

01:10

Laser *Community*

THE LASER MAGAZINE FROM TRUMPF



ON THE FUTURE OF FIBER

BY ITS INVENTOR
PROF. PHILIP RUSSELL
→ Page 24

Driving pleasure

BorgWarner's road to the
dual-clutch transmission

Advocating goggles

Gus Anibarro is passionate about
safety at laser workplaces

2861°C

The mystery in the "keyhole"—and how
researchers are unmasking its secrets

PUBLISHER TRUMPF GmbH + Co. KG, Johann-Maus-Straße 2, 71254 Ditzingen, Germany, www.trumpf.com

RESPONSIBLE FOR CONTENT Jens Bleher **EDITOR-IN-CHIEF** Holger Kapp, Telephone +49 (0) 7156 303-31559,

holger.kapp@de.trumpf.com **DISTRIBUTION** Telephone +49 (0) 7422 515-121, Fax +49 (0) 7422 515-175, laser-community@trumpf.com

CONSULTING Helmut Ortner **EDITED BY** pr+co. gmbh, Stuttgart, Norbert Hiller, Martin Reinhardt

CONTRIBUTORS Catherine Flynn, Elise Kammerer, Bernd Müller, Jan-Frederik Nekarda, Martin Reinhardt, Prof. Philip Russell, Ralf Schluricke,

Julia Schmidt, Monika Unkelbach, Verena-Christina Weber **PHOTOGRAPHY** Steve Adams, Florian Bilger, KD Busch, Angelika Großmann,

Jim McDonald **DESIGN AND PRODUCTION** pr+co. gmbh, Stuttgart/Germany, Gernot Walter, Markus Weißenhorn,

Martin Reinhardt **REPRODUCTION** Reprotechnik Herzog GmbH, Stuttgart/Germany **PRINTED BY** frechdruck GmbH, Stuttgart/Germany

01:2010

IMPRINT



The debate is as topical as it is controversial. Germany is currently following a strategy prevalent in many other countries of promoting research and development through tax incentives.

The list of countries where research is eligible for preferential tax treatment includes the USA, Japan, France and Great Britain. It is immediately apparent that all countries with a pronounced industrialized, innovation-oriented economy utilize tax-based stimuli. This approach with its tremendously broad impact opens up great opportunity, particularly for small and medium-sized enterprises. One should, of course, consider whether or not tax incentives are indeed suitable as engines for innovation. Experience shows that the real key to new findings in cutting-edge technology has often been closely defined support for networking to link scientists' research ardor with engineering effort.

An international comparison shows that innovative ideas with targeted project support can be translated very successfully into products. The story of the laser industry's achievements in Germany is a prime example of this. The "Photonik 2020" initiative is laying the foundation in Germany for coming years so that research efforts in optical technologies can continue to concentrate on the issues

Pioneering spirit — properly promoted!

that are forward-looking and promising. Common to both approaches is the formation of clusters. Industry and research join forces, profit from the exchange of ideas and the involvement of many disciplines — and achieve training effects, as well. Neither the USA nor Japan can boast of any comparable initiative. Rather, we observe in both economies a greater degree of industrialized support, closely controlled by specific interests. Only rarely are interdisciplinary links forged between research and practice in those regions. In China, by contrast, other means are used to successfully support cluster formation.

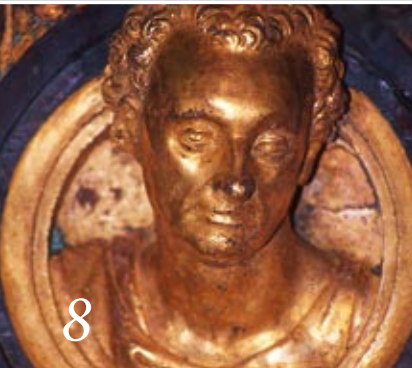
For this reason project support must not be relegated to the back burner in Germany or the EU. Those who are pushing the debate on tax incentives should always be aware that a fiscal solution must not be implemented at the expense of closely defined project support. Whether this is realistic in times of tight funds is doubtful. In any case the target set down in the Treaty of Lisbon — to earmark three percent of gross domestic product for research — must not result in ill-conceived programs for action. Rather, we must guarantee both the intensity and precision of research support for optical technologies.

PETER LEIBINGER

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



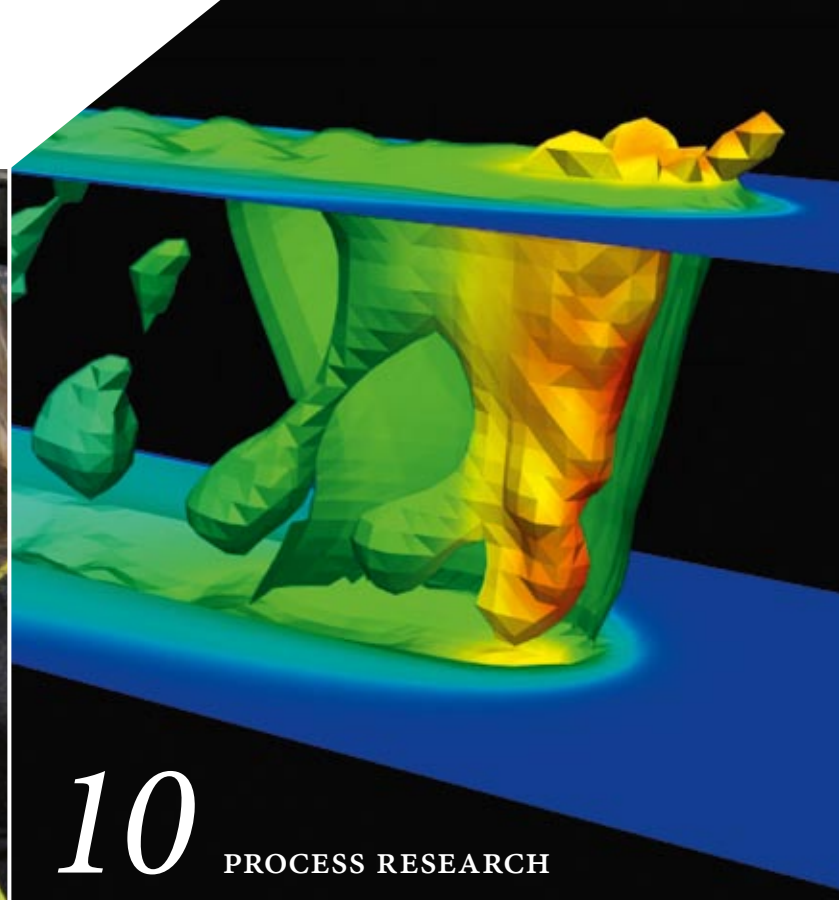
6



8



15 STATEMENT



10 PROCESS RESEARCH

COMMUNITY

TOPIC

STATEMENT

Lasers and people at a glance PAGE 06

PROF. ANNETTE SCHAVAN STARTS PHOTONIK 2020 // Photonics21 gets to the next round PAGE 06 // People: Jean-Claude Sirieys, Dr. Nathalie Picqué, Prof. Jürgen G. Heinrich PAGE 07 // **LASERS RESTORE ART** // Methods: CFP cutting, Conductor paths for OLEDs, laser shearing // Green wave PAGE 08 // PROF. KATAYAMA TALKS ABOUT HIS TWIN LASER PAGE 09

- 07 NETWORK NODE
- 07 QUANTUM LEAP
- 30 MARKET VIEWS
- 32 RECORD

TITLE

UNDER STEAM

Until now, trial and error was the only way to find the right laser cutting parameters. Current research is changing this. PAGE 10

IN THE EYE OF THE STORM

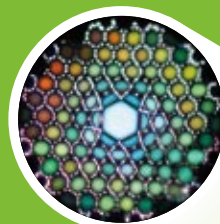
What happens in the keyhole? Messages from the thermodynamic micro hell. PAGE 12

“Responsibility begins with *each individual*”

Responsibility is not a job, rather a life philosophy,” explains pilot Verena-Christina Weber. PAGE 15



18 DUAL CLUTCH



FIBER OPTIC CABLES 24



16 LITRON



TRACEABILITY 21



GUS ANIBARRO 26

REPORT

SCIENCE

PEOPLE

A fine business

"Everything depends on the precision of our work," explains Litron founder Mark Plasse. "Often even the life of the end user." [PAGE 16](#)

Two point five

How BorgWarner developed a clutch that shifts one hundred times faster than a person blinks. [PAGE 18](#)

A long recall route

One-hundred percent quality, one-hundred percent traceability. TESAT cannot afford anything else. [PAGE 21](#)

PHILIP RUSSELL

Mastering the flow

"Impossible" was once the judgment of industry experts concerning Philip Russell's photonic crystal fiber. Today, his invention represents the future of fiber optics. [PAGE 24](#)

"Wear your goggles!"

