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Laser Community

THE LASER MAGAZINE FROM TRUMPF

WWW.TRUMPF.COM

You are expecting a revolution.
But what will it look like?

CFRP!

So tiny

Martin Langkamp and Henri Paus love workpieces the size of dust motes

So quiet

Twelve thin laser seams give drivers peace

WORTHY IDEA

HOW MICHAEL YAN OPTIMIZES PRODUCTION WITH LASERS → Page 26

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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

01:2011

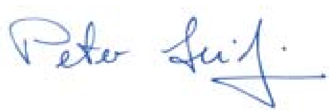
IMPRINT

Hansbauer / LCC TU München

More often than not, it pays to swim against the current. Pioneering inventions and cutting-edge innovation emerge when gifted engineers give free rein to their imagination and break from traditional ways of looking at things. This is especially true on a small scale. Engineers at the German Freudenberg Gruppe had the seemingly absurd idea of fabricating a simple part using a high-tech laser tool. This "idea" was judged innovative enough to win the German Award for Innovation. Instead of punching and deep-drawing simmerrings millions of times, the laser is now used to cut and weld them. After that, they are bent. This process uses 85 percent less material. The new machine developed for this process has enabled Freudenberg to reduce its annual steel consumption by 1,800 tons and cut climate-harming CO_2 emissions by 2,700 tons. In collaboration with the Otto Bihler Maschinenfabrik, our application engineers have integrated a TruFlow high-performance laser into the new machine. In fact, the laser was a key element for the solution, which the jury called a "shining example of intelligent resource efficiency."

Thoughts are free!

But we have to think outside the box on a large scale, too. The intense drive to optimize weight, especially in the automotive industry, has spurred a rise in the use of composite materials. The field is still wide open and new methods and processes are currently in the experimental stages, but we may be on the threshold of a revolution. In addition to sheet metal and high-strength steel, materials like carbon, ceramics, nylon and boron as well as natural fibers are playing an increasingly important role. Completely new production concepts have to be developed for these composite materials with their enormous stiffness, stability and resistance. As we work toward a robust process for mass production in the coming decades, we have to scrutinize the entire process chain and challenge proven engineering designs. In this new world, all hopes are pinned on the laser, especially because traditional processes will quickly reach their limits with the new materials. We can make the best use of this opportunity in laser technology if we give free rein to our imagination in the application labs. Whether on a small or large scale, we will come up with new ideas on a sustained basis only if we give ourselves the freedom to think outside the box and from different perspectives. The laser industry has the potential to achieve this — with laser light as a tool in hand, nothing can stop clever minds from finding new and creative applications for it.



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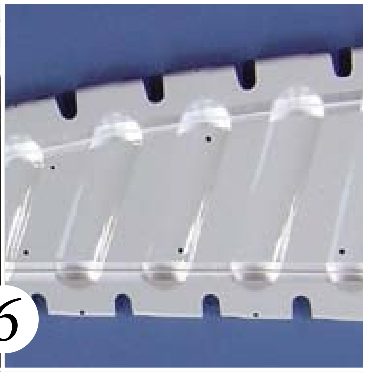

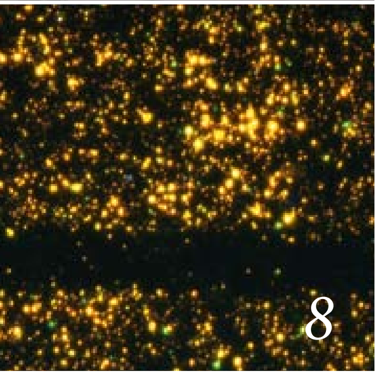

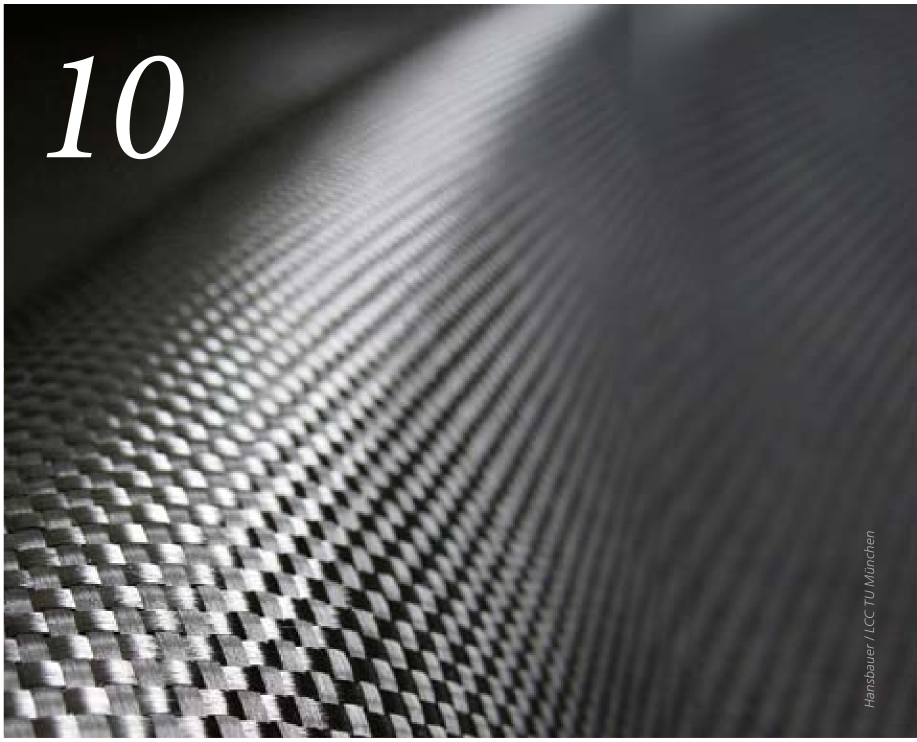

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STATEMENT

The need for better thinking

The world could be beyond many problems, if we started thinking differently, says Prof Eward de Bono. He's been trying to establish tools for "lateral thinking" for the past 40 years. PAGE 19

REPORT

"Smaller is better"

IMS is building machines for very small parts. But that's not good enough for Henri Paus and Martin Langkamp. They want to take small to the next level. PAGE 20

Quiet Please!

The newest slip ring seals from KACO promise silence. A laser-welded muffler makes this possible. PAGE 23

Thinking outside the box

Those intending to store gas in a refrigerator-sized box for 30 years have some pretty creative thinking to do. PAGE 26

PEOPLE

"Work together: this is my message"

Laser technology in the USA is advancing too slowly for Jyoti Mazumder's taste. The renowned American scientist postulates improved networking between science, politics and research. PAGE 28

S P O T

--- RECORD LASER

The free-electron laser from the **Jefferson Lab** in the USA can cut through steel six meters thick. For the first time, scientists succeeded in supplying the particle accelerator with 500 Kilovolts. *www.jlab.org*

--- AWARD FOR INNOVATION

Freudenberg Dichtungs- und Schwingungstechnik received the German Award for Innovation for a waste-free, laser-based production process. *www.der-deutsche-innovationspreis.de*

--- CHINA

China's economic growth has had a positive impact on the laser industry there. According to analyses by market research institute **China Reports**, China's growth has stayed at between 20 and 30 percent in the last few years. *www.chinabgao.com*

--- ANTI-LASER

A team from **Yale University** led by physicist **Hui Cao** developed the perfect, coherent absorber that, theoretically, can absorb 99.99 percent of laser light. This should aid in the development of optical integrated circuits. *www.yale.edu*

--- LASER SINTERING

According to **Wohlers Associates'** annual report, laser sintering is becoming increasingly widespread. 40 percent of laser suppliers would like to add this process to their portfolio. *www.wohlersassociates.com*

--- ARMENIA

The **Armenian Academy of Science** is currently operating a program to develop laser technology in the country. It received advice from international experts at a conference. *www.sci.am*

--- ENDOWED CHAIR

Prof Alois Herkommer holds the chair of the newly endowed professorship for "Optic Design and Simulation" at the **University of Stuttgart. TRUMPF** is one of the sponsors. *www.uni-stuttgart.de/ito/eng/index.php*

Photonic Agenda

EU Commissioner Neelie Kroes emphasizes the importance of photonics

As part of the annual meeting of the European technology platform **"Photonics21,"** President **Martin Goetzeler** gave EU Commissioner **Neelie Kroes** the most recent paper on the Commission's vision. In her closing speech, Kroes praised the merits of photonics research for Europe's productivity, economic growth and employment policies. She sees in photonics a considerable opportunity for Europe to become an economic and technology leader in this industry and called on everyone to work together to achieve this ambitious goal. Joint efforts are required from politicians, scientists and businesses throughout all European member countries to face the major societal changes that are coming in the near future, such as energy efficiency and demographic change. She fully supports public-private partnerships in research and innovation between the European photonics industry and the **European Commission.** *www.photonics21.org*

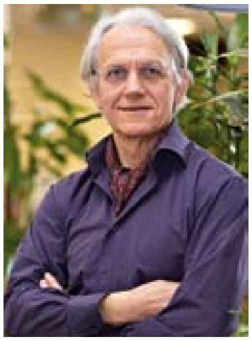
Welding in no time at all

Laser-optimized aircraft components speed up production

The best way to reap the benefits of laser welding is to make the joining procedure part of the planning process for the parts to be joined. The results of a cooperative partnership between **Airbus** and the **"Centr-Al" competence center** at the **Bremer Institute for Applied Laser Technology** drove this point home. The laser experts worked with the aircraft manufacturer to develop an inner landing flap, a part of the drive system on the wings of commercial aircraft. Joining geometry that minimizes yet allows warping and optimized system technology ensure the accessibility of the joining areas in every process step. The developers thereby achieved a welding speed of 12 meters per second. *www.bias.de*

The bulkhead is a weight-bearing part of the inner landing flap.

