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Laser Community

THE LASER MAGAZINE FROM TRUMPF

Growing graphene

Carbon lattices fight corrosion

Cutting plastic

Lasers and thermoforming for thinner walls

CRAZY TIMES

PAUL SEILER EXPLAINS WHY MANY PEOPLE THOUGHT HE WAS MAD

→ Page 26

WWW.TRUMPF.COM

Less is more!

Pressure is growing to achieve more with fewer resources. Suppliers with laser know-how stand to gain.

PUBLISHER TRUMPF GmbH + Co. KG, Johann-Maus-Strasse 2, 71254 Ditzingen / Germany; www.trumpf.com
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Product quality, production speed and cost efficiency have long been seen as a magic triangle, the measure of all things in industrial manufacturing. But the rise of sustainability issues has now introduced a fourth element, and it is the crucial key to a future worth living. The "Blue Competence" initiative, launched by the German machine tool industry, makes perfectly clear what is needed to achieve sustainability. We at TRUMPF are committed to this cause, which is also embodied in our "efficiency plus" campaign within the company. But what does it actually take to cut the consumption of resources, energy, space, raw materials, consumables, and water? You not only need the right tools, but the right attitude, too. Consistently encouraging people to make conscious and intelligent use of resources is far more effective than simply making a broad appeal to save. The idea is to act prudently and to show restraint.

A healthy dose of soft skills is enough to put businesses on the right path. Producing goods sustainably requires a willingness to listen carefully. That means listening to your customers in order to understand their needs, and listening to your suppliers to understand why they act as they do. To make sustainability a living, breathing process, you also need to keep your eyes open. That means focusing on details and considering the impact they might ultimately have and, also, looking at the big picture to identify relationships and interactions. Sustainability also requires the ability to shift perspectives, a willingness to change and, most crucially, transparency. Opening ourselves to all the partners along the value addition chain, granting detailed insights into what we do, exchanging experiences in a group. Only by talking intensely with each other can the partners in the value chain learn from each other and work together to produce things in an energy-efficient, resource-conserving and eco-friendly way. That's when every instance of saving starts to have a positive impact — in both economic and ecological terms.

Exercise prudence!

Lasers can play a key role in this process; that's been clear for quite a while now. Light is a tool that supplies the driving force and makes many new developments possible. The shift from cathode ray tubes to LC displays or from halogen to LED headlights are just two of countless examples. There's virtually no limit to our speculations about what the laser might achieve in the future as a business enabler and process shaper. And that's why we can't just sit back and accept the goals imposed on us by legislators in the form of directives or regulations. If we're serious about sustainability, then we need to embrace continuous improvement processes — with no holds barred.

PETER LEIBINGER, D.ENG. H.C.

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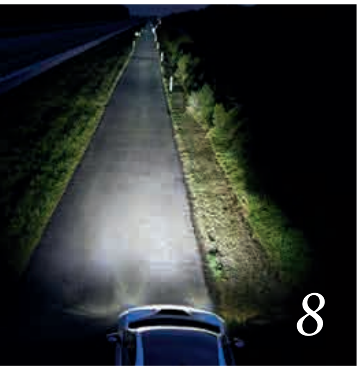

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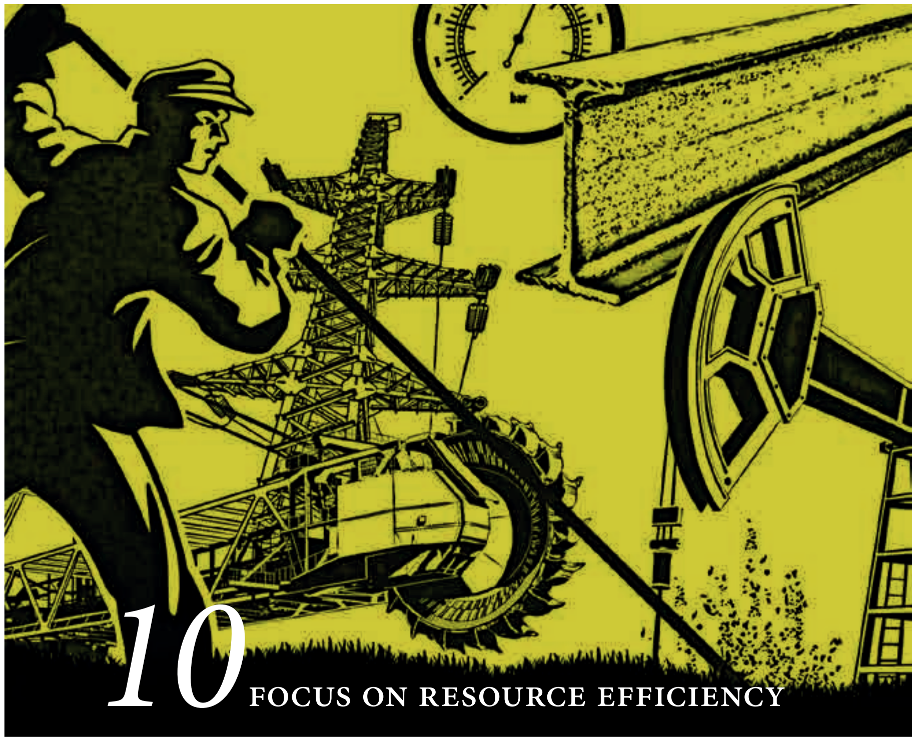
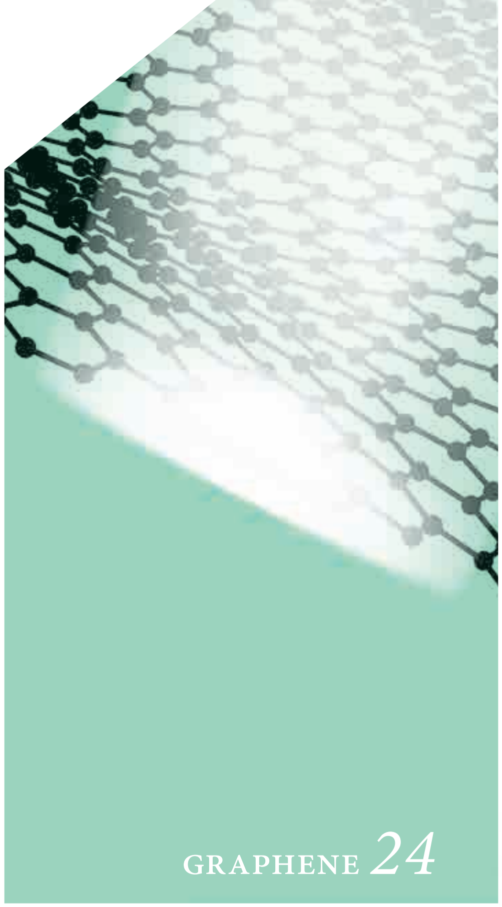