Safety expert Gus Anibarro helps laser users to protect themselves from themselves. Here, he describes why this is so difficult. [PAGE 26](#)

S P O T

--- MADE IN KOREA

Jenoptik AG has opened a new **Laser Application Center** near Seoul, Korea. Since March, customers and interested parties from a variety of industries have been able to test and further develop various lasers and production methods. www.jenoptik.com

--- AGAINST GRAVITY

Two researchers at the **University of Rochester** in the USA have made water run uphill. This is possible due to the fine grooves that they engraved into the surface of a silicon disk using a laser. www.rochester.edu

--- LASER ON THE RIVER

In Papenburg, Germany, **Meyer Werft** hosted the **6th Laser Days Weser Ems**. The shipyard is an international leader in the shipbuilding industry when it comes to using laser technology. www.ipt.fraunhofer.de

--- MICROLASERS

ETH Zürich introduces the smallest laser in the world. It's only 30 micrometers in size, but it emits wavelengths of 200 micrometers. www.ethz.ch

--- DEPOSITION WELDING

In Houston, Texas, researchers and users discussed the potential of additive methods in production during the **Additive Manufacturing Workshop** hosted by the **Laser Institute of America (LIA)**. www.laserinstitute.org

--- CLUSTER

The **Photonics Research Cluster** — the first of six at this point — will start up in 2010 on the **campus of RWTH Aachen University**. A cluster is a cooperative on-site partnership between universities and businesses. www.rwth-aachen.de

--- PEARLS

Real or fake? China or Japan? Researchers at the **Johannes Gutenberg University** in Mainz are able to use the laser to determine the authenticity and origin of pearls. www.uni-mainz.de

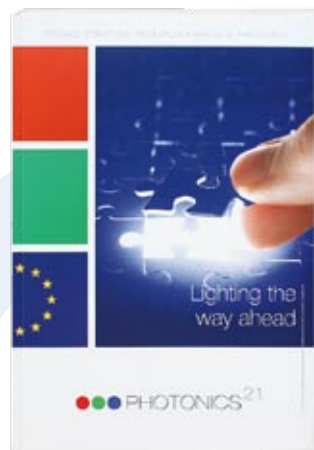
“The laser is the success story of the German economy.”

Prof. Dr. Annette Schavan,
Federal Minister of Education
and Research

Industry with a future

Optical technologies: “Photonik 2020” strategizing kicks off

■ The field of photonics receives a great deal of support from business people, scientists and politicians. At the end of “The Wonder of Light” gala, which celebrated the 50th birthday of the laser, representatives from business, research and various organizations met to begin strategizing for “Photonik 2020.” During the course of 15 workshops, more than 300 experts worked on a plan for the targeted promotion of optical technologies. Together, they defined the research areas and activities that should be the focus of a national effort for the next ten years. Their efforts were supported by Annette Schavan, Federal Minister of Education and Research. She referred to the laser as “the success story of the German economy” and announced support for reinforcing and further expanding the leading position of photonics as a key technology. www.optischetechnologien.de



Where to go from here?
The second Strategic Research
Agenda will define the
path for the next few years.

Key technology

Photonics21 kicks off a new initiative

■ The Management Board of the Photonics21 technology platform has established a work group for the Europe-wide promotion of the photonics industry. This action is a response to a memo from the European Commission from September 2009, in which the Commission ranked photonics among five key technologies. In cooperation with industry consultants, the mission of the new work group is to closely examine the competitive conditions and positioning of the individual key technologies. This also includes funding for research and development within the EU. The resulting guidelines on efficient funding and the strategic alignment of key industries will be submitted to the European Commission at the end of 2010. www.photonics21.org

“French Photonics Community strives for greater integration”



Jean-Claude Sirieys

With the support of the French government, the Comité National d’Optique et de Photonique (CNOP) has kicked off an initiative to better integrate Europe-wide optics and photonics research work being conducted in France. One of many ways to achieve this is enhanced exchange of information. This places France on the best path to its own technology platform for photonics, explains Jean-Claude Sirieys, President of the CNOP.

“Dr. Nathalie Picqué’s research on frequency comb technology for molecular spectroscopy is of fundamental importance”



Dr. Nathalie Picqué

The American Physical Society (APS) has awarded its “2010 Beller Lectureship Award” to French scientist Nathalie Picqué. The APS grants this award for outstanding achievement in physics outside the USA. Part of the honor in receiving this award is being the keynote speaker at the APS annual meeting. Dr. Picqué, a leading scientist at the Centre National de la Recherche Scientifique (CNRS), conducts research in the Laser spectroscopy department under Prof. Theodor W. Hansch.

“Lasers are increasingly processing ceramics and glass”



Prof. Jürgen G. Heinrich

Current research results are the focus of the first “International Symposium on Materials Processing Science with Lasers as Energy Source,” hosted by the Laser Application Center (LAC) at the Technical University of Clausthal. Headed up by Prof. Jürgen G. Heinrich, the researchers there explain new findings on using the laser to process ceramics, metal and glass and share information with industry concerning current projects. www.mpsl-ecers2010.de

NETWORK NODE

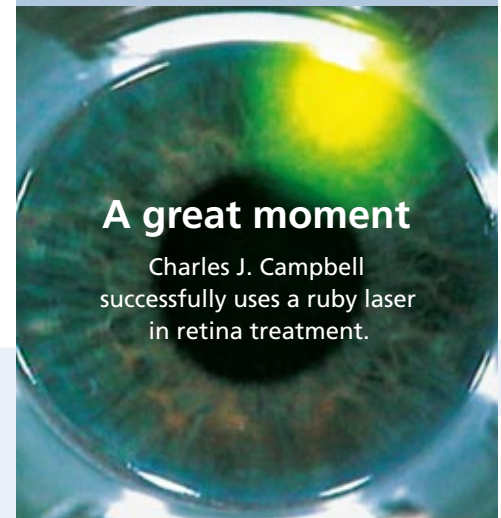


■ The stated goal of the Lairdside Laser Engineering Centre (LLEC) is to improve the competitiveness of Great Britain’s

industries. The Centre, located near Liverpool, operates as a middleman between university research and industrial manufacturing. The LLEC develops laser applications for industry and focuses on 3D laser machines, CAD/CAM interfaces and process development. The LLEC works closely with the Laser Group from the University of Liverpool — the largest university-based laser processing and research group in Great Britain. A part of the Northwest Laser Engineering Consortium, the LLEC also works with the University of Manchester. This gives the LLEC access to the latest findings from basic research that it then makes accessible to manufacturing industries. In addition, the Centre conducts feasibility studies, continuing education and training opportunities, as well as consults with and supports companies in implementing technology and establishing contact between British and other European institutions.

www.lasers.org.uk/llecl/index.htm

Quantum Leap

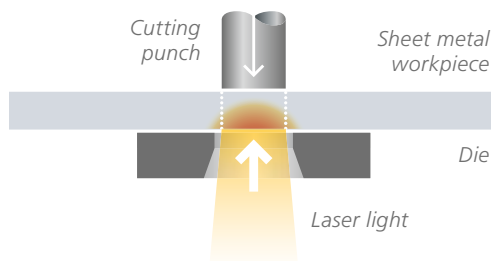


A great moment

Charles J. Campbell successfully uses a ruby laser in retina treatment.

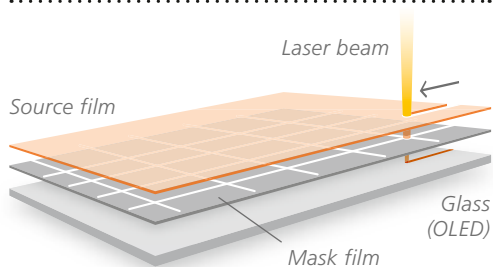
1961

CONCEPTS



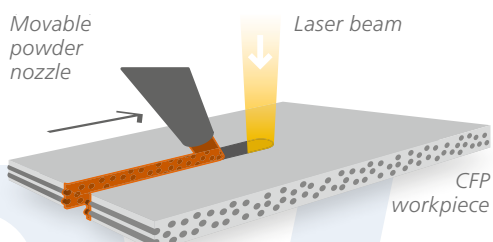
--- LASER SHEARING

The Fraunhofer Institute for Production Technology combines shearing on punch and nibble machines with lasers. The light heats up the shearing area and increases the fluidity. For V2A stainless steel sheet metal, the percentage of the area smoothly cut increases from 30 percent to 90 percent. www.ipt.fraunhofer.de



--- CONDUCTOR PATHS FOR OLEDs

Fraunhofer ILT is working on a new method of producing conductor paths for OLED lighting elements. Under the laser light, the source film melts and vaporizes. The mix is transferred to the glass along a cut in the mask film. The mix solidifies the conductor path. www.ilt.fraunhofer.de



--- CFP CUTTING

When it comes to laser-cutting carbon fiber reinforced composites (CFP), thermal damage is unavoidable. The Laserzentrum Hannover demonstrates a method in where a powdery filler material smooths and seals the cut edge. www.lzh.de



Almost as good as new: Laser cleaning: before and after shots from one of "the Gates of Paradise" doors.

New Shine

Ultra short laser pulses restore old masterpieces

Two Italian scientists have developed a method of cleaning works of art using laser ablation. Until now, lasers used to clean works of art made of metal and stone often left some discoloring. Salvatore Siano and Renzo Salimbeni from the Institute for Applied Physics, also referred to as "Nello Carrara," developed a system in which the laser's pulse duration can be adapted during ablation to the changing material properties of the surface layers to be removed from the artwork. This new method enables restoration of important works of art like "the Gates of Paradise" doors by Lorenzo Ghiberti at the Baptistery in Florence. Restorers have been experimenting and working with short pulse lasers since the beginning of the 1970s. The Berthold Leibinger Foundation is also currently funding a project at the Stuttgart State Academy of Art and Design. www.ifac.cnr.it



Green lasers in the lab: Mounting for the crystal that generates the green radiation

Green Wave

Energy record for micro processing

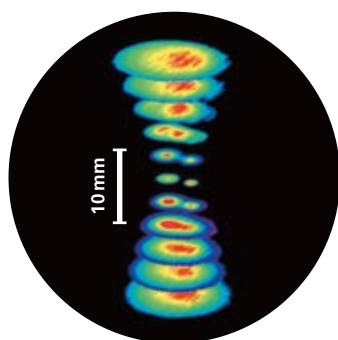
A new TruMicro laser from TRUMPF delivers a record 400 watts of output in the green spectrum. Under lab conditions, it even reached 700 watts. While solid-state lasers, as a rule, radiate in a wavelength of about 1,000 nanometers; the new laser operates at 515 nm. It is therefore aimed at applications in the semiconductor industry, in particular. Its most important material, silicon, absorbs short-wave light (green or ultraviolet) considerably better than infrared. TRUMPF's green laser is up to the tasks performed by Excimer lasers that are used in flat screen monitor production for remelting coatings made of amorphous silicon into polycrystalline silicon. But the green TruMicro laser can do the work at significantly lower costs and with much more flexibility.