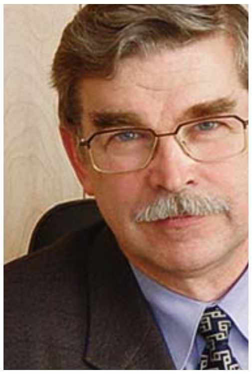
"ELI will become the laser with the world's highest intensity"



Gerard Mourou

Under the leadership of laser experts, **Prof Gerard Mourou** and **Prof Toshiki Tajima**, the most powerful laser "Extreme Light Infrastructure" (ELI) was developed in Bucharest. ELI is supposed to put to rest any misconceptions about the shortest pulse only being achieved with an increasingly stronger laser output. The connection may be correct, but inversely: in order to shift the boundaries to an increasingly higher pulse intensity, the pulse duration has to become shorter. *www.munich-photonics.de*

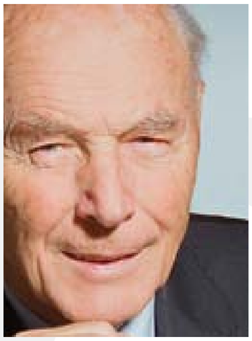
"The laser is key to modernizing production technology in Russia"



Ivan B. Kovsh

Since 2005, the **Laser Innovative Technological Center** (LITC) network managed by the **Laser Zentrum Hannover** and the **Bayerisches Laserzentrum** has been advising Russian manufacturers on the opportunities for laser use. Local organizations such as the **Laser Association** (LAS) are also taking part to establish important connections. LAS President **Ivan B. Kovsh** sees a great opportunity here for technical personnel to become certified in the use of this technology. The LITC is planning to expand to include surface processing in the near future. *www.cislaser.com*

"Today, Dr. Welling has the right to celebrate his achievements as pioneer in laser technology"



Herbert Welling

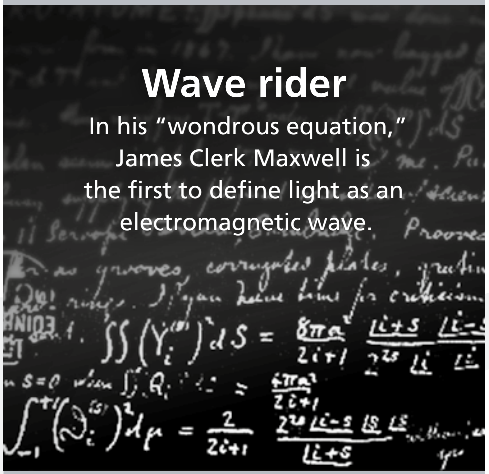
Emeritus Physics **Prof Dr. Herbert Welling** received the Grand Order of Merit from the Federal Republic of Germany in recognition of his scientific research. The Minister of Science in Lower Saxony, **Dr. Johanna Wanka**, presented the award to him on behalf of the German Federal President Christian Wulff. Welling was among the founders of the **Laser Zentrum Hannover** in 1984 and was its director until 1998. His work paved the way for the **QUEST** excellence cluster at **Leibniz University.** *www.questhannover.de*

NETWORK NODE

ICFO
The Institute of Photonic Sciences

The Institut de Ciències Fotòniques (ICFO) located near Barcelona is an independent non-profit research center. It was founded in 2002 by the Catalan government with the Technical University of Catalonia. The goal of the ICFO is to drive pioneering research and educate and train the next generation of scientists. To do so, students are encouraged to start their own companies based on their research projects. That is why the Institute works closely with other leading international research centers and select global corporations. Thanks to this support, about 20 groups are able to work on diverse projects from the ICFO's four core groups at a 9,000 square meter facility. Projects include non-linear photonics as well as quantum, nano and biophonics. Researchers have the use of more than 50 different labs with the most modern equipment, among them a super high resolution light microscope and the most advanced production technology. The ICFO will remain in its expansion phase until 2014, ultimately employing about 300 scientists. *www.icfo.es*

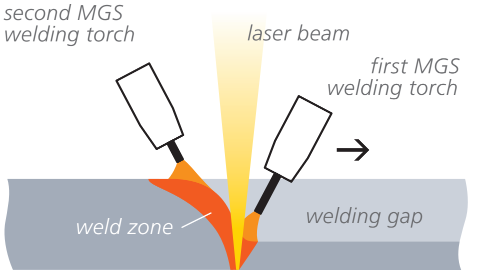
Quantum Leap



1864

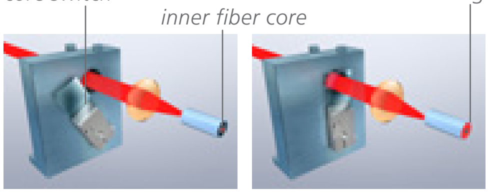
Frédéric Remouchamps, Source: VDI Technologiezentrum GmbH; BIAS/Airbus; Gerard Mourou; Ivan B. Kovsh; QUEST Hannover

CONCEPTS



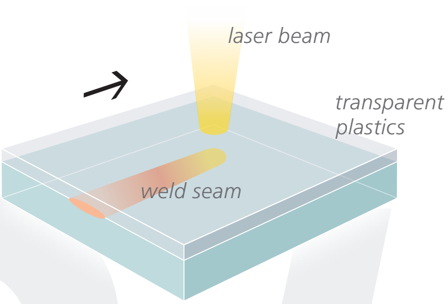
-- HYBRID WELDING

In the process developed at the **Laser Zentrum Hannover**, MGS welding bridges the gap between thick sheets of metal while laser welding joins them in the base. This means that both the laser beam as well as the light arc swing across the seam. *www.lzh.de*



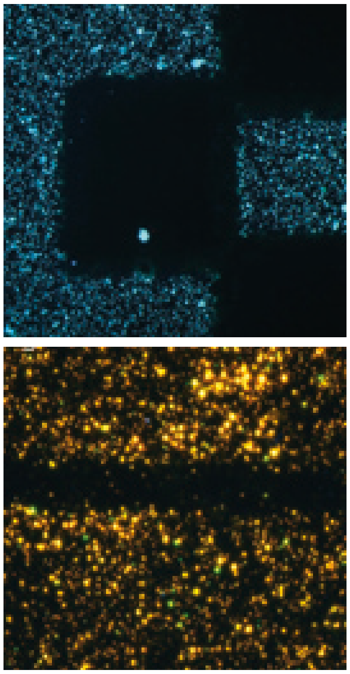
-- OPTICAL LASER CABLE

TRUMPF's 2in1 fiber allows users of solid-state lasers to rapidly switch from cutting (left) to welding (right). The system control unit automatically couples the laser beam into either the inner fiber core or the outer ring of the optical laser cable by means of a core switch. *tinyurl.com/trumpf2in1e*



-- PLASTICS WELDING

Researchers from the **Fraunhofer Institute for Laser Technology** have succeeded for the first time in joining two transparent plastics. The decisive factor in the process was the selection of the right wave length of 1,700 nanometers. *www.ilt.fraunhofer.de*



The marking produced by the laser under the fluorescent microscope.

Now you see me

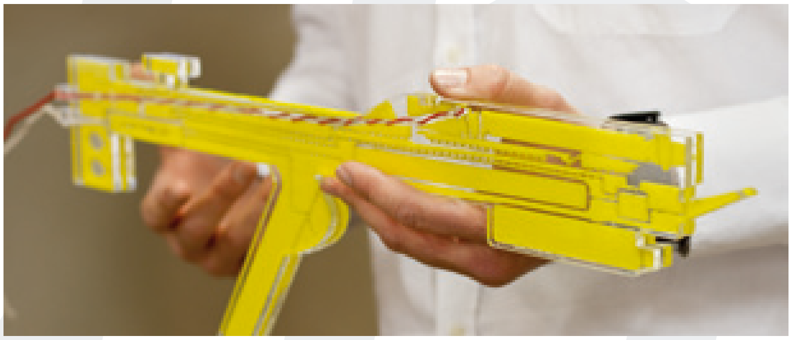
Transparent laser marking protects against product piracy

Each year, product piracy in the industry causes millions in losses. A new marking process from the research institution **Innovent** is designed to protect original products more effectively. The trick to this: the marking is not visible to the naked eye; it has to be placed under UV light. Developers are striving to achieve this result through the use of integrated fluorescent dyes — nanoparticles in a thin layer separated by atmospheric-pressure plasma. A laser annihilates the fluorescent light effect on an area and thus marks barcodes or company logos into the fluorescent layer. The entire marking process, which can be easily integrated into production lines, is suitable for processing mass goods in short cycle times. *www.innovent-jena.de*

Lifesaver

Laser cutter small enough to fit in a rescue worker's backpack

Two students from **Ball State University**, located in Indiana, want to help accident victims with laser technology. The Beam of Life Device (BOLD) developed by **Adam Odgaard** and **John Benjamin** is a portable laser cutter for rescue workers and is intended to replace conventional hydraulic devices. Using BOLD, the rescue workers are not only considerably faster, but also more mobile — the beam source fits into a backpack and weighs only a bit more than 20 kilos. Despite the handheld design, there is no lack in performance: with a full battery charge BOLD theoretically cuts more than 90 meters of car steel. A laser beam also makes less noise than a hydraulic device, another important advantage in accident situations. Odgaar and Benjamin are currently in the process of starting up their own company and hope to go into volume production by the end of 2012. *cms.bsu.edu*



BOLD is so handy that rescue workers can work flexibly even in narrow spaces.

