set up his own business.

ACHIEVEMENT He founded 4Jet in 2006 with two employees and a determination to build laser systems – not heavily customized machines, but rather machines that could be sold in relatively high numbers. In 2011, 4Jet's 50 employees generated sales of more than 10 million euros. The company is now firmly established in the tire and photovoltaic industries.

Ralf Kreuels

How do you produce so much with just 50 employees?

The only things we actually do in-house are design engineering and programming. Design engineers, optics experts, laser process engineers and software developers make up half of our workforce. They are equally involved in the development process right from the very start, which is what gives us such fast time to market. We also have technicians who install and maintain the systems at the customers' sites. We retain tight control of everything relevant to know-how and buy everything else. The systems are assembled here, but by external subcontractors. Running our own production line would make things much too complex because we are not in the business of producing large batches.

Do you intend to stick to this business model?

Yes, I feel confident this is the right model. It works perfectly for young high-tech companies like us, helping us grow more rapidly and making us less vulnerable when the economy is weak. High-tech company founders need to focus on three things: customers, technology and financing. Manufacturing does not have a place in that mindset, in my opinion.

Are there as many opportunities now as there were five years ago?

Exciting opportunities are always emerging, because new technologies create new markets. Laser technology is a fantastic playing field for entrepreneurs. The performance of lasers for micromachining jumps from 200 to 1,000 watts in what seems like no time at all. It takes just twelve months of development to double laser system speed. That drives down the prices of solutions that would previously have been far too costly. That's why 4Jets laser systems can successfully compete against inexpensive conventional techniques such as sandblasting. We focus on replacing existing production processes with laser techniques. "But of course laser technology also offers the opportunity to develop completely new applications, and not only in the field of coating technology. We are constantly seeking new opportunities stemming from the use of new materials. For example, researchers are working on flexible organic displays that could be structured and sealed using a laser."

So which niches look particularly promising for entrepreneurs at the moment?

(laughs) That's my secret! I have to say that the situation in the solar technology industry is difficult for newcomers right now. Five years ago, many of the companies were still starting out and didn't have any established suppliers; procurement contracts ran just a couple of pages. Nowadays people negotiate right down to the last euro. But there will always be niches — we even found some in the tire industry, which is a very long-established market. International markets are becoming more and more important — exports account for more than half of our turnover — but that is primarily a challenge for sales and marketing.

Germany is a leading light in laser research — how does that affect you?

The research and development work people are doing in the fields of beam sources and optics is crucial to us. 4Jet wouldn't even exist if it weren't for the strength of the German laser industry. We are often one of the first companies to employ a new laser in a machine. Germany's expertise in laser research gives it an advantage over Asia, and one that it will maintain for years to come. ■

Contact: 4JET Technologies GmbH, Jörg Jetter,
Phone +49 2404 552 30–0 joerg.jetter@4jet.de

Go east

The photovoltaic boom is just getting off the ground in Asia. Prof. Armin Aberle argues that this is the place to be – for companies that can offer laser technologies suitable for solar cell manufacturing.

The use of lasers in solar cell manufacturing has recently experienced a shift in focus. The debate on what kind of role lasers should have in solar cell manufacturing has been replaced by a different question: How much can the speed and efficiency of the manufacturing process be boosted, now that laser techniques are firmly established? Laser processing is a versatile tool that enables high throughput rates in this sector — and its role is now seen as crucial. Growth in the laser market in Asia is closely tied to growth in the solar industry. As a result, both markets face similar challenges.

Despite high initial investment costs, a considerable number of solar cell manufacturing plants have been successfully established in recent years — especially in Asia. The fact that many PV manufacturers are firmly focused on producing high volumes at low cost means that silicon appears to be the only solution capable of providing the main source of clean solar electricity in the foreseeable future.

Prof. Armin Aberle is Deputy Chief Executive Officer of the Solar Energy Research Institute of Singapore.

Solar Energy Research Institute of Singapore

Interesting research is being conducted into organic solar cells, but these devices cannot yet compete with silicon cells. Silicon, the second most abundant element in the earth's crust, might seem a rather conservative and unadventurous choice in today's fast-moving world, but it will almost certainly remain the most important material in the PV industry for many years to come.

The silicon shortage of a few years ago was not due to a lack of raw material, but rather a lack of conviction that solar energy will indeed play a significant role in the near future. Those doubts have evaporated and it is clear now that the demand for silicon will grow enormously over the coming decades, with silicon solar cells becoming a major source of global electricity by 2030. Increasingly, Asia is emerging as the center of the solar cell manufacturing industry. Operations are shifting from West to East — and low-cost labour is no longer the primary reason.

So what makes Asian countries so attractive? Surely not just the abundance of sunlight? The main factor that is prompting Asian countries to become key players in the global photovoltaic industry may well be their belief in a prosperous future. Huge numbers of well educated and hard-working people are striving for success and recognition. In today's globalized economy, free from any limitations on where raw materials, machines and expertise can move, companies are understandably eager to set up their operations in Asia. Decisions are made quickly, and the governments are keen to work together with industry to develop regulations and provide easy access to financing at affordable rates. This business-friendly environment is also aided by the fact that governments are willing to invest in start-up companies and stay invested until the business is well established.

Seeking to attract specialized human resources and machinery from all over the globe, Asia is also showing a stronger belief than the West in the importance of a manufacturing base instead of directing too many efforts into the services sector. The construction sector — both public and private — is another major driver of growth in the Asian region.

The path towards energy-efficient, solar buildings is a long one, but architects are increasingly eager to include these technologies right from the start of the planning process. ■

More information: www.seris.nus.edu.sg

Where's the laser?

IN STONEWASHED JEANS: When French designer François Girbaud pioneered stonewashed jeans, he created a popular fashion trend. But accomplishing this iconic look required large amounts of water and chemicals, leading to a thumbs-down from environmentalists. Girbaud took note and developed the 'Watt Wash', an innovative and eco-friendly solution. The new process radically reduces the quantity of water consumed and uses a laser to carry out the lion's share of the work: the laser beam sculpts the surface of the material by simulating the effects of wear and creating patterns. Let's hope this approach becomes as popular as stone-washed jeans did! *www.girbaud.com*

Gernot Walter


25,5 GIGAPASCALS ...
... of pressure must be produced with the aid of a laser beam to fabricate diamond aerogels. The result is a truly extraordinary material which is as light as a feather, highly resilient, and chemically inert. That makes it the perfect coating for equipment used in space — and also for window panes. And the catch? Scientists are currently able to produce it only in microscopic quantities.
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