“A versatile multi-talent”

Laser scientist Prof. Seiji Katayama was looking for an unconventional laser concept: A flexible 26 kW system consisting of two disk lasers with different outputs.



Prof. Seiji Katayama has been working at the Joining and Welding Research Institute of the University of Osaka since 1981 and as a professor since 2002. He became well known by virtue of welding processes for aluminum and new bonding techniques for metal-to-plastic joints.



The picture shows the spatial proliferation of the 26 kW laser beam downline from the processing optics. Seen at the “waist-line” of the beam is the intensity of the 16 kW laser (right) and the 10 kW laser

What is the advantage of this technique and of using high-power lasers?

Using twin-fibers gives us a high degree of flexibility as we can use either the 10 kW laser on its own, the 16 kW laser on its own or the two combined, providing 26 kW — a highly versatile multi-talent. In Japan there are several industrial applications, in the steel and heavy industry sectors for instance, where high-power lasers can be used to weld thick plates. We would like to produce sound laser welds in 12 mm thick steel plates of a high tensile strength. We have succeeded in welding plates as thick as this with a 12 to 16 kW disk laser.

What new facts did your research reveal?

It was found that hot wires should be used in preference to cold ones because the quality of hot wire welds is far superior. With a 10 kW fiber laser it was also rather difficult to produce sound welds with negligible oxygen content. On the other hand it confirmed that 16 kW disk lasers could produce sound welds with extremely low oxygen content.

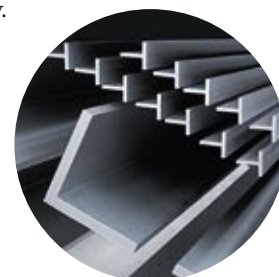
What applications do you use the 26 kW laser for and which materials are processed with it?

We would like to achieve defect-free welding operations on 25 mm, 980 MPa high-tensile steel plates. Materials like this are commonly used in pipelines, ships, etc. I also expect that such a high-power laser could be employed to weld aluminum alloys, copper and the like. But the problem with back reflection must first be addressed. We have already experienced such a problem on two occasions when welding steel with a high-power fiber laser, the beam of which was applied perpendicular to the surface of the plate under the defocused conditions. We understand that the way to resolve this problem is either to use a tilted-incidence laser beam or to suppress back reflection by forming a molten pool quickly.

Do you also use hybrid laser welding equipment?

As far as welding thick plates of high tensile strength alloy is concerned, our three-year project mission was to establish high-power laser welding processes for the production of sound full-depth welds. We have now been asked to establish full-depth hybrid laser-arc processes for welding of 25 mm thick plates of HT 980 high-tensile-strength steel within the next two years.

High-power welding: steel sections for facade construction





UNDER

*Laser Cutting:
Until now, trial and
error was the only way
to find ideal process
parameters.*

STEAM

There's no way to use the laser without ripples, spatters and vapors. But maybe there is? New research is attempting to tame the beast.

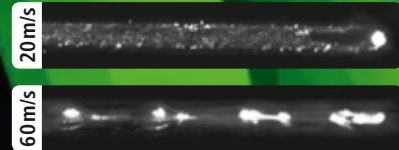
■ The simulation of a metal block. And suddenly its interior is ablaze, in all the rainbow's colors. A swirling funnel eats its way into the material. The maelstrom pulses at its edges. Droplets and clouds of vapor spew from the hole in every direction. In a thousandth of a second it is all over—at least in the simulation by Dr. Andreas Otto, physicist and lecturer for photonic technologies at the University of Erlangen. Otto is one of 30 laser researchers and users who meet annually at the snowy ski resort of Hirschegg in Kleinwalsertal, Austria. The explosive topic of this workshop: What actually happens in the metal when the laser beam's brute energy welds, cuts or marks it?

Up to now the honest answer to this question was: "We haven't a clue." The dynamics of the molten material in the "keyhole"—that's what experts call the capillaries the laser burns into the metal—are largely unknown. "Our goal is to better understand what's happening in the sauce," explained Rudolf Weber from the Institut für Strahlwerkzeuge IFSW (Institute for Laser Tools) at the University of Stuttgart, who organized the workshop. Weber knows that "half the participants go to Hirschegg because they are looking for answers to unanswered questions in laser processing." And the other half work at the IFSW to find answers to these questions. Laser users urgently need these answers. Because until now

they have been adjusting output, defocusing, feed speed and other parameters according to the principle of trial and error. This functions just fine as long as the laser beam welds or cuts steel. Yet when it comes to modern lightweight construction materials like aluminum or special types of steel like cast steel with a high percentage of carbon, the cost and effort for tests quickly become extremely high. For simulations that could shorten the test series, the findings concerning the processes and interactions inside the keyhole are not sufficient in most cases. That is why promising application ideas often do not get beyond the starting phase. This is unfortunate because joining cast material and steel opens up new geometric opportunities and saves weight. Aluminum and copper bonds, for example, are urgently needed for current-carrying components in electric and hybrid autos. That also means that parameters like spot size or laser intensity have to be reconsidered in order to be able to weld such materials.

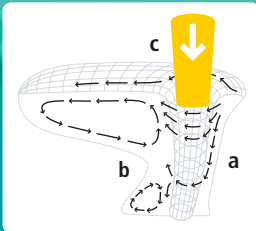
In the central lab at the Ulm-based Wieland-Werke AG, Dirk Herrmann is also working on the difficult task of welding copper. The company delivers semi-finished products like coils, tubes and profiles made of copper and copper alloys to customers who turn them into radiators, plug-in connectors → *Continue on page 14*

Plasma The plasma over the keyhole defies closer inspection. Neither temperature nor its properties — is it even really plasma? — can be precisely defined. The keyhole obviously contains free electrons. The electrons enable the formation of unwanted plasma to be automatically detected because the plasma „short-circuits“ the cutting nozzle and the workpiece. Experienced operators detect the cutting quality simply from the light emission. This represents an opportunity for a process check to be automated. But for automation to happen, the „plasma“ and its interaction with the processes in the keyhole have to be explored more closely.



Trail and crawler

A moving ship creates waves in its wake — the same thing happens in the molten bath when the beam plows through the metal. As with the ship, the faster the object moves — in this case the capillary around the beam — the higher the stern wave. The waves solidify into humps, small bumps, in rank and file. The flatter and smoother this track is, the better the weld seam. With increasing laser output, a swirling counter-current develops at the base of the capillary in the direction of motion that leads to beads and splatters. Control systems that monitor the surface can counteract this, but they see only the surface. The camera cannot identify pores that develop inside the component due to strong local deformations of the capillary.

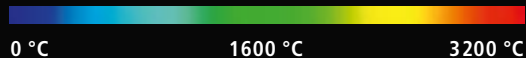


Flow conditions A complex flow system builds up around the capillary during welding and cutting. On the irradiated surface, a downflow current (a) develops that can drag additional materials down with it. In the trail, two vertical flows circulate in opposite directions (b). They swirl the molten material that is flowing around the capillary (c) horizontally while more material is added from the bottom.

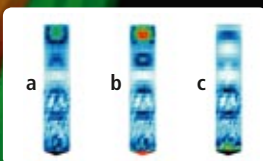
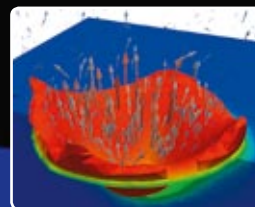
Selection of materials If the metal contains zinc, for example, the molten bath dynamics change. If there is overpressure in the steam capillary of only 0.2 bar, the presence of zinc can explosively increase the pressure several bars. The metal vapor that escapes quickly carries the molten material along with it, creating splatters. The joint project CuBriLas is currently researching the benefits of green lasers for use on heavily reflective copper. They would be able to gain an initial absorption value of 60 instead of three percent in the red metal.

IN THE EYE OF THE STORM

Macro model of an unknown world: Scientists are under pressure to identify the processes that occur in the keyhole and to understand how they interact with one another. Computers offer simulations that could shorten the amount of testing needed, while allowing new processes to be modeled. Yet there is still a long way to go. Each advance brings with it new questions

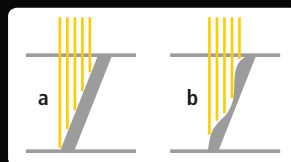


Piercing The striking laser beam generates a lake of molten metal. If the lake's surface reaches the boiling temperature, the steam bubble presses the molten material from the side and downwards. With solid-state lasers, this process is more turbulent than with CO₂ lasers. One assumption is that this could be related to the beam quality. Modern solid-state lasers, however, achieve a beam quality comparable with that of CO₂ lasers. Yet, these differences during the piercing process remain. By now, there is a lot to be said for finding the cause in the uneven absorption of the solid-state laser light. Currently, researchers are working on "quieter" piercing processes for solid-state laser cutting systems in which the beam power increases in milliseconds instead of microseconds.

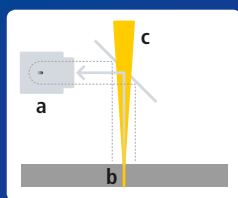


Absorption The beam of a CO₂ laser (a) is relatively evenly absorbed across the entire irradiated surface. For solid-state lasers (b), on the other hand, absorption occurs unevenly and at the entrance of the capillary. This effect so close to the surface leads to turbulences and splatters. However, current tests have shown that this effect can be considerably weakened using an azimuthal polarization of the beam (c). The energy becomes absorbed more evenly, which greatly reduces splatters.