Gernot Walter; Innovent Jena; Adam Odgaard

"Direct View"

Thanks to a new X-ray machine, scientists from the Institute for Laser Tools at the University of Stuttgart (IFSW) can look directly into the workpiece during the welding process. Project Manager Felix Abt explains why this is an important step forward in laser research

As project manager, Felix Abt coordinated development of the X-ray machine. In the process, he oversaw the work of an interdisciplinary team at the IFSW and other partner companies.

The laser head welds the workpiece from above while to the left of the X-ray tubes, the piece is lit up. The camera on the right takes the photo. In addition, the broadly designed unit provides enough space for further diagnostic devices.

Why should we look directly at a workpiece during the welding process?

For no reason other than to understand what is happening in the workpiece. Only through this view can we examine the highly dynamic changes in the emerging steam capillaries and the associated currents in the molten metal. Undesired effects like spattering or pore formation often occur at high speeds. We can now begin searching for the causes and limiting factors — that is enormously important for basic research as well as further development of industrial applications.

What have the options been so far to observe the process?

Obviously, you can observe the process in real time using cameras. But for our purposes, this view of the surface alone is not enough. It is a stopgap measure to weld behind a glass wall. However, this process changes the associated factors too much. A scientist always wants to observe the unadulterated process. X-ray is the logical consequence. In Japan, there has long been such a machine, but its technology is not as cutting edge as it once was.

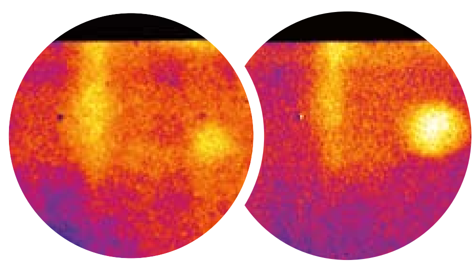
How do these X-ray machines work and what makes yours better?

An X-ray tube emits its quanta conically through the interaction zone. This produces an enlarged shadow of the welding process on the imaging screen. The scintillator converts the X-ray quanta into visible light. A high-speed camera records the shadow cast thereby facilitating — for the first time — a high-resolution view into the inside of the workpiece with image rates around 5,000 images per second.

Can such an X-ray process be integrated into an industrial process? What about quality assurance?

Unfortunately, not yet. It is too complex even with today's modern technology. However, there are already several inquiries from companies that would like to test their processes at our labs where we can shed light on almost any process with our state-of-the-art equipment.

View through the eye of a camera of six millimeters thick aluminum being welded through the eye of the camera. To the right next to the capillaries, you can easily see how a process pore forms.



Angelika Grossmann; IFSW

CFRP!

Industrial production of a raw material, the industrial processing of which is still in its fledgling stages. This picture shows the fabrication of multifilament carbon fibers at SGL near Augsburg.

Carbon Composites / SGL Carbon

WOVEN INTO OUR DREAMS

The opportunities offered by fiber-reinforced plastics, the role of the laser in their rise, and how the material requires a complete rethinking

THE AUTHORS

Prof Klaus Drechsler *holds the SGL Group Endowed Chair for Carbon Composites at the Technical University in Munich and heads up the Fraunhofer project group for function-integrated lightweight construction in Augsburg, Germany.*

Dr. Uwe Stute *is the head of the Department of Technologies for Non-Metals at the Laser Zentrum Hannover e.V., one of the few institutes researching laser applications for composite materials in industrial process chains.*

Prof Axel Herrmann *is head of the Faserinstitut Bremen FIBRE (Fiber Institute of Bremen) which researches the development and processing of fiber-reinforced materials. At the same time, he is intensely committed to sharing new findings and applying them to industrial production.*

VOLUME PRODUCTION WITHIN REACH

Can a material whose price per kilogram can be in the multi-digit range be successfully used in mass production? "Yes," says **Prof Klaus Drechsler**

Fiber-reinforced plastics (FRP) — especially those with carbon fiber reinforcements suitable for heavy loads — stand out due to their outstanding potential in lightweight construction and design. Compared to steel, they offer a 60 percent weight savings in many application fields and up to 25 percent when compared with aluminum. Carbon fiber materials have been used for many years in aircraft construction and for niche vehicles. In those areas, the desired effects justify the expensive material while the low tool costs for small quantities of workpieces made of fiber-reinforced plastics pay off in terms of calculating profitability. These benefits disappear if fiber-reinforced plastics are used on a mass scale in finished goods. The combination of high-tech material and manual processing caused many approaches to fail, not least because the costs cannot be amortized in short cycle times.

If you want to replace steel with fiber-reinforced plastics, you have to keep two essential factors in mind. The first is to automate the production of carbon fiber-reinforced plastic (CFRP) workpieces. The second is the need to focus the development and process chain on the special needs of the fiber-reinforced materials. This begins with the optimal structure concept and ends with quality assurance. For example, three different startup scenarios are conceivable in the automobile industry. First, metal and car-

LCC TU München; Laser Zentrum Hannover; CTC GmbH bon fiber-reinforced plastic could be hybridized on a structural level, although the CFRP applications change the properties of the workpiece. The second scenario is to hybridize on the component level in which the CFRP and the metal components are joined into one component with the desired properties. Finally, the third scenario would be a complete carbon fiber-reinforced plastic car body.

More automation

The third scenario offers the greatest potential for lightweight design and construction, but also represents the highest risk. The hybrid variants facilitate local and optimal use of metals and plastics with implementation that is comparably risk-free. On the other hand, the concepts for hybrid joining have to be developed to take this route.

In any case, all roads lead to process automation. In aircraft construction, important progress has been made in this direction in the last few years. Examples include tape-laying robots for duromers or thermoplastic semi-finished products, where much more tape-laying is needed compared to the manual laying of fibers. At the same time, these robots have a greater reach which is important for the large-scale hull and wing components that are soon to be produced using this process.

> Hybrid concepts facilitate the local and optimal use of metals and plastics with implementation that is comparably risk-free

Inspired by the textile industry

Another important step is to transfer the processing concepts from the already highly automated textile technology in connection with resin injection processes. This technology additionally provides for reinforced fibers to be oriented best to handle heavy loads and the part to come very close to its final shape. With multiaxial textiles for flat structures, weaves for profiles and fibers for local reinforcements, a “model kit” for shaping complex components is available. One-sided sewing techniques make it possible to join the individual textile structures to improve handling or to implement a three-dimensional fiber reinforcement. This has led to a high damage tolerance as well as high structural integrity for impact stress. For all production processes, the use of low-cost carbon fibers is gaining importance because, first of all, it’s less expensive, and secondly, because it facilitates greater productivity.

Nevertheless, in order to achieve good mechanical properties, the fiber textile process itself must be performed on a spreading machine that undulates as little as possible. Very interesting developments are currently taking place in the areas of matrix technology, the so-called snap-cure resin, or the impregnation and hardening technology with processes such as integrated microwave processing with resin preparation, injection and hardening as well as thermoplastic injection and continual pultrusion of complex profiles or laser-processing technologies. Thanks to the consistent implementation of research and development results in industrial production, the use of high-performance fiber-reinforced plastics is inching closer to reality in mass production of automobiles. This is of major importance, particularly against the backdrop of ever increasing system weights due to hybrid and electronic drives. Electric cars also represent very interesting potential as a platform for CFRPs because they offer completely new composite-based structural concepts. ■

Email the author: klaus.drechsler@mytum.de

During the process of Tailored Fiber Placement (TFP) a carbon plaiting machine stitches the carbon fiber bundles onto the carrier material. This allows optimal adjustment of the fiber orientation to the load of the workpiece.

The door hinge made of carbon fiber-reinforced plastics holds the door of a helicopter. This workpiece is a result of the “Flexnaht” research project, which studied the automated processing of CFRP by means of sewing technologies.

Fiber-reinforced plastics are inhomogeneous materials. That is the essential challenge for laser processes

Cutting *Cross-section of a laser cutting edge. The discolored heat input zone and the exposed fiber ends are clearly visible.*

THE PROMISE OF THE LASER

The road to fiber-reinforced plastics in mass production is via the laser, says **Dr Uwe Stute**, who reviews the opportunities and challenges ahead

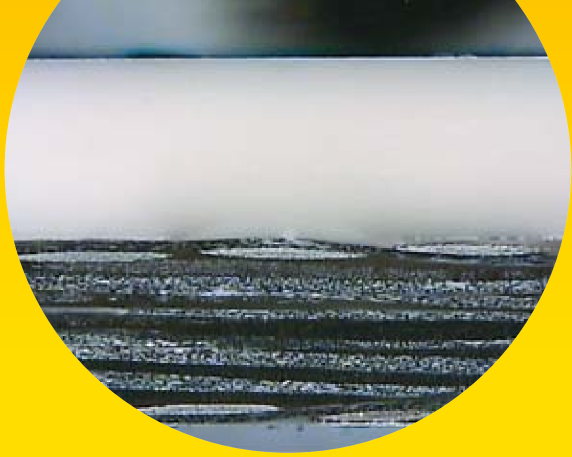
What makes the laser an appealing tool for fiber-reinforced plastics is exactly what made it so successful in sheet metal fabrication: laser light is non-wearing and is contact free. It achieves consistent production results, even on complex geometries. This creates considerable opportunities for laser use in the processing of composite materials because here, too, components have to be joined and cutouts or holes made. In addition to that, there are processes like trimming, which involves finishing work on the component's contour after manufacturing and repair. All are tasks that lasers can perform quickly and precisely in large-scale production.