10 FOCUS ON RESOURCE EFFICIENCY

COMMUNITY



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REPORT

Professionals in plastics

Thin films and plenty of light: Georg Geiss is developing an alternative to injection molding. PAGE 22

SCIENCE

PROF. MINLING ZHONG

Atomic fence

Graphene could offer perfect corrosion protection just a few atoms thick — but only if ways can be found to apply it to large surfaces quickly and efficiently. SEITE 24

PEOPLE

"Everyone said I was completely crazy"

Laser pioneer Paul Seiler describes the wild era in laser's nascent years. SEITE 26

efficiency+

At TRUMPF, resource efficiency means highly productive machines designed for highly efficient manufacturing. Even the machines themselves can be produced without waste. Find out more: *www.trumpf.com/en/company/ressource-efficiency.html*

SPOT

--- SLS FOR EVERYONE
A key patent on selective laser sintering (SLS) has expired. That could give 3D printing a boost similar to the one that followed the expiration of patents on fused deposition modeling. *www.3dprint.com*

--- BLC TURNS TWENTY
When interest in lasers soared in Bavaria's automotive heartland, a group of professors decided the time had come to combine their expertise. This year marks the Bavarian Laser Center's 20th anniversary. *www.blz.org*

--- THE SEARCH FOR ALIEN LIFE
Scottish scientists have received government backing to build an infrared laser detector to assist in the search for alien worlds. They hope to install the device in the European Extremely Large Telescope now being built. *www.hw.ac.uk*

--- FASTER PULSES
A novel technology developed by a team from the Philipps University of Marburg (Germany) enables semiconductor lasers to emit light pulses faster and more efficiently than ever before. *www.uni-marburg.de*

--- NEW NANOLASER
A research group at Germany's University of Bayreuth intends to develop a novel nanolaser over the course of the next five years. Scientists hope that these nanoscale optical systems will help break the diffraction barrier. *www.uni-bayreuth.de*

--- MAKING FLIES FLIRT
Infrared laser triggers flirtation. When a team from the Howard Hughes Medical Institute (USA) activated neutrons in a fly's brain, the fly promptly began courting the next best object. *www.hhmi.org*

--- GRAPHENE MADE FROM SEMICONDUCTOR MATERIALS
Scientists in Luxembourg have succeeded in producing artificial graphene from traditional semiconductor materials. This ultra-thin super-material has the potential to revolutionize the fabrication of optical devices. *www.uni.lu*

192 high-powered lasers bombard the target zone in the center of this cylinder.

Heading for a breakthrough

First-ever fusion with positive energy output and plans for petawatt laser

In theory, the path to laser fusion has long been clear. At the National Ignition Facility (NIF) in California, 192 lasers packing 500 billion watts of power are fired at a tiny surface coated with fusion fuel, causing the hydrogen atoms to fuse. This process has been successfully carried out time and again. But now, for the very first time, scientists have managed to achieve fusion with a positive energy balance. "We basically got more energy out of the fusion fuel than we put into it," says Dr. Omar Hurricane, a researcher at the NIF. However, this only represents one small step forward. Even though the current laser can produce a fusion reaction, it is still not capable of triggering a self-sustaining process. "But we're going to keep pushing!" says Hurricane. The team has now commissioned a petawatt laser providing a thousand billion watts of power to help achieve their goal. *lasers.llnl.gov*

This LAM implant changes shape after a temperature change, thus easing insertion.