Front of the capillary The steam pressure drives the material on the irradiated surface along an inclined plane downwards (a). In practice, the irradiated surface looks like an escalator (b): In fact, the steam pressure presses the molten material into waves. The vertical beam thus meets the material at many different angles and is absorbed accordingly. This effect is considerably more distinctive with solid-state laser beams than with CO₂-beams: with the former, the absorption is considerably more dependent on the angle. This is an essential reason why CO₂ lasers cut more evenly. A solid-state laser beam can also cut well "remotely". The steam pressure escalator is enough to drive out the molten metal from the gap even against gravity.



Weld depth The output of the working beam generally defines the working speed. Yet more beam output does not always yield more speed. With too high an output, the vertical current in the keyhole prevails and the molten material becomes partially ejected instead of swirling in the path of the base and evenly sealing the gap. The Institute for Laser Tools (IFSW) at the University of Stuttgart has been testing a control system in which a camera (a) monitors the weld-through hole (b) behind the beam (c). The system continuously measures the hole and responds to any change by adapting the laser output.



Simulations: For three days Dr. Andreas Otto's computer at the department for photonic technologies at the University of Erlangen worked to calculate the simulation of several seconds of the welding process. The monitor shows how the capillary surface pulses, how drops of

metal splatter and how steam sprays out up and out from the seam. However, the simulations currently take into account only the current dynamics and the steam pressure. In the next step, the thermodynamics in the metal should be taken into account. Only then can the simulation also forecast tensions, deformation and the probability of cracks at different parameters.



→ Continued from page 11 or solar absorbers, for example. These customers, too, would like composite materials “for customized products that combine numerous functions,” says Herrmann. Plugs, for example: It would be ideal if they were wear-resistant and hard in the front connector and yet bendable and ductile in the rear cable connector. Due to its high electrical and thermal conductivity, copper is indispensable in many applications. Yet it is precisely these properties that make the welding of copper materials so difficult. Getting the energy to the point quickly is the name of the game, according to Herrmann, in order to outmaneuver the thermal conductivity of the reddish metal.

TRUMPF is currently participating in a research project on a green laser which should manage this and apply up to 60 percent of the energy to the metal instead of only 2 percent. The benefits of the green laser for welding copper materials are currently being intensely explored in a joint project (CuBriLas) sponsored by Germany's Federal Ministry of Education and Research. In the future, we will be able to weld copper as smoothly as steel,” Herrmann asserts. Until then, however, there are still a few difficulties to overcome. The new measuring equipment from IFSW should contribute to these efforts.

5,000 new images per second Volker Rominger, an IFSW graduate student working at Trumpf, has produced high-speed videos of the capillary that show the laser beam drilling into the metal during welding. The videos demonstrate that with a slower feed speed and lower laser output, fewer ripples and splatters are produced. But slowing the laser down cannot be the solution. Rominger is looking for settings in which ripples and splatters do not occur at all. And if they do, they are specifically produced. After all, what is a disaster for one user, can be a blessing for another. In other words, those who cut sheet metal are pleased when ripples form in the molten material, because ripples act as a kind of perforation that help the laser do its job. Dr. Rudolf Weber is pragmatic: “If you cannot solve a problem, you should capitalize on it.”

Nevertheless, the problem still needs to be understood. The x-ray machine the IFSW is building should help with understanding. It delivers live images from inside the metal during welding. The institute intends to take up to 5,000 images per second — a world record. The x-ray should illuminate what is happening in the molten bath instead of seeing



Dirk Herrmann,
Wieland-Werke AG,
Ulm, Germany

“The green laser will considerably improve the welding suitability of copper materials.”

“If you cannot solve a problem, you should capitalize on it.”



Dr. Rudolf Weber, Insti-
tut für Strahlwerkzeuge
(IFSW), University of
Stuttgart, Germany

just what is on the surface — “everything else was speculation,” admits Felix Abt, who is responsible for building the machine at IFSW. The images should tell us, among other things, how much the welding depth is dependent on the laser settings. It is presumed that air bubbles will not show up in the x-ray images because they are hard to image. The machine is also only somewhat suited for materials other than steel, like copper, which is very dense for the x-ray light. The good news is there are still enough research questions that future workshops will be held in Kleinwalsertal. ■

Contact:

Universität Erlangen, Dr. Andreas Otto,
Telephone +49 9131 85-23 240, andreas.otto@ipt.uni-erlangen.de
IFSW Universität Stuttgart, Dr. Rudolf Weber,
Telephone +49 711 68 56-68 44, weber@ifsw.uni-stuttgart.de

Verena-Christina Weber
is the co-pilot of a
Boeing 737 at TUIfly.

“Responsibility begins with each individual”

“We are also responsible for the things
we have not done,” says pilot Verena-Christina Weber.
This applies both in the air and on the ground



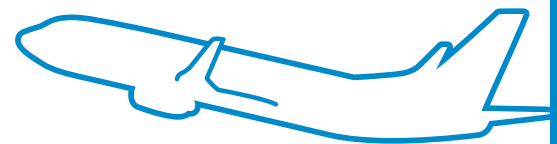
■ For every action, there is a subsequent reaction in the form of success, failure, gain or even liability. We are responsible not only for what we do, but for what we do not do. If we act irresponsibly we damage our environment or endanger it.

The word “responsible” also contains the word “response”; we have to be able to explain our action or non-action at all times. Since response is a form of communication, I look forward each day to giving a brief statement to our passengers that makes them feel that both pilots behind the cockpit door are aware of their responsibility—and consider it a positive experience. Responsibility begins with each person in the form of personal responsibility. Only those who take responsibility for themselves can be responsible for others. For me, this means that I adapt the structure of my recreational activities and sleep culture. Because as a pilot, whether a red-eye flight or an early morning flight, I have to be on time and ready to go. With the necessary licenses and medical aptitude certificates, I have proven that I am also physically able to assume responsibility for my actions. This involves the necessary simulator and test flights that ensure that I meet all of the necessary criteria. As pilots we bear a great deal of responsibility. Through our personality and education, we can also meet these responsibilities in critical situations. I believe that values, experience and knowledge form this foundation. Vision and passion are the drive, and the specific goals give me focus.

This makes it possible for pilots to make complex decisions. That’s why we are indispensable in the cockpit. Joint responsibility begins when I start my work day. First, my responsibility for other colleagues in the

cockpit as well as the cabin team, then, of course the passengers. “We on the flight deck want to wish all of you a wonderful good morning and welcome you aboard this Boeing 737-800! My name is Verena Weber and I am your pilot for today’s flight.” That is how I welcome the passengers over the PA system. This is the first time they hear my voice and realize that I am taking over responsibility for them during the flight.

The cabin crew takes care of passengers’ immediate safety and their wellbeing. Flight preparation, execution and follow-up are included in the responsibilities of the cockpit crew. This means that each team member must be able to rely on the others. Responsible action is only successful if they are all aware of their obligations. That is why I expect committed, responsible behavior from all team members. Only when there is a mutual sense of responsibility can everyone perform his or her duties—in the air and on the ground. ■



E-mail to the author:

verena.weber@vcockpit.de, Vereinigung Cockpit, www.vcockpit.de

.....



Litron President, Mark Plasse, in his "laser alley". His company captivates America's industries with precision processing.

A fine business

Mark Plasse follows the three golden rules: Do high-quality work at reasonable prices. Make the customer feel like a member of the team. And: When you have to, push knowledgeable advice.

■ The success of Litron is based on its competence as an integrator and job shop at the same time. This puts the U.S. company in a secure position, no matter how challenging the environment gets. The strategy of this privately-held laser systems and services provider is remarkably straightforward: offer high-quality precision

work at a competitive price with a relatively quick turnaround, usually five to seven days for contract work and three months or less for system work; and foster relationships in which each customer feels like a member of the team.

Since its startup in 1997, Litron has become the leading U.S. supplier of laser sealing services

for the aerospace and medical industries. In addition to manufacturing medical devices and high-reliability (high reliability) electronic housings for clients such as Boston Scientific, St. Jude Medical, Northrop Grumman, Raytheon and Lockheed, the company also does work in the defense, industrial and electronic markets and has begun to

build an international client base with customers in Ireland and Puerto Rico. Today Litron is a full contract manufacturer running production every day of the week.

Most of Litron's work involves very small devices and extremely small weld areas on parts that are often "mission critical," as in the case of electronic components for satellites, fighter jets or medical implants such as pacemakers. These parts can mean the difference between life or death and therefore demand a high level of precision, accuracy and reliability — perfectly suited for laser technology.

In 13 years of operation, the company has purchased about 50 TRUMPF lasers. Most have ended up in precision manufacturing systems designed for customers, but twelve lasers — for cutting, welding and marking — Litron keeps busy in its own production area. In the so called "laser alley" eight different TRUMPF laser types and generations are on display — lined up along a corridor.

Company founders, Ron Lalli and Mark Plasse, had used a variety of lasers over their combined 60 years manufacturing and laser experience. However, within a year of observing the results and user-friendliness of TRUMPF lasers, Litron sold all of its other lasers, replaced them with TRUMPF lasers, and instituted a company mandate to only use TRUMPF lasers, both in the shop and the systems it builds.

"Our systems are used to manufacture expensive and intricate parts. We need to feel confident that the systems we build will work flawlessly and our customers will be satisfied. TRUMPF gives us that confidence," says Litron President Mark Plasse.

His insistence on TRUMPF lasers has cost him a client once or twice, Plasse admits, but it doesn't bother him. "We are not concerned with getting every sale; we are concerned with getting every sale right," he says, adding that since Litron laser systems are built with top of the line equipment, maintenance is significantly less than systems with inferior components. And successful systems ensure more successful business relationships.

"We are not looking just to do a weld or build a system; we want to create long-term customer

relationships," says Plasse. Company employees work hard to create relationships in which clients can come to them with questions and they're comfortable offering advice. Litron customers frequently praise not only employees' expertise, but also their ability to help them to understand laser welding and other laser processes.