Tough stuff However, mechanical processes still dominate, even though cutting materials does entail considerable risks. Mechanical load caused by the pressure of drilling can easily lead to delamination. In addition, mechanical tools wear out quickly when working constantly on hard carbon fibers, a fact that is especially noticeable on the cost side. This is driving customers and developers to look for an alternative. However, they are faced with the issue of heat input, which is inherent in the laser process. Those who intend to begin using the laser to produce fiber reinforced plastic components in industrial serial production must, above all, determine to what extent the laser's heat input zone adversely affects a component's functional properties.

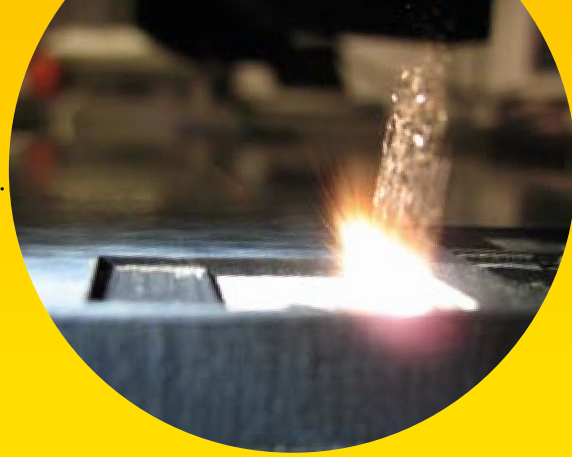
This is where one of the decisive differences between processing CFRPs and sheet metal is evident. Fiber-reinforced plastics are structured from different materials and are not arranged in homogeneous layers. This means an even greater challenge when using the laser because the physical parameters such as spectral absorption, melting and vapor temperature from the different materials will vary in the composite. Therefore, a short-pulse UV laser has to apply about 40 times more energy to evaporate carbon fiber than in the PEEK matrix that surrounds it. It becomes even more problematic if the laser has to separate the CFRP. On the other hand, it could be useful for joining and repair processes because this difference between fibers and matrix makes it possible to selectively remove the matrix material.

Developers are currently researching new processes, focusing particularly on cutting and drilling using short-pulse and high-performance lasers, joining thermoplastic fiber reinforced plastics and removing materials, such as for repair.

CFRP!



Welding *Longitudinal section of a laser welded seam. It joints a non-reinforced attachment part to a CFRP structural element.*



Removal *The possibility to remove material layers selectively makes the laser a promising tool for the repair of structural components.*

Cutting and drilling

Cutting or drilling performed on FRP components is required, for example, when a component needs to be trimmed or prepared for rivets. If you apply the fusion cutting process used in sheet metal fabrication to composite materials, you can achieve comparable speeds with high-performance lasers. However, material changes will appear along the peripheral areas that penetrate several micrometers to even a few millimeters into the material.

The essential variable required to reduce the thermal penetration depth and minimize the heat input zone is the duration of the interaction between laser and material. This variable can be influenced either by higher feed speeds with the same energy per unit length or by the use of pulsed laser systems. These systems work with pulses in the range of 10^{-12} to 10^{-6} seconds. This range allows the pulses to efficiently vaporize the carbon fibers while barely penetrating into the matrix. Nevertheless, these lasers have considerably lower maximum average outputs compared to continuous beam lasers. This means that material thicknesses in the millimeter range are very difficult to cut cost effectively. However, beam source manufacturers and researchers are already working on high-performance ultra-short pulse lasers with average outputs of up to one kilowatt. In fact, the first lasers of this type are already being produced and soon will be an option to closing this gap. This picture will change once again when we begin to sort the applications according to functional features and specify the requirements for the peripheral area. This will enable better definition of the laser's areas of applications. At the same time, we are already seeing that many applications dominate due to the necessary processing costs and that "compromises" are being made if the cutting speed is right.

> Mechanical processes still dominate in industry, yet the incentive to use suitable laser procedures is strong

Joining fiber-reinforced thermoplastics

The industry is already using lasers to weld non-reinforced and chopped fiberglass reinforced thermoplastic materials. However, fiber-reinforced plastics have long been missing the thermoplastic matrix systems. In addition, even with the CFRP materials, the light almost exclusively couples into the carbon fiber. In an uncontrolled process, this results in inconsistencies in the weld connection with the fiber layer, making laser transmission welding (LTW) through carbon fiber-reinforced material impossible. The solution, therefore, lies not so much in the process alone, but in an approach that takes both the material design and construction as well as the intended process into consideration. This approach is currently being pursued both by manufacturers and researchers. Initial successes have already been achieved in the use of a controlled laser process to weld non-reinforced attachment parts to CFRP structural elements. This process, which can be automated, is fast and comparably inexpensive, making it a great candidate for use in production over the medium term. →

CFRP!

Repair concepts The repair of structural components made of composite materials such as those used for aircraft represents a special challenge compared to the repair of metal components. Fiber-reinforced plastic obtains its optimal strength from the layers of fiber. This layering must be reproduced even though the repair process separates fibers. To this end, a kind of shaft structure is incorporated into the component, filled in again layer by layer or with an insert and then joined via the consolidated matrix. As a rule, the shaft structure is currently fitted in mechanically by means of grinding. However, this process has tolerances and it is difficult to automate. The ability to precisely remove material laterally and vertically with pulsed laser sources offers the option of automated precision removal with a resolution in the micrometer range. When it comes to adhesives, the laser has two ad-

For CFRP components to come out on top, they have to permit repair

ditional advantages that can be leveraged. Due to the different thresholds for fiber and matrix removal, the laser can selectively expose the fibers, thus enabling mechanical clamping and greater resistances. Furthermore, UV lasers can break chemical bonds and thereby activate the surface, which also permits an improved compound.

Where to go from here? The opportunities that the laser has to offer can vary greatly depending on the different requirements of the components. Functional and quality requirements define the limits of permissible material modification in the peripheral areas. Nevertheless, these limits vary from industry to industry, like aerospace and automotive. Yet the range of materials is highly diversified so that there are still many details and basic questions left to be answered by researchers and developers. However, there's a good chance that laser technology will replace mechanical processes in certain steps in the CFRP process chain just as successfully as it did in sheet metal fabrication. ■

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*Foam core and the dry **partially finished fiber part** lie as reform in the hardening tool.*

*The surface layer, consisting of **multi-axial lattice**, is applied and completes the structure.*

*To smoothly infuse the resin, **flow aids** and **runners** are needed that distribute the resin on the surface and thus facilitate and thus facilitate impregnation of the fibers of the fibers.*

*During **Infusion**, the resin front is easily visible. It runs evenly across the component, ensuring a pore-free and error-free infusion.*

The side panels of the vertical fins of the Airbus A 320 can be integrally manufactured. The highly integral construction method for big component parts is a major advantage of fiber reinforced plastics

AFTER THE METAL AGE

The ever increasing replacement of metal parts with those made of carbon fiber reinforced plastics means we are again entering a new era in design and production. **Prof Axel Herrmann** and **Benjamin Teich** from Composite Technology Center Stade GmbH present examples of the use and benefits of carbon fiber

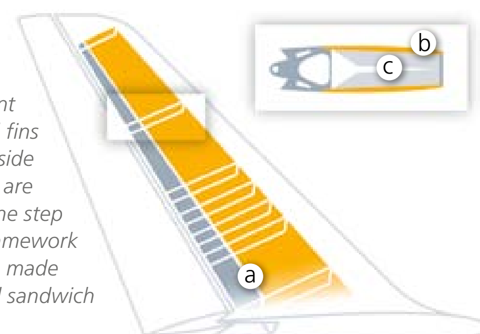
Due to their mechanical properties and production methods, fiber composite materials offer design opportunities that differ greatly from those for metal materials. These mainly include the anisotropy or the directional dependence of their mechanical parameters and the opportunity to freely define these directions in the design and production of the workpiece. Moreover, carbon fiber-reinforced plastics (CFRP) stand out due to the later material emerging to some extent directly as a component. For example, a matrix — like an epoxy resin — surrounds the initially flexible and easily formed partially finished fiber part, hardening and “fixing” the part into its final shape.

These methods allow for highly integral constructions of very large components that need no connecting elements like screws or rivets. This means that carbon fiber — an inherently light material — in combination with a design suitable for it offers immense weight-saving potential. Imagine, for example, a car body that consists of only a few parts or even only one part. At the same time, the construction and associated production process determine the cost of parts to a high degree. An efficient design therefore requires a comprehensive understanding of the mechanical properties and possible production processes. Only then do solutions succeed that not only reduce weight, but also offer greater feasibility.

One example from the aerospace industry is the research project The Next Generation of Vertical Fins (SLW-NG). With general project management being handled by CTC GmbH, a new construction and a new production concept is being developed for the vertical fin of the Airbus A320. The main goals were to reduce costs and shorten lead times in production by 20 percent respectively, along with a 5 percent weight reduction compared to the previous vertical fin.

The essential elements in the new design are the so-called framework fins and the side panels with resin-infusion technology produced in one step. These side panels are a dual-skinned concept without a stringer on the inside of the skin. This skin concept is based on a modular, adaptive, integrated design (MAID) that mitigates or entirely eliminates the disadvantages of the traditional sandwich designs with its honeycomb core. For the industrial and automated production of the MAID panels, production technologies were developed that enable infusion and hardening of all required components in one step. The process doesn’t use a gas-tight autoclave for hardening; instead it needs only one open tool in a chamber furnace with a vacuum buildup.