A treat for the ear

Generative processes for medical use

Laser additive manufacturing (LAM) opens new doors for many branches of industry. The most recent example in medical technology shows what this process can actually do. The German *Laser Zentrum Hannover* is working with the Hannover Medical School to create aural implants which, during the operation and responding to a change in temperature, change shape. This substantially simplifies the insertion procedure. LAM can also be used to produce implants that remain in the human body only temporarily. The organism can slowly decompose grids such as this, made of magnesium powder. *www.lzh.de*

"The era of the high-power laser dawned with my invention in 1964."

Dr. C. Kumar N. Patel

Fifty years have passed since Dr. C. Kumar N. Patel laid the foundations for the laser's successful modern-day use as a tool. In 1964, while working at Bell Labs in the USA, he discovered that carbon dioxide was an excellent laser-active medium. Based on his findings, he was the first person to build a CO_2 laser. This finally gave scientists access to a continuous-wave laser in the multi-kilowatt range. Even though solid-state lasers are steadily gaining ground, the CO_2 laser is still the most popular type of laser for industrial use. In 2000, Patel became a professor at the University of California, where he teaches in the field of in laser technology. *www.lia.org*

"Fondly known as 'Laser Liz,' Ms. Kautzmann has made a vital contribution to promulgating expertise."

ILS chief editor David Belforte praises Elizabeth Kautzmann

Elizabeth Kautzmann, laser and fabrication program manager at FANUC America, has been awarded the 2014 "Women in Manufacturing" STEP Award. "More fondly known as 'Laser Liz,' she is a valued contributor in the field of industrial laser material processing," says David Belforte of Industrial Laser Solutions. The STEP Awards were launched to foster the role of women in the manufacturing industry. "These women are the faces of exciting careers in manufacturing," says jury member Jennifer McNelly from The Manufacturing Institute.

www.themanufacturinginstitute.org

"The beam source itself has set a new world record."

Prof. Thomas Graf

A team of researchers from the Institute for Laser Tools (IFSW) at the University of Stuttgart, Germany has demonstrated the favorable performance of a new picosecond beam source when working carbon fiber reinforced plastics. They processed the materials using a pulse length of eight picoseconds, pulse energies of up to 4.5 millijoules and mean power of up to 1.4 kilowatts. "Due to the unique combination of high-energy, ultra-short pulses and mean power in the kilowatt range, our beam source enables high-precision processing at productivity levels never seen before," says Professor Thomas Graf, head of the IFSW.

www.ifsw.uni-stuttgart.de

Lawrence Livermore National Laboratory, Mandy Ott, University of California, Los Angeles, FANUC America, Universität Stuttgart, Laser Zentrum Hannover

LASYS
June 24–26, 2014, Stuttgart, Germany; International trade fair for laser applications in materials processing www.messe-stuttgart.de/lasys

LASER OPTICS CONFERENCE
June 30–July 4, 2014, St. Petersburg, Russia; International conference on laser research, technology and applications www.laseroptics.ru

IMTS
September 8–9, 2014, Chicago, Illinois, USA; The leading American trade fair for manufacturing technologies www.imts.com

LASERS FOR MANUFACTURING
September 23–24, 2014, Schaumburg, Illinois, USA; The LIA conference offers networking plus the latest in laser technology and manufacturing solutions www.lia.org/conferences/laserevent

INTERNATIONAL CONFERENCE ON ADVANCED LASER TECHNOLOGIES
October 6–10, 2014, Cassis, France; Series of conferences on the latest research findings, organized by the Moscow General Physics Institute www.altconference.org

LASER WORLD OF PHOTONICS INDIA
October 8–10, 2014, Mumbai, India; Conference and exhibition for the Indian laser and photonics community http://world-of-photonics.net/en/laser-india

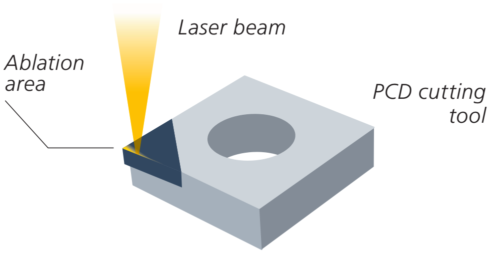
ICALEO
October 19–23, 2014, San Diego, California, USA; International Congress on Applications of Lasers & Electro-Optics www.lia.org/conferences/icaleo

EUROBLECH
October 21–25, 2014, Hannover, Germany; International technology exhibition for sheet metal working www.euroblech.com

FABTECH / AWS
November 11–13, 2014, Atlanta, Georgia, USA; North America's largest metal-forming, fabricating, welding and finishing show www.fabtechexpo.com

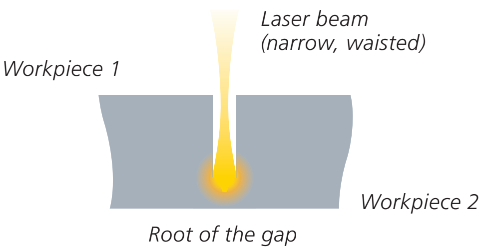
9TH JENAER