Offering both laser systems and services creates a harmonious balance that not only en-

hances Litron's relationship with clients, but also its bottom line. System work can wax and wane depending on the environment and customer needs, but steady contract work with jobs running throughout the year helps fill any gaps. And most of Litron's job shop customers are also system customers, and vice versa. About 75 percent of system clients are still job shop customers.

System customers often turn to Litron to manufacture parts until their systems are up and running, or after they are, to handle prototype work and part testing and avoid holding up production. In some cases, particularly with medical device prototypes, Litron will handle the contract work for the life of the product. In other cases, such as hermetic laser sealing in the clean room, clients foresee building a system and bringing the process in-house once testing is complete and volumes are higher.

Litron's class 10,000 clean room builds another mutually beneficial relationship with customers. The 3,000 square-foot clean room with two glove box units for hermetic laser sealing was initially built to manufacture hi-rel electronic

packaging. Designed to meet the needs of aerospace clients, Litron's clean room also offered other new business opportunities. "We realized the medical industry could also benefit from the setup," Plasse explains, "and that's where we've seen a lot of growth lately."

Future Litron initiatives continue to be driven by, and beneficial to, both the business and its customers. In addition to implementing more

"Our products are literally of vital importance for our users. This requires extreme precision and reliability"

lean manufacturing projects and continuing to train employees, the company has begun the process of getting ISO 13485 certified. "Certification will help us better serve our customers — particularly our growing client base in the medical device market — and give them the assurance we're meeting all of the standards they require," says Plasse. "It's a necessity, but also something we feel will make us that much better at what we do." ■

Contact:

Litron Inc., Mark Plasse, Telephone +1 413 789 0700,
sales@litron.com, www.litron.com



Litron specializes in the machining and laser sealing of hi-rel hermetic packages and implantable medical devices.

Two point five

In 2.5 seconds to 100 km/h: Behind acceleration legends like the Bugatti Veyron is often hidden a secret hero, the dual clutch from BorgWarner

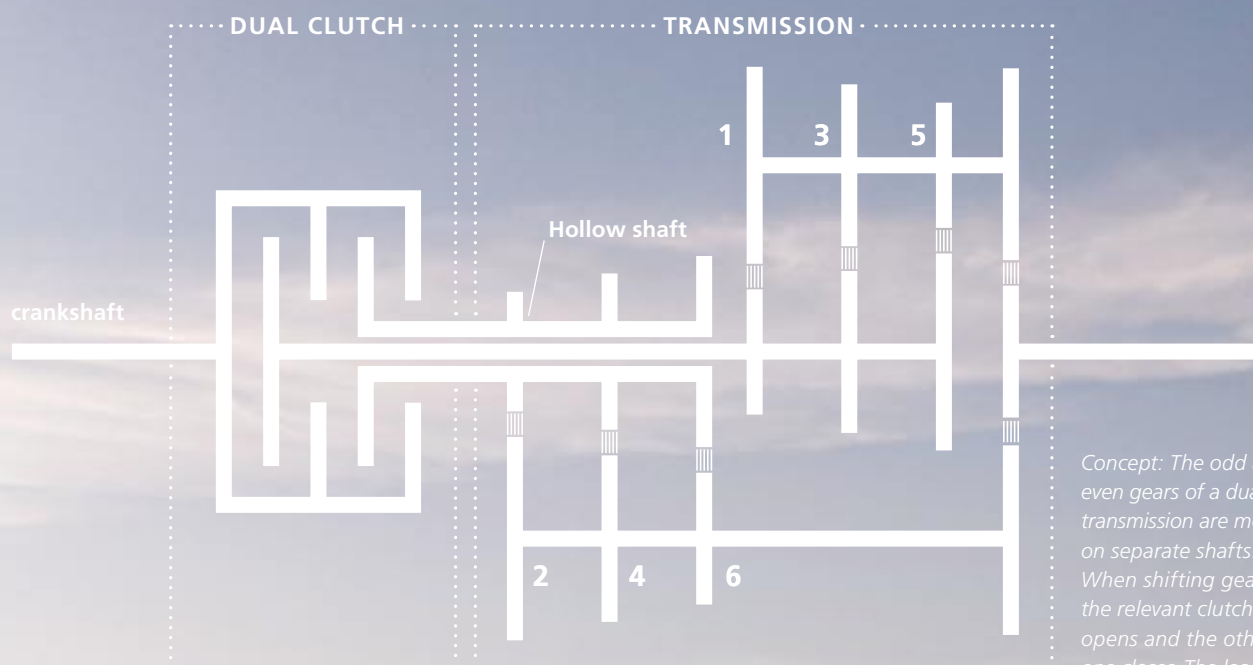
■ A phenomenal 1001 horsepower and 1,250 Nm of torque propel the Bugatti Veyron from zero to 407 km/h — without a shifting point the driver can even feel. Only the tachometer needle and the regular revving of the engine mark the seven shifting points. Yes, this superb sports car can apply the power of its sixteen cylinders, running in a W block, without interruption — even while shifting gears. This is thanks to a dual clutch developed by BorgWarner Drivetrain Systems which has supplied the dual clutch units, about the size of a dinner plate, in series production since 2003. The Volkswagen Corporation was the pioneer, and it was followed by renowned gearbox builders Getrag and Ricardo. Today seven of ten wet dual clutches on the world's transmission market are built by BorgWarner.

As far back as the 1980s Porsche sought to turn the dream of every transmission engineer into reality: joining the agility and driving pleasure of a stick shift with the convenience of a conventional automatic transmission. But technical hurdles kept the concept from going into volume production. For years, the idea of a dual clutch transmission languished in transmission engineers' desk drawers. That fairytale slumber continued into the late 1990s, when the idea was revived by VW. The 2003 debut was in the Golf R32 and the Audi TT. The partner of choice was BorgWarner. "One of our core competences is in developing and producing wet friction plates and separator plates, the heart of each and every clutch. The design and arrangement of these components determine the properties of the clutch — such as friction coefficient, drag torque losses and thermal flows. What's more, we already have wide-ranging experience with wet friction plates in automatic transmissions," explains Ludwig Moch, who is responsible for planning the production facilities at BorgWarner and who helped engineer the manufacturing line for the dual clutches, set up in the Thur-

ingian town of Arnstadt. Philip Meidt, market analyst at BorgWarner, adds: "When VW inquired about friction plates for a wet dual clutch, we went ahead and submitted a proposal for the entire assembly. To comply with the VW specifications we had to pack our knowledge into one complete module. To do this, our engineers had to strike out into unexplored territory."

Feasible — but also affordable? One central challenge, according to Moch, was cost: "It quickly became clear that we were going to have to use both stamping and machining procedures when manufacturing the clutch. And, the resulting parts could be joined most economically with welding." The developers then employed comparative A/B testing to select the most suitable welding procedure. Friction welding failed due to problems with dimensions. Axial tolerances could not be maintained with that process and the great amount of energy used in electrode type welding caused distortion. Finally only two low-warp processes were left in the running: electron beam welding and laser beam welding. "The electron beam process takes place in a vacuum. This means that every component would have to be placed in a chamber which is then evacuated prior to welding. This option would be too time-consuming and labor-intensive for our purposes and would have slowed down the production line considerably," Moch explains.

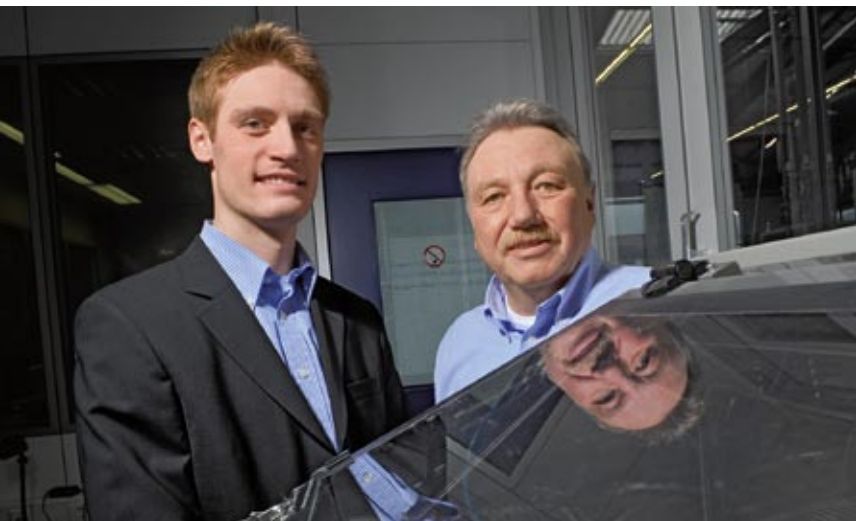
The first fledgling steps were taken by today's dual clutch specialists at the end of 2001 with the support of an independent, specialized service company. In a series of tests, the developers identified the ideal material choice. Thus the sheet metal parts for the rotating housing had to accept shaping and punching and withstand extreme load at the high end of the rotation speed range. The job then was to weld this to the hub. Here the external services company had employed a TRUMPF laser machine from



Concept: The odd and even gears of a dual clutch transmission are mounted on separate shafts. When shifting gears, the relevant clutch opens and the other one closes. The load simply "jumps over."

Below: The Bugatti Veyron is a particularly nice wrap for the dual clutch.





Dual clutch success concept: market analyst Philip Meidt and Ludwig Moch, responsible for planning the production facilities, expect an increase in production.

“When VW requested the friction elements, we offered the entire clutch”

Philip Meidt

“Only laser seams meet our technical and efficiency requirements“

Ludwig Moch

the outset. “Welding temperable steel is made difficult by its carbon content. That is why we decided on a steel that lends itself to welding. Then we harden the steel later, after carbonization,” Moch explains. The trick: More material was left in place along the components’ edges and this excess was turned down again after carbonization and hardening. “Thus two materials with excellent welding properties are married here,” the engineer added.