All partially finished carbon fiber-reinforced products are dry prior to resin infusion. This also applies to the reinforcements of the foam core. The MAID panel design developed here makes it possible to use automation for preforming and tape-laying. Because the panels of the vertical fins are only slightly curved, they can be made easily and cost efficiently. Different core reinforcement systems can be applied in the foam core. This enables the MAID panel properties to adapt to: local load application reinforcements, core material properties, robustness of the composite for impact loads and prevention of damage to the core. Cracks are also prevented from developing and the connection between the surface skin and the core is improved.



The centerbox (a) is the supporting element for the vertical fins SLW-NG: Two side panels (b) that are produced in one step enclose the framework fins, which are made of a reinforced sandwich design (c).

All these factors make the structure and production concept of the MAID panels very flexible, easy to optimize and highly industry-friendly. At the same time, it can be transferred to the most diverse application areas — outside commercial aerospace — where flat, lightweight structures are needed. These might include the hulls or superstructures of modern yachts and ships, the passenger compartments of high-speed trains, components for automobiles, wind turbine blades or even highly rigid wakeboards.

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*Fiber-reinforced composites have also found their way into machine construction: In the TruLaser 7040 fiber **laser cutting machine**, a cross beam made of CFRP is now half the mass of the same component made of steel. This quadrupled the dynamic rigidity, resulting in a productivity boost of around 70 percent.*

*Ever lighter is an on-going refrain in sports equipment. In many sporting goods, such as tennis racquets and golf clubs, there is still a little bit of a conflict between the rigidity of the fiber-reinforced plastics and the desired elasticity. For **bicycle frames**, on the other hand, this rigidity is a welcome addition to the low weight.*

*To generate as much electricity as possible, the rotors of a **wind power system** must turn as fast as possible — even in a gentle breeze. Rotors made of carbon fiber-reinforced plastics are light-weight but can still absorb high forces. Another plus: these large components can be made from just a few pieces.*

The use of fiber-reinforced composites on a large scale is only a matter of time — and the right processes

*The use of fiber-reinforced plastics in passenger car components results in considerable weight reduction — a key to the breakthrough of **electric vehicles**. Fiber-reinforced composites possess an impressive ability to absorb energy, allowing them to tolerate a good amount of damage.*

CFRP.

*The smooth surfaces of fiber-reinforced plastics make them easy to clean. In addition, they don't conduct electricity, can't be magnetized and are highly transparent in X-rays. All these properties make them very attractive for medical uses — such as imaging applications, like **CT scanners.***

BWM Group; Siemens; DeVice - Fotolia.com; Diplomarbeit Felix Fröhlich / LCC TU München; TRUMPF

The need for *better thinking*

What's the biggest problem facing humanity? Is it climate change? Is it overpopulation? "No, it is poor thinking," says Prof Edward de Bono

We have done nothing about operational thinking for 2,400 years. We have done nothing since the Greek Gang of Three (Socrates, Plato and Aristotle). When Greek thinking appeared in Europe during the Renaissance, schools, universities and thinking were in the hands of the Church. It did not need creative, constructive or design thinking. What it needed was truth, logic and arguments to prove heretics wrong. So good thinking was developed for finding the truth and has served us very well in science. Culturally we have never developed thinking for creative value. Individual inventors and entrepreneurs have shown such thinking, but it has never been part of culture or education.

We regard creativity as a mysterious gift which some people have and others can only envy. We feel that the best we can do is brainstorming sessions or sitting beside a stream and playing Bach. But that is not true. It is old-fashioned rubbish. Creative thinking is a logical process. But it is a different logic. It is the logic of patterning systems. In 1969, I wrote a book called "The Mechanism of Mind". Therein I described how the neurons in the brain allow incoming information to organize itself into patterns. This book was read by one of the leading physicists in the world: Prof Murray Gell-Mann who received his Nobel prize for discovering the quark. He liked the book so much that he commissioned a team of computer experts to simulate what I had written. They reported that the system worked exactly as predicted. From this basis we can develop the formal and deliberate creative tools of lateral thinking. These can be used to generate new ideas. A workshop for a steel company in South Africa generated 21,000 new ideas in a single afternoon using just one tool of lateral thinking.

On a political level our thinking is concerned with analysis and judgment. We do not seek to design the future or the way forward. Many years ago at the United Nations, I tried to set up a group to do some creative thinking. This proved impossible as they said they were not there to think but to represent their countries.

I now pursue a big project of setting up a "Palace of Thinking," which would have two functions. The first function would be to receive new ideas worldwide and to publish the best ones. The second function would be to organize creative meetings for generating new ideas on world issues and problems. I am looking for an impressive and iconic building in any country that would like to contribute to the world by hosting this place. Countries would be invited to send their best thinkers — to think, not to represent their country. ■

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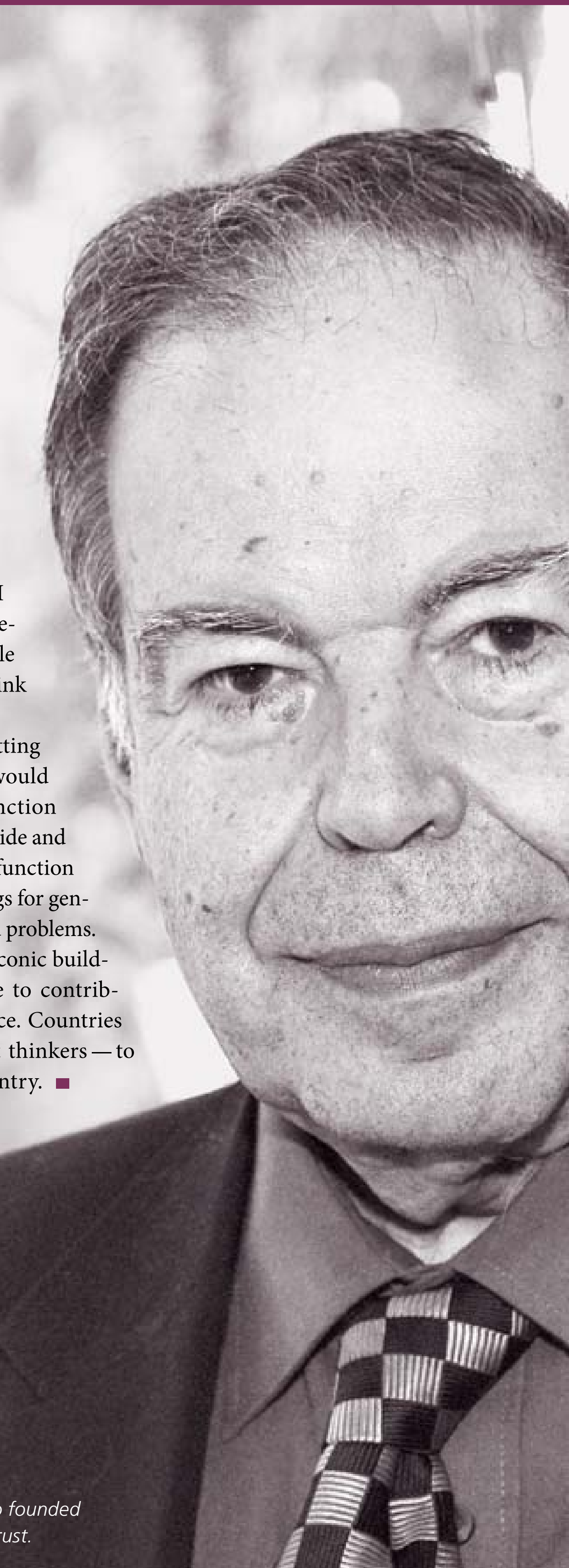

In 1969, Edward de Bono founded the Cognitive Research Trust.

Edward de Bono

“Smaller is better”

IMS in Holland builds production plants for microcomponents such as cell phone speakers and medical implants. Martin Langkamp and Henri Paus rely entirely on the laser, which they see as a technology rife with development potential

Your company produces very small products. To what extent has laser technology opened new doors for you?
Martin Langkamp: In certain industries, the doors have long been wide open. Many of our customers come from the high-tech industry, including Philips and Sonion — a hearing aid manufacturer. Using our machines, they manufacture very small products, such as speakers and microphones, for their end products. The laser is the perfect tool for these products. The automotive industry is very familiar with what the laser has to offer in sheet metal fabrication. It's only logical that companies apply this experience to small electronic components like pressure sensors that are being installed more and more often in passenger cars. It is generally safe to say that the customers who tend to introduce several new developments each year have already identified the laser's potential and thereby naturally assume that we will integrate this technology into our machines. Whether automatic or semi-automatic assembly lines, our modular concepts can meet both demands. Mass production has the added benefit that a beam source can supply several machines by means of a laser light cable.

> "For many microprocessing applications, there is no longer an alternative to the laser"
>
> *Martin Langkamp*

Is it less prominent in other industries?
Henri Paus: For customers in the medical industry, there is a lot more convincing to do. Until recently, the laser did not play a major role for them in production. The product cycles in the medical industry are much longer, which means so is the development cycle. As an illustration, we have been researching the concept of production plants for medical implants for five years, and the project is scheduled for completion in 2014. Benefits like flexibility or speed alone are not enough to convince potential customers in this industry.

How do you make a powerful argument in favor of it?
Paus: The answer to that is obvious: quality. Customers from medical technology are very picky. That shouldn't come as a surprise because with implants, there is absolutely no leeway in terms of quality. At the end of the day, each part has to be perfect so that there is no doubt it will last a lifetime. Health professionals also check the products under the electron microscope, which enlarges the implant by a thousand, so you certainly see every single little defect. This is an entirely different world that we, as integrators, first had to familiarize ourselves with. But we firmly believe in laser technology and know that it is the only way we'll be able to produce the desired quality for the long term. That is why we have set up our own clean room, had our company certified as a medical equipment manufacturer, and are actively working hard to educate potential customers about the benefits of the laser. Meanwhile the spark has been ignited.

Martin Langkamp (right) and Henri Paus develop large assembly lines for small parts.

For certain applications, do you have any option other than the laser?
Langkamp: In the case of welding, there is no alternative to the laser in microprocessing because the products have gotten so small. The electrode in resistance welding is about 0.1 mm in size. That may sound small, but the end products are only a bit bigger. They would be completely melted. Only the laser enables us to work with sufficient precision. Therefore, in micro-welding, we use TRUMPF lasers as standard equipment. In contrast, for cutting applications, there is still a little room to maneuver because the laser does not yet entirely meet our demands.

What direction should future laser development take?
Paus: In the markets we are active in, components are becoming smaller and smaller. For the dimensions that we would like to work in, even the laser is too big; so technology must be able to work on even a smaller scale with greater precision. For some materials, the protruding burr created during the cutting pro-

> “Even the laser is not always a sophisticated enough tool for our needs. Laser technology has to continue to evolve”
>
> *Henri Paus*

cess is larger than the entire end product! This is an absolute no-go, especially with implants.

Langkamp: Here’s another example that we were lucky enough to find a solution for: A cell phone speaker contains a thin membrane only a few micrometers in size that absorbs the sound vibrations. This film must be precisely cut to fit without damaging the sensitive material. No cutting laser was able to deliver satisfactory results. We had to find a new solution, which we were luckily able to do with TRUMPF’s help. We modified a marking laser to perform at the necessary parameters. We often work to the limit and rely on TRUMPF to continually improve and enhance laser technology.
Paus: Every production decision naturally entails certain causes and effects. In the case of a laser application, however, we work with TRUMPF to perform welding tests after each milestone and integrate the results into the entire process. This usually makes it necessary for modifications to be made to the product. Of course, we then have to repeat the test. So there is a constant back and forth in terms of process ideas and design suggestions.

So does this mean that the end product itself is not yet set in stone?
Langkamp: No, in fact in almost all of our projects, the end product has been modified considerably by the end. And we’re very proud of that. We’re not just laborers who assemble a machine made up of purchased components; we’re actively involved in process and product development.

With so much coordination, do you have any time left over for production?
Paus: We don’t spend a lot of time on production. At the most, we do the prototype and the first production run in-house. Otherwise, we outsource production to other companies that were once our competitors. We allocate core competencies in a such a way that complements the companies in our network — but we are the brains behind the operation.
Langkamp: Our company handles only those projects that have a high development time and effort. Otherwise, we manage the coordination and assign the project within our network. In both cases, we put together small, expert teams that can concentrate on just a few tasks. We juggle many projects simultaneously, but are able to assign employees with the right expertise and skill sets to the appropriate projects. After all, even in the era of laser technology, our highly skilled employees are our most important resource in a very competitive market. ■

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IMS is an integrator for microcomponent production plants. From Almelo, the Netherlands, the company delivers turnkey assembly lines worldwide to customers in the high precision, medical technology and electronics industries. IMS has 50 employees and is the biggest company in the WWINN Group, which owns INNLab and ESPS. While INNLab mainly handles process development, ESPS takes care of after-sales. Together, the companies posted earnings of over 18 million euros in 2010.

Ralf Kreuels

Twelve laser weld seams attach the silencer in the slide ring seal right down to the micrometer.

Quiet Please

A small part makes a huge difference: the gasket silencer from KACO has put an end to loud water pumps

It whines. It squeaks. It whistles. A noisy water pump is just as bad as a broken fan belt. In the best-case scenario, the pump just has to be replaced. In the worst case, the engine has to be replaced. The basic problem of a broken water pump is clear: air gets in the sealing system where there should only be coolant. The inherent vibrations of the water pump can become a disruptive airborne noise. Luckily, this annoyance rarely occurs. If it does, automobile manufacturers have to deal with the complaints, which also get back to the sealing system manufacturers like the well-known company KACO. "We have to avoid taking the fall for this problem whenever we can," explains Tobias Hoffmann, manager of product development. "It can almost always be traced back to the engine's operating conditions. No matter how good the seal is." A parts supplier obviously has almost no influence on the engine as a whole. The interactions between the different factors are already much too complex anyway to rule out

> "Each tiny deviation would change the features of the silencer considerably"
>
> *Helmut Baier*

the development of vibrations entirely. "As things stand currently, this is simply impossible," adds Eckhard Ogaza, manager of the the AXIA Sealing Systems Business Division. "We really can't prevent the causes, but perhaps we can prevent the symptoms." To this end, not even a single intervention is necessary because the simple, yet clever solution is a silencer — a stainless steel ring with several tiny metal tongues.

Warm instead of loud

KACO welds the silencer to its new sealing system CS 2 ANS — ANS stands for "Anti-Noise Solution." Like all current slide ring seals produced by KACO, this seal consists of several assemblies. The silencer has metal tongues that protrude into a hollow space between the individual parts and have a specifically defined contact to the outer wall. On the welded side, the silencer absorbs the undesired vibrations through the friction created by the tongues rubbing against the wall. All of the energy that would otherwise produce noise is discharged here as heat. "A truly obvious solution," notes Eckhard Ogaza. "Nevertheless, someone had to come up with the idea of using it in this context."

The right balance

It didn't take much to get from the idea to the design, but implementation was a different story. "You have to remember that we move within incredibly small dimensions," says Production Manager Helmut Baier. "Even the smallest deviation from the tolerances can cause the properties of the part to change drastically." Too much friction would suppress the vibrations, but could impair the seal. Additionally, each new component not only has to be perfectly integrated into the modular concept of KACO's products, but also into the fully automated production line. "We produce over 18 million water pump seals annually. To do that, we need the greatest possible speed and process reliability," adds Baier. "So we knew straightaway that we would end up relying on laser welding. After all, we had already had some good experience using this technology."

Without the efficiency of the laser in precision machining, KACO's modular concept would have been impossible anyway. Today, simple parts can perform key functions by simply being welded together. In the past, many more elaborate parts would have been needed. And several solutions would have been downright impossible. This solution allows sealing companies like KACO to respond more flexibly to the needs of their customers. In general, the same seal is installed in each water pump, but with minor differences. Automobile manufacturers can choose between different high-performance sliding materials or use optional parts like the silencer.

A look at tomorrow

Developers knew early on that they would use a laser for the new process. There was, however, a question remaining: Which one? "Because we had discussed the process parameters in detail, we were able to give very specific requirements," says Tobias Hoffmann. "Therefore, we needed only two or three visits to the TRUMPF laser application center. After a few welding tests, we knew that the TruFiber 200 was the right tool for us." There were several reasons for opting for the fiber laser. With an extremely thin stainless steel part like a silencing ring, it is vital that the welding process produce as little heat as possible. Otherwise, the part could become deformed. Thanks to its precisely focused laser beam, the TruFiber 200 applies the heat purposefully to the component and produces very fine weld seams. The PFO scanner optic produces the weld seam geometry in seconds without the component or the optic moving.

Currently, the TruFiber 200 exclusively welds the CS 2 ANS, yet other solutions are being considered. "Finally, we can also adapt the process parameters for new applications and simply store them in different programs," says Eckhard Ogaza. "This flexibility simply gives us more leeway for future developments." But product development was not a quick endeavor: KACO had accumulated more than 100,000 test hours by the time the part was production-ready in October 2010. But it has definitely paid off — drivers and their now no longer tortured ears can confirm this. ■

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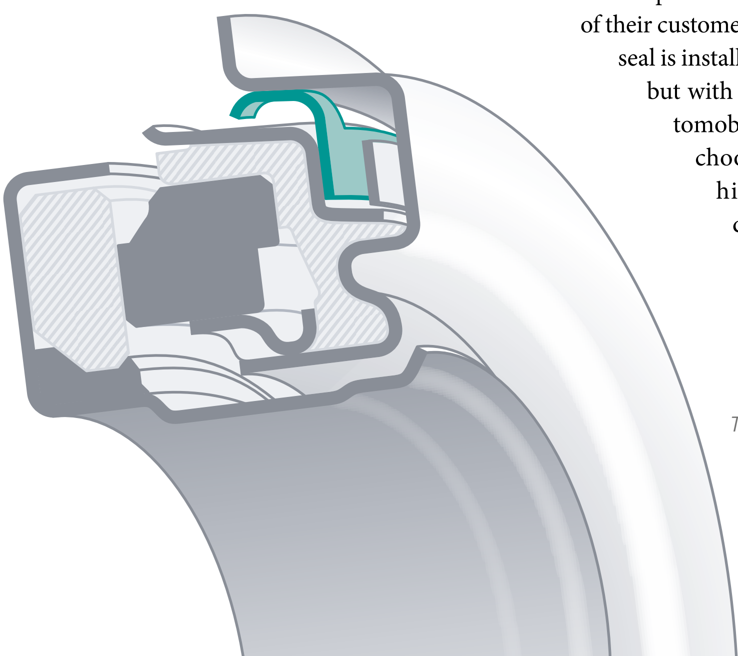

The cross-section of a slide ring seal: the silencer prevents noise from developing through microfriction.