A glance at the million After BorgWarner had successfully welded the initial prototypes using a TRUMPF laser, it became quite clear that the assembly line at the newly built plant in Arnstadt would have to be outfitted with laser sources from Ditzingen. “The fact that our equipment builders also had experience with integrating TRUMPF lasers was another important consideration in the decision-making process. In addition, we benefited significantly from the laser manufacturer’s technical expertise in regards to the specific application.”

Today six CO₂ laser beam sources are at work in eleven welding positions. Five of those sources serve two stations each, alternately.

This means that while the laser is welding at one workstation, a completed part is being removed from the other station and new semi-finished components inserted. Market specialist, Meidt believes that these capacities will not be sufficient for very long. “We expect that by 2012 last year’s production figure of about 500,000 units will have more than doubled. The dual clutch has long since migrated from the sports car segment to the mass market. More and more manufacturers are offering dual clutch transmissions, in every class of vehicle.” In order to meet the growing demand in China, BorgWarner has entered into a joint venture with the alliance of Chinese carmakers, the China Automobile Development United Investment (CDUI). At present the company is setting up production in the China so that it can supply the Asian market from a local source. ■

Contact: BorgWarner Drivetrain Systems,
Philip Meidt, Telephone +49 6202 601-406, pmeidt@borgwarner.com,
www.borgwarner.com
.....

OVERVIEW OF BORGWARNER

BorgWarner ranks among the leading global automotive suppliers. The company provides its customers with key technologies for engines and drivetrains. With a workforce of 12,500 working at 59 locations in 18 countries, the company recorded sales figures of US\$ 4.0 billion in 2009. The company works with all the major brand-

name automotive manufacturers. BorgWarner Drivetrain Systems has five locations in Europe. Its German technology center, based in Ketsch, is the leading force in the development of the dual clutch while the Arnstadt facility handles final clutch assembly.



Cutaway model of a dual clutch: Two disk packages on two shafts.

It costs about 200 million Euro to send a news satellite into space. So it has to be reliable for at least 15 years



A Long Recall Route

When transposed numbers can cost millions, a sharp eye is required

■ “There is no such thing as a recall in space,” explains Eberhard Möss, group manager of the Department for Hybrids, Assembly and Packaging at Tesat-Spacecom, with a smile. With his team of technicians and engineers, he makes sure there are no break-downs. In Backnang near Stuttgart, the company produces telecommunication payloads for satellites, says Möss, adding “this means anything that can be found between the antennas.” This includes devices called Microwave Hy-

brid Integrated Circuits. These MHIC modules measure exactly 9.8 x 8.3 millimeters. The small housings are made out of ceramics and metal whose insides contain sensitive semiconductors. The modules are installed in the satellites and amplify, mix and align the emission signals. “We insert, connect, measure and test. This is the only way we can guarantee a service life of 15 years for our products in space,” he says. Thirty-two work steps are necessary — and the modules →

do not begin their journey into space until they have passed a service life test of more than 270 hours. There, they ensure proper reception. The time and expense are enormous, but necessary: A defective component can cost millions — therefore it is important to avoid errors. If something happens, you have to know what has caused the errors. “Traceability is an important aspect in space travel,” emphasizes Möss. “We have to account for the entire production chain.” The manufacturer must meet strict criteria to obtain certi-

cation by the European Space Agency (ESA). As of late, a TruMark Station 5000 equipped with a green TruMark 6230 marking laser, an optical camera and an external PC equipped with Cognex image processing software helps Tesat to do so. As a central unit, the computer activates the station, records camera images and data, and starts the corresponding program. A semi-permeable mirror is attached in the optical path of the laser through which the camera takes a picture of the workpiece. The Stuttgart-based specialists for optical testing systems from AIT Göhner GmbH integrate the necessary hardware and software. Production is done in a clean room, which has its own special requirements: At Tesat, water, not air cools the laser so that the airflow in the clean room is not disrupted — this is the only way the machine can meet production conditions.

There are more than enough duties for the new laser system at Tesat, marking is only one of them. “The marking laser enables us to remove gold or other metals as well as impurities,” says Möss of the new application. The laser removes a gold layer of a few nanometers in the form of a line from the housing cover — even on vaulted components. Möss does not want to say any more about that. “Everything is strictly confidential,” he emphasises. The applications have one thing in common: They require a precise beam guidance system. When it comes to positioning, the PC directs the mirror above the laser and analyzes the position of the cover on the three corners using the camera. From this, it calculates the position of the center of gravity and the angle. Once the coordinates are defined, the removal program starts. The laser system uses the same process when cleaning the surface. Cleaning is required if the surface area of the circuits gets soiled or dirty. The laser removes the nanometers or few micrometers of film down to even the smallest surfaces. Removal must be done accurately; adjacent areas may not be damaged. “That is why we decided in favor of a laser with a wavelength of 532

nanometers. It has enough power to do removal work, but can also do sophisticated inscriptions,” adds Möss.

For Tesat, the main advantage offered by the new machine configuration is its process dependability. A major example: a four-digit serial number should be readable from the housing rim, so it can then be transferred to the cover. “Until now, the operator had to use a magnifying glass to read the inscribed number on the 6.1 mm-wide rim and write it down by hand,” says Möss. “This method does entail the risk of transfer errors.” Today, the camera records the numbers automatically. The modules are placed on a workpiece carrier, which is called a “waffle pack,” and attached to a diagonal device on the work surface. On the Z axis, the mirrors scan the modules gradually, the camera records the numbers and transfers them to a database. The operator has to intervene only if the camera cannot read one of the numbers. Then the operator reads the number on the camera image and enters it into the editing mask.

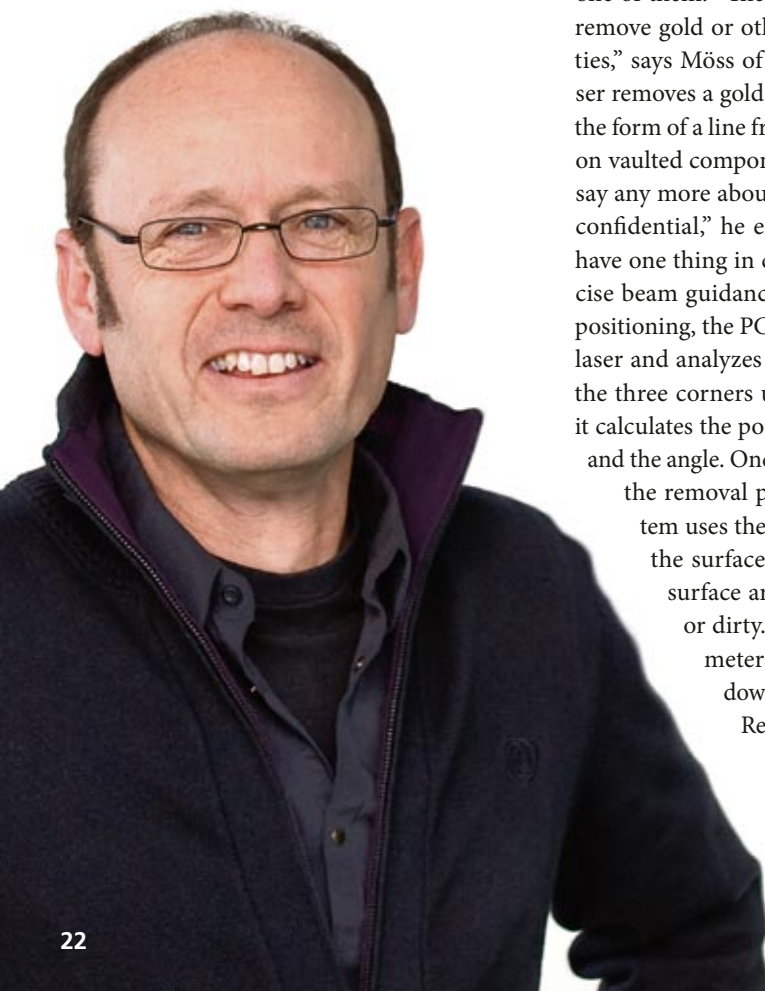
Once all the numbers are recorded, the laser marks the small housing with clear lettering and a data matrix code. This has the advantage that up to 50 characters can be encoded in the narrowest of spaces. “Even if larger sections get lost, it can always still be read,” says Möss. This data is also used to automatically configure the measurement systems — the operator simply inserts the workpiece and the system reads the necessary data from the data matrix code. The task could also obviously be handled by a robot, but it would hardly be used to capacity: “About 20 satellites are built annually worldwide,” says Möss. This limits the production volume at Tesat to about 10,000 to 12,000 modules per year. Therefore, speed is not decisive — it’s quality that really counts. ■

Contact:
Tesat-Spacecom GmbH & Co. KG ,
Eberhard Möss, Telephone, +49 7191 9 30-1313,
eberhard.moess@tesat.de, www.tesat.de

AIT Göhner GmbH,
Michael Göhner, Telephone +49 711 238 53-10,
michael.goehner@aitgoehner.de, www.aitgoehner.de
.....

“There is no such thing as a recall action in space”

Eberhard Möss, Tesat-Spacecom





Michael Göhner,
AIT Göhner GmbH

“WITH HIGH QUANTITIES, THE SYSTEMS DO THE MATH”

What size does an enterprise have to be, so that optical test systems pay off?

For high quantities, the use of such systems pays off very quickly, regardless of whether it is in a large or small company. In smaller amounts, optic test systems make sense if the quality assurance is highly weighted or a high positioning accuracy is of importance.

How can optical test systems be used in laser processing?

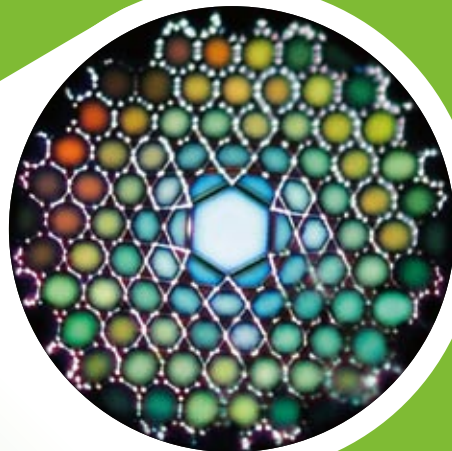
The systems are used for marking, but also for cutting, welding or structuring — they check the alignment and guidance of the laser unit. After processing, the system checks whether the result is correct, especially when it comes to data matrix codes. This ensures the traceability in subsequent processes.

Are cameras always easy to integrate into laser systems?

It is comparatively easy to integrate cameras into TRUMPF laser systems. One option is to integrate the camera into the beam path of the laser. This only works if the image cross-section corresponds to what is needed and the lighting meets the requirements of the application. If the systems are reliably designed, no problems should be expected. Above all, the camera must be protected so that the laser does not process it.

Fully automated: Step-by-step, the laser mirrors scan the modules, the camera records the numbers on the housing, and the computer control transfers them directly into a database.

Cross-section of a photonic crystal fiber: The structure is made up of tiny, parallel hollow fibers that are clearly visible.



A new type of hollow fiber holds great promise: It guides far more power than today's fibers and would even be able to guide the light of industrial CO₂ lasers. The trick: the light moves between the glass instead of in the glass

Photonic crystal fiber (PCF) is a novel type of micro/nano structured light-guide consisting of a thread of glass with a regular lattice of tiny hollow channels running along its length. These channels act as strong scatterers, allowing light to be trapped within a central core, which can be hollow or solid glass. Hollow-core PCF is particularly interesting, since it solves a long-standing problem in optical physics: how to increase the depth of focus of a lens without increasing the diameter of the focal spot. To achieve this, one must overcome a fundamental property of empty space—the diffraction (or spreading out) of a beam of light as it propagates. A hollow glass capillary cannot confine light since at optical frequencies no glass exists that has a refractive index less than unity—the condition needed for confinement by total internal reflection in a hollow-core. Although a thin film mirror could in principle be formed on the surface of a hollow-core, the super-high reflectivity values needed for ultra-low loss make this unrealistic, especially in small single-mode cores, when the ratio of circumference-to-area becomes large. In contrast, hollow-core PCF, which guides by the photonic band gap effect, offers for the first time a workable solution to this problem, providing in the best case a loss of 1 dB/km at 1550 nm, i.e., only half the light is lost after 3 km of propagation. In a 1 km length of such a fiber the light bounces off the mirrors an astonishing 3 million times before it reaches the end. When

we consider that the core-surround has a curved surface and that a new mirror is used at every bounce, it is clear that photonic band-gap mirrors are quite remarkably perfect.

The fascinating thing is that one can sustain, over km-long path lengths, a perfectly controlled single-mode transverse intensity profile and better than 99 percent overlap between light and a low index material (gas or liquid) filling the core. The ability to guide light in an empty core, with less than one percent of the light travelling in the glass, also means that much higher power can be transmitted, which could be very important in laser machining applications. In addition, the small light-glass overlap means that higher material losses, for example at 10 μm wavelength, can be tolerated. Given the correct investment and an excellent R&D team, it seems likely that ultra-low loss high power hollow-core PCF could be developed for this important wavelength, using infrared glasses.

A challenge in the fields of microfluidics and optical tweezers is how to achieve optimum control of the viscous and radiation forces acting on a single particle or cell, while monitoring its optical and chemical properties within a fluid environment. Inside the hollow-core of a PCF guiding laser light, a dielectric particle can be trapped laterally in the bright center of the guided mode, while experiencing a constant propulsive force along the fiber axis. In recent work

by Prof. Philip Russell

Mastering the Flow

we have shown that, if the core is filled with water, a micron-sized particle can be transversely trapped, held stably against a fluidic counter-flow using radiation pressure, and moved to and fro (over 10s of cm) by ramping the laser power up and down. Accurate studies of the drag forces in a narrow fluid-filled micro-channel become possible, because the particle is located in the center of the single guided optical mode, resulting in highly reproducible radiation forces. The mechanical flexibility of hollow-core PCF offers the unique possibility of guiding dielectric particles along a reconfigurable curved path.

Liquid-filled hollow-core PCF could be used as a flexible opto-fluidic interconnect for transporting particles or cells from one microfluidic circuit to another. In biomedical research, minute quantities of chemicals (perhaps photo-activated through the transparent fiber cladding) could be applied to a cell held stationary against a fluidic counterflow, allowing the effectiveness of drugs to be studied at the single cell level. Since the refractive index of cancer cells differs from that of healthy ones, it may be possible to distinguish them by their different speeds through the liquid.

Non-linear interaction between light and matter increase with the intensity of the light, giving rise to many striking phenomena such as the generation of new laser frequencies (or colors). Gas-filled hollow-core PCF is ideal for

studying such nonlinear interactions in gases. The very low optical attenuation allows almost unlimited path lengths and the single-mode nature of the guidance maintains a constant gas-light overlap. An example is backward stimulated Raman scattering in hydrogen gas.

Molecules are in a constant state of random agitation at ambient temperature. When a laser “pump” beam passes through, they act as nano-scale phase modulators, creating optical sidebands through frequency modulation in a process known as Raman scattering. Above a certain threshold pump power, very high conversion efficiency into the lower-frequency “Stokes” sideband occurs. The effect is known as stimulated Raman scattering (SRS) and is frequently used to convert the wavelength of laser light.

In recent work we have studied transient effects in backward SRS over long interaction lengths. Prior to the availability of hollow-core PCF, detailed experimental studies of such effects were very difficult if not impossible. In the focused beam geometry, the interaction length is limited by beam diffraction, so that to observe SRS at short time-scales one needed to pump at multi-GW powers, leading to a beam self-focusing, self-phase modulation, and the generation of additional

SRS components. In hollow-core PCF such deleterious competing linear and nonlinear effects are avoided. Moreover, by designing the fiber to have a narrow guidance band, it is possible to suppress higher order Raman sidebands. In our experiment, pump pulses were launched into a hydrogen filled PCF while a weak Stokes pulse was launched from the other end. As it passes through the counter-propagating pump pulse, the backward Stokes pulse experiences continuous gain, reaching a peak power far in excess of the pump power. At the same time its profile steepens and its temporal duration falls well below the phase relaxation time of the molecular oscillations.

Photonic crystal fibers represent a highly versatile new generation of flexible light guide, offering unique opportunities for enhancing light-matter interactions, with applications in many fields such as biomedical, chemical and environmental sensing, gas-based nonlinear optics, generation of broadband white-light supercontinua and high power laser light delivery. ■



*In the 90's, **Prof. Philip Russell** came up with the idea of and developed the process for manufacturing photonic crystal fibers. Now he is the director of the Max Planck Institute for the Physics of Light in Erlangen*

E-mail to the author: philip.russell@mpl.mpg.de

As director of education,
Gus Anibarro heads up the
training program at the
Laser Institute of America



Lasers are wonderful tools, explains
safety expert Gus Anibarro — provided
that you know how to use them correctly

*“Wear your
goggles!”*

W

When did you first develop a passion for lasers?

The first time I saw a laser, aside from in the movies and television, was in a rapid prototyping lab at the University of Central Florida. We used a laser for rapid prototyping to create a solid model. My assignment was to design and create a cup using the laser and I immediately saw its advantages. At the same lab, another professor used the rapid prototyping machine to create an exact replica of a patient's skull from an MRI (Magnetic Resonance Imaging). This 3D model was used to help a neurosurgeon identify the location of a brain tumor before performing surgery. I was both awed and fascinated by the laser technology.

What attracted you to the Laser Institute of America?

One of the things I like best about the LIA is the opportunity it affords me to interact with highly technical people and very technical applications in many different fields—industrial, research, military, medical. I'm still fascinated that one tool, a beam of light, has so many applications. Secondly, through the training we do, we help keep people safe. We help our customers implement safety programs that keep their employees safe, and that's a good thing. Providing laser safety education fulfills part of LIA's mission.

What achievement are you most proud of?

I'm particularly proud of the laser safety officer courses—both online and in-person—that I created. As a result of those courses, there are 500 people around the globe that help ensure a safer working environment for people using laser technology.

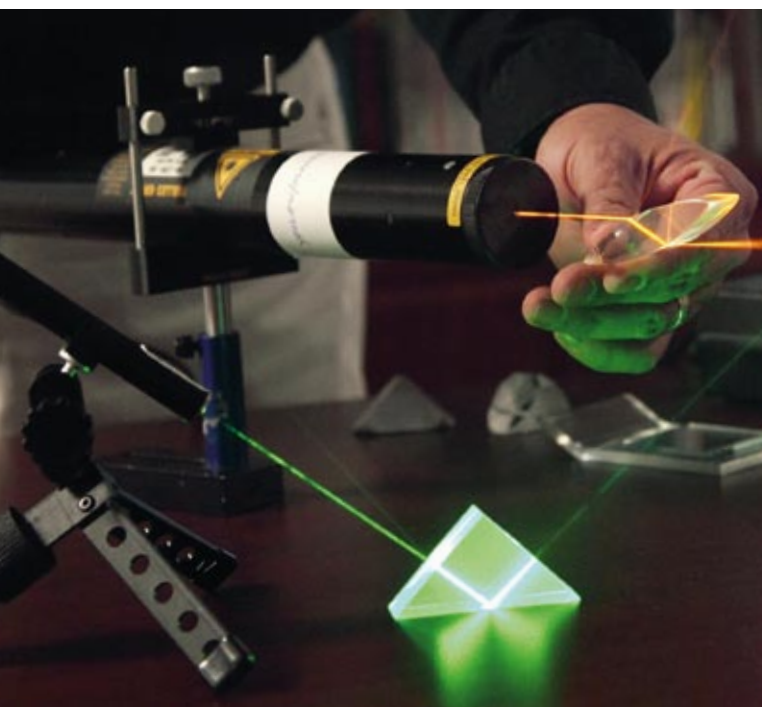
What inspires you to do your job so well?

I really enjoy training. I enjoy talking to people and discussing how to stay safe. I don't want people to get hurt. Lasers are beautiful tools, but can be dangerous too. Safe use of lasers is good for everybody. And as for me, I'm glad to contribute to that safety.

Are there any common misconceptions people have about lasers?

From time to time when I say that nobody's ever been killed by a laser beam, I see surprised faces. As far as I know, there hasn't been a documented case of someone killed directly by a laser beam in any setting. Statistically, most laser-related deaths result from

PEOPLE



LIFE Gus Anibarro has earned two degrees: a Bachelor of Science in mechanical engineering and a Bachelor of Arts in psychology, equipping him for the technical and human aspects of his career.

LASER While studying at University of Central Florida, Anibarro was awed by a laser employed to create an exact model of a human skull that pinpointed a tumor's location before neurosurgery.

ACHIEVEMENT Designed by Anibarro, LIA laser safety officer courses—both online and in-person—have produced more than 500 professionals around the globe working to maintain the highest standard of laser safety.

exposure to non-beam hazards, such as electrocution. Another dangerously widespread misconception is: “I know where the beam is, so I don’t need eye protection.” I’ve heard that before.

Name one thing every laser operator can do to make his/her job safer.

Wear your goggles! Not wearing eye protection is the most common safety mistake. The majority of laser-related injuries happen to the eye. Many eye injuries could have been avoided if the person was wearing eye protection of the right optical density and specific to the wavelength(s) being used. Enclosing the laser beam with protective equipment is another way to improve safety.

Sometimes safety glasses are required in areas that seem safe.

What hidden dangers require safety glasses?

Reflective surfaces. Frequently I’ll go into an area like a research lab and I’ll see, for example, a computer monitor sitting on the optical table. The researchers may not think the monitor is a reflective hazard, but it is. Shiny equipment or shelving can also pose a risk. One injury occurred when a researcher was working in a laboratory and not wearing eye protection. He looked away for a second, turned back, and looked directly into a beam reflected by a slightly turned mirror. The beam ruptured the back of his retina. His vision recovered eventually, but it isn’t what it was before the accident. Or, if the laser is on continuously, you could walk into the beam path because you don’t see the beam—that’s happened. Sometimes in an industrial setting, there aren’t signs indicating there’s a laser in use. And I’ve seen lasers being serviced that don’t have the temporary control areas they should. Often it’s the most obvious things that people miss. It all boils down to the need to have an appointed laser safety officer.

“The majority of injuries caused by using the laser are to the eyes”

Why is laser safety so much more important than it’s been in the past?

Part of it, I think, is because of regulations. I know companies want safe facilities and want their employees to work safely, but the driving force behind that is government regulation by the U.S. Occupational Safety and Health Administration and similar regulatory agencies around the world.

What positive advances are you seeing in laser safety?

Protective devices are getting better. You can interlock doors with lasers’ electrical systems, so if somebody opens a door it’ll shut off the laser. This helps to prevent accidents like the one, where a fellow took a piece of tape and put it onto the head of the laser. He didn’t know the beam was on and

it cut a nice clean hole through his finger. Another advancement is better eye protection. If you work in a research lab with multi-wavelength lasers, you can now find eye protection that covers more than one wavelength.

How are laser manufacturers working with the LIA to make equipment safer for the growing number of laser users?

Through our laser safety courses, laser engineers are learning about hazards and safety standards before they design a new piece of equipment. This way, they can design engineering controls (the preferred method to limit exposure to the laser beam) into the laser system and make the laser safety officer's job a little bit easier too. We've seen a couple of manufacturers already make such safety enhancements in their laser system enclosures.

“Frequently, people forget the things that are basically very obvious. That is why safety officers are so important”

In what way are international safety standards important?

International laser safety standards are important because it gives every user and manufacturer one set of safety standards to follow. For example, if you're manufacturing a laser in Germany for sale to the United States and you comply with the International Electro-technical Commission (IEC) standard, you have now met the U.S. code of federal regulations for lasers. The same is true if you make a laser for sale in Europe.

How do professionals working with lasers go about becoming certified?

Interested professionals should apply to the Board of Laser Safety. The Board reviews the applications and assesses whether someone is qualified to sit through the examination or not. If qualified, the person sits for the exam, and if he/she passes, the person can wear the title of certified laser safety officer.

What are the benefits of certification?

Certification certainly leads to recognition. In some instances I've heard it increases the professional's pay. Most of it is the satisfaction of knowing you've met a standard established by the laser community. It's an elite, but growing, group. There are 300 to 400 certified laser safety officers in both medical and non-medical fields. ■

Contact:

Laser Institute of America, Gus Anibarro, Telephone +1 407 380 1553,
gus@laserinstitute.org, www.laserinstitute.org



FOR THE SAKE OF SAFETY

The Laser Institute of America (LIA) has made the development and safe use of laser technology its mission for 40 years. Co-founded by laser pioneers like Dr. Theodore H. Maimann, the organization today is mainly dedicated to the education and advanced training of those working in the laser field. Seminars on laser safety are also part of the organization's range of services as well as the training of laser safety officers and hosting international congresses. LIA members include researchers, manufacturers, integrators and users—all who want to work together to make laser applications safer.



More light, more power

Crystalline solar cells make up 80 percent of the market. The laser does not play a big role in their production “yet” says Jan-Frederik Nekarda from Fraunhofer ISE

Jan-Frederik Nekarda does research on laser applications for manufacturing crystalline solar cells at the Fraunhofer ISE.

■ Laser applications are nowadays already “state of the art” when it comes to producing thin layer solar cells. However, this type only makes up 20 percent of solar cell production. Eighty percent are crystalline cells, which are produced without the laser playing much of a role. Of these, almost 100 percent are produced using a standard process whose efficiency potential is almost exhausted. However, the growing competition and countries’ new regulations such as the German Renewable Energy Act, are forcing manufacturers to lower costs and implement more productive processes and more efficient cell concepts.

Laser processes are being used in almost all currently researched process sequences that are conceivable for industrial implementation. The highest cell efficiency factors can only be achieved with more accurate and sophisticated surface structures. The laser is perfectly suited for this — and is inexpensive compared to other processes.

The new approaches can be divided into three groups: The first group optimizes the front end of the solar cells. Its purpose is to increase the light yield: Thinner contact fingers mean less shadowing or coverage as well as the use of new selective emitters, which also collect short-wave light. Thinner contact fingers can be generated by the laser removing the dielectric layers and then subsequently electro-plating these lines. Selective emitters are produced by the laser that melts the dopant in a targeted way onto the surface into silicon. Both processes are currently moving from the lab into the pilot phase.

The second group’s goal is to reduce the energy losses when diverting the power to the back-end. In using these cell concepts, instead of full-surface contacting which has been standard so far, an isolating dielectric passivation is applied. The electrical

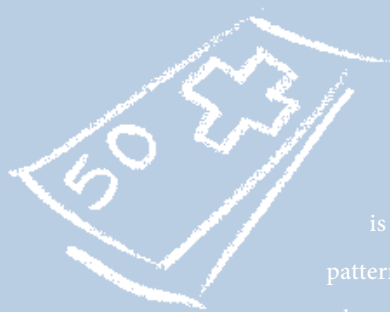
energy obtained is diverted through local contacting, for which there are two methods of producing it. In the first, the passivation layer can be removed prior to the metallization process. In the second method, it is possible to ablate the metal layer into the silicon locally through passivation. Both methods are addressed in the pilot study.

The third group attempts to do without metalization and thereby tries to avoid shadowing the front side partially (metal wrap-through) or entirely (emitter wrap-through) to increase efficiency. Instead of gathering the energy produced on the front end with the lead fingers, these cells guide it through the so-called VIAS — micro holes drilled through the chip using a laser — directly on the back-end.

The integration of this process into the production of crystalline solar cells is a matter of time. When it comes to drilling the VIAS and structuring the back-end there are no true industrial alternatives to lasers. The processes have already proven their suitability in the lab. The question of when these processes become standard will primarily depend on how fast the developed processes can be scaled to the industrial requirements, how fast and how far the standard solar cells can be improved and how strongly companies will be forced to take the economic risk that always accompanies innovation. The decreasing feed-in rates and increasing global competitive pressure could help laser technology in crystalline photovoltaics take off. ■

E-mail to the author:
jan.nekarda@ise.fraunhofer.de
.....





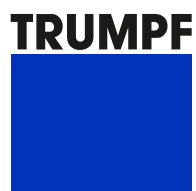
Where's the laser?

IN YOUR WALLET: There have been counterfeiters since money was first used, but several security features on bank notes are making life difficult for them. An example is the the so-called microperf security element with “tilt effect”. This type of banknote has two patterns made up of microscopic, unequally perforated holes that can only be produced using a laser on a special machine. On the Swiss franc banknote, you will find a number of micro-perforated holes under the denomination. If you hold the note vertically against a bright light, you can see the Swiss cross. If you tilt the note away from you, the cross disappears and the nominal value of the banknote appears. It's sophisticated technology that counterfeiters have not yet mastered.

In one *quadrillionth* of a second ...



... from 0 to 100 km/h: Bombing action accelerates at lightning speed with a femto-second laser helium atom. The intensive electro-magnetic pulse "strikes against" the electrons, which simply drag the atomic core along with it. In the future, this is how laser light could position atoms precisely on a surface or push them systematically into a reaction.



Laser Community

LASER COMMUNITY IS THE TRUMPF MAGAZINE FOR USERS.
SUBSCRIBE NOW: WWW.TRUMPF.COM/LASER-COMMUNITY