Production Manager Helmut Baier integrated the TruFiber into his company's existing production line.

As manager of product development, Tobias Hoffmann made sure the silencer had the right balance.

At KACO, Eckhard Ogaza is responsible for the AXIA seal systems.

KD Busch

Thinking outside the box

JST switchgear boxes must store insulating gas for 30 years.
Engineers have come up with a creative way to make that happen

Switchgears, which distribute electricity, are the node points of energy supply. They are the size of a refrigerator and therefore take up a lot of space, especially when more than one switchgear is used. The reason for their size is cogent: to prevent voltage discharges, there has to be enough space between components inside the box so that the air in the housing can provide insulation. The Chinese Hainan Jinpan Electric Co., Ltd (JST) is expanding its transformer business and now also offers the most advanced switch- gear technology: gas insulated switchgears — filling the boxes with SF6 gas. The advantage of this approach is that the components are better insulated and the circuit breaker and busbar components can be arranged in more compactl space. But this technology has created a special challenge for the box builders that seams have to be leak-proof over a long period of time so that no gas escapes. "We are talking about a service life of 30 years," emphasizes JST General Manager Michael Yan. The right tool for producing these leak-proof seams is the laser. The process is state of the art in GIS business nowadays. However, the dimensions of the sheet metal parts have to be extremely precise because the lasers must work within narrow tolerance ranges. Because the only way the weldings last for a long period of time is unsing highly precise components. For this reason, the sheet metal parts of the boxes must be cut with the laser. "Edges of punched parts are too imprecise in that they cannot be exactly placed on the fixtures and jointed with zero tolerance," explains Michael Yan. Also, JST cannot depend on employees' that have the same high level of skills in welding by hand each and every day. Laser welding is the ideal approach for this task which it executes precisely at constant quality. When performing gas-tight welding, the focus spot must be placed exactly in the middle of the joint gap, this is the only way the weld truly seals the joint seam reliably. An integrated probe in the welding head checks automatically whether this is done precisely. It moves along the workpiece and determines the exact positioning of the joint seam for the welding process. Once the laser has tightly welded the seam, the probe checks the position for the next seam.

Rethinking the box design Using the laser requires engineers to rethink the box design. Typically, a box is composed of two U profiles

The silent servants: Fixtures play a decisive role in the new and leaner production process (left).

The use of laser welding to produce weld seams that can seal in gas for over 30 years. This led to a completely new box design (above).

JST General Manger Michael Yan is establishing yet another business mainstay with gas-insulated switchgears (right).

turned 90 degrees to one another and welded together. The wings of one profile will later form the side walls of the box; the wings of the other side will form the floor and ceiling. It's a simple procedure, but it has design disadvantages: The bended corner causes accuracy problems. It is not possible to weld these tightly with the laser because it works without filler wire. That is why the JST box is made out of individual sheets for the box's side walls that can be precisely positioned for welding. The laser does this work quickly and the seam remains leak-proof. Another change is necessary with protruding sheets at the edges of the box. Inner areas are not accessible to the laser and narrow sections also lead to tolerance problems. Working with TRUMPF, JST has modified the box design accordingly. The edges are now easily accessible and combined so that there are fewer weld seams. Moreover, less material is needed.

> The "expensive" laser replaces the combination of punching, bending and manual welding. It's paying off

Efficiently produced Before the laser welds the box, there are three steps to preparing the components. First the sheets are cut and fully processed, and in a second step, they are welded with a 4-kilowatt TruFlow Laser in the TruLaser Cell 7040. Then an interim step follows in which the sheets are joined to the box with the help of a TIG manual welding tool. The manual operation is necessary so that the box can be easily positioned on the fixtures. In the fourth step, the machine draws the laser seam. The TruLaser Cell is equipped with three movable tables. For each work step, one of the tables with the suitable fixture is used. While the components in the laser cell are being welded, the operator can prepare the new workpiece on the next table. The fixtures represented a special challenge for JST: "Our boxes always have the same width, but we produce them with different lengths — at the moment they measure 330, 660 and 990 millimeters," says Michael Yan. Now, for the first time, each size can be produced on one set of fixtures. The basic fixture developed by TRUMPF remains the same, but depending on the length of the component, it can easily be reconfigured. "This enables us to save on investment costs for additional equipment as well as the time needed for retrofitting," Michael Yan explains. Production steps like assembly and quality control, which were also needed for manual welding, are no longer necessary. "Using laser welding, we were able to increase the processing efficiency by 30 to 40 percent. Because we did not have to do nearly as much rework," says Michael Yan. This means he is one decisive step closer to his production target — Modern Scale Production. ■

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Wants to bring his students closer to industrial reality: Jyoti Mazumder

How do you prepare your students for a career in 21st century laser processing?

When I teach a class, I invite companies — such as TRUMPF — to come to my lectures. I also bring my students to local industries. I want my students to not only know the theoretical framework, but also the real-world applications and the perspectives of those who use this technology in their day-to-day operations. For any new technology to grow, it has to have a value. And the only way you can show the value is to expose students to its uses. I try to instill a culture of innovation, where students learn how to take a problem and, in order to solve it, apply knowledge from many different areas.

What role does your experience as a former student play here?

During my undergraduate years from 1967 to 1972 at Calcutta University, laser technology was not part of any curriculum. Only a few professors were doing laser research. The field was so new, even the smallest invention would get notice in the press. So I studied metallurgy and then received an invitation from William Steen at Imperial College to join their graduate program there. This was pivotal to my career. Bill, a young lecturer and a pioneer at that time in laser education, promised me work in a brand-new, fast-moving field — lasers — where I would be exposed to leading scientists from around the world. And that's exactly what happened. Bill took me to all the big labs and conferences and I got to know some of the pioneers, from the Noble Laureates who invented the laser to people who worked with it in the factories. I learned from them and tried to contribute to the field myself. By the end of my studies I was steeped in laser technology. And this led me to the University of Southern California, where I helped set up a National Laser Center. I felt I had many opportunities for hands-on experiences and this is the approach I try to use with my own students.

“Work together:

Did that trigger your commitment for the Global Alliance for Research and Education in Laser Aided Manufacturing, or GARELAM?
The whole idea of organizing that workshop in 2006 was to see whether everyone could join hands and share some of the common technological knowledge of laser necessary to accelerate its spread. There was plenty of enthusiasm, but no corresponding investment from the United States government. Europe, for example, invested close to half a billion dollars annually in laser technology for ten years. Nothing like that has happened here yet. There is also much we in the United States can learn from how Europe prepares its students for the laser field.

Are there differences in the way students are trained to become laser specialists in countries of Europe as compared to students in the USA?
There's a very big difference. Europe now has a centralized institute for training students of lasers that is based in Austria, ARGELAS, run by the Austrian Laser Association. It functions as both an information clearinghouse and a specialized training facility with members from the fields of laser manufacturing and industrial laser applications. In the United States, we have not been as successful continent-wide as in Europe. However, under the National Science Foundation's Industry-University Co-operative Research Center (I/UCRC), we have a consortium of industries and universities doing something similar. Also, at many colleges in Europe one can get a degree in Laser Engineering. Here, the best one can do is a degree in Mechanical Engineering specializing in laser. At Michigan, for example, we offer specialized courses in laser processing as well as a master's and Ph.D. degree program in Laser Processing Research.

How does a country create the right conditions to train good laser engineers?
Speaking for the USA, I would like to see more specialization here because laser comes from a background of physics. It was invented by physicists, and developed mostly by physicists. The engineer has literally no background knowledge on optics and the things you need for laser. When I teach a processing course, I have to spend about four weeks of the class educating my students about the physics of lasers. What I'd like to see is many more courses in lasers and optics, along with the engineering or laser processing side of it. We need government investment, too. Germany invested a tremendous amount of money in laser technology and you can see the results. Most of the bigger laser firms are from Germany and every state in Germany now has a specialized institute focusing on laser.

GARELAM didn't live up to expectations — so what do you do now to give students the change to gain the same experience you did?
When laser projects abound, students flourish. So let's make those projects happen by expanding the network of relationships between universities and industries. The consortium I/UCRC, which includes the University of Michigan, and others, along with about 25 industries, meets twice a year to discuss problems and identify projects and funding to find solutions. Another way to evangelize laser technology is through The Journal of Laser Applications, a publication for which I was honored to serve as Editor-in-Chief until December 2009. I also work through the societies, such as the Laser Institute of America. LIA is the prime society for pooling laser technology and disseminating information, while bringing government, industry and universities together. And of course, on a personal level, as I travel around the world, attending conferences and giving lectures, I take this message with me of encouraging people to work together to spread laser technology. ■

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If you want to push the practical use of laser technology, you have to 'soak' young academics with experience in the first place — says professor Jyoti Mazumder, who experienced such a deep immersion himself.

this is my message"

LIFE Since 1996, Prof Jyoti Mazumder has taught at the University of Michigan's Departments of Mechanical Engineering and Materials Science and Engineering. But he finds time to take his students beyond the lab, and into the applied world of factory floors and humming machines.

LASER Mazumder's laser view is expansive. He dreams of transforming the field "from a technological art to scientifically based engineering."

ACHIEVEMENT Last year, the American Society of Mechanical Engineers awarded Mazumder its Thomas A. Edison Patent Award for the development of closed loop Direct Metal Deposition (DMD) technology. The patent dramatically shortens the lead time from design to production.

BUSINESS IS BOOMING

Dr Arnold Mayer, of Optech Consulting, analyzes the laser market's rapid rise in sales.

The economic crisis in our industry is finally over. Compared to the weak volume of 3.8 billion euros in 2009, the world market has heated up a remarkable 55 percent to 5.9 billion euros in 2010. Lasers and laser systems for microprocessing have recorded particularly strong growth in demand. Many applications in growth industries, including semiconductors, printed circuit boards, flat screen monitors and solar cells, are driving the market. The strength of these industries in Japan, China, Korea and Taiwan is an important factor for growth in the Asian laser market. A strong recovery in the standard laser machine segment has also contributed to rapid market development. Thus the demand for laser cutting machines worldwide is on a distinctive rise with the growth regions of Asia, Eastern europe and South America once again standing out.

Market Shares The share of laser beam sources in the overall volume of laser systems sold is estimated at almost 2 billion euros. Solid-state lasers represent the largest share on the basis of value in the laser source market. This means rod, fiber and disk lasers with their broad spectrum of beam outputs and pulse parameters are in greatest demand. Coming in second place on the market are CO_2 lasers. With beam outputs in the multikilowatt range, they are a dominating force in laser flatbed cutting machines, the single largest segment in the laser system market. Excimer lasers continue to maintain a significant market share in laser microprocessing, particularly in microlithography. As the newest technology, diode lasers naturally still have the smallest market share.

The following comparison highlights the laser's importance as a tool in production technology. The worldwide market volume for laser systems in material processing is about 13 percent of the volume for machine tools — a total of 45 billion euros. Since 1993, growth in the volume of the laser system market has increased fivefold, skyrocketing by 440 percent.

However, what we cannot forget in our euphoria over these figures is that the demand for lasers and laser systems for material processing is greatly affected by the economy's boom and bust cycles. Though growth averaged a respectable 12.5 percent annually between 1993 and 2008, there were large fluctuations in either direction. There were even years when growth exceeded 25 percent, while in other years the market shrank. The financial crisis of 2009 caused a drastic decline of 41 percent, which has since been almost completely balanced out, although sales are not yet record-breaking. The record is still held by the year 2008, with a market volume of 6.4 billion euros. Should the overall economy continue to recover, I am certain that the market will break the record this year and the upward trend will continue for the long term.

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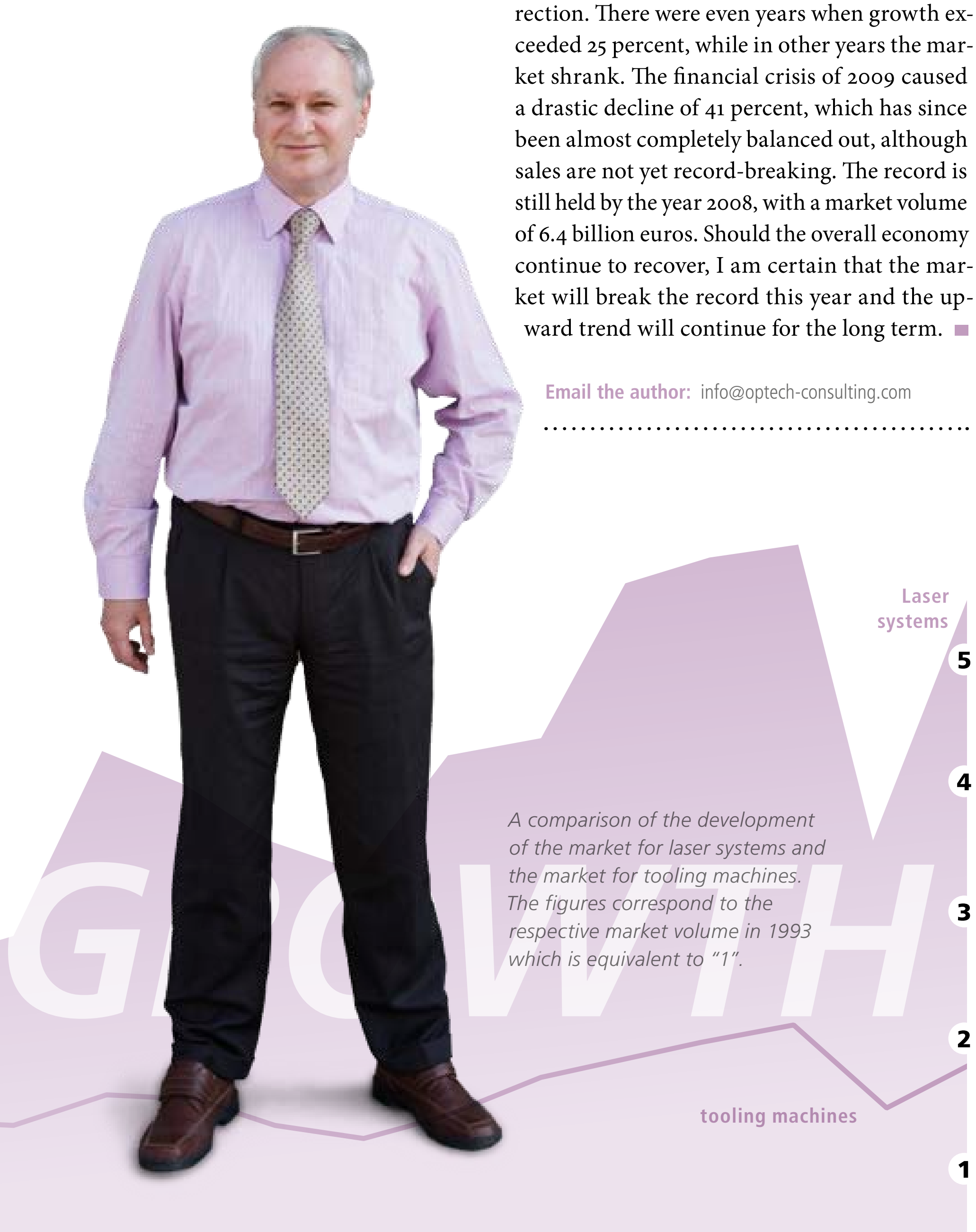
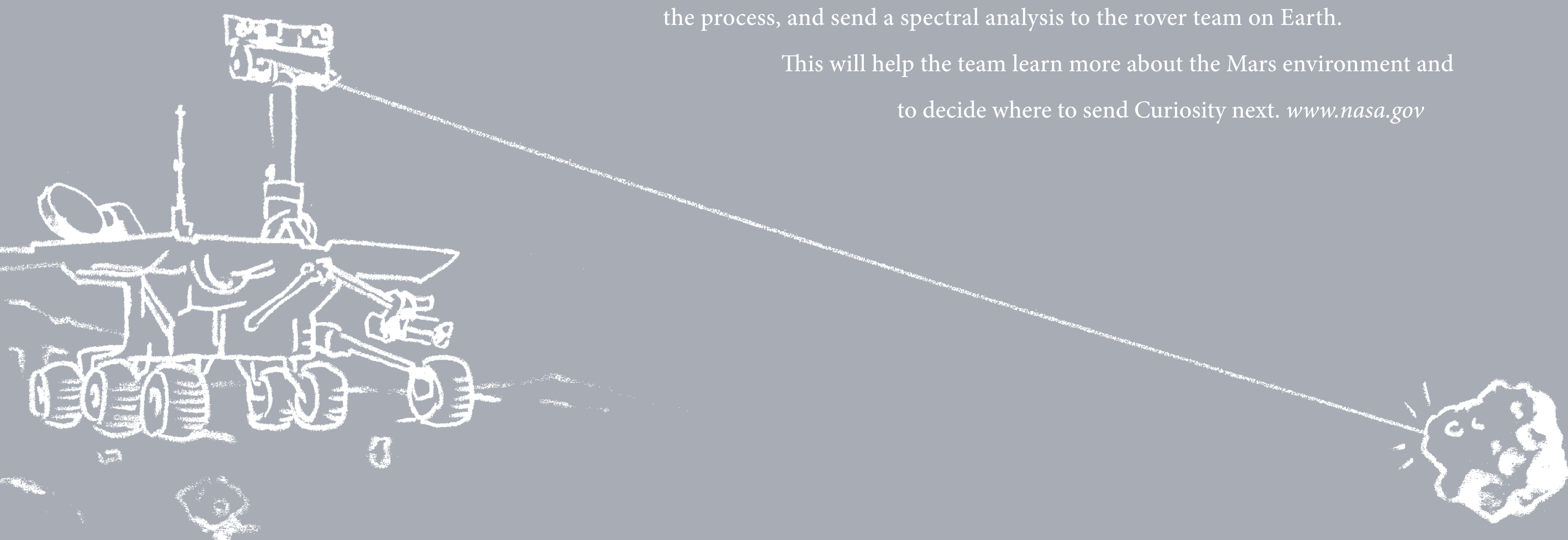


A comparison of the development of the market for laser systems and the market for tooling machines. The figures correspond to the respective market volume in 1993 which is equivalent to "1".

Where's the laser?

ON MARS. When the next NASA Mars rover lands on the fourth planet from the sun, its robot, Curiosity, will fire a few shots from its "laser cannon," not against hostile aliens, but rather in the name of science, or to be more precise, geology. From a range of up to 7 meters, the laser cannon will zap pin-sized spots on Martian rocks, creating ionized gas clouds. The "ChemCam" device on rover will film the process, and send a spectral analysis to the rover team on Earth. This will help the team learn more about the Mars environment and to decide where to send Curiosity next. *www.nasa.gov*



Angelika Grossmann, Gernot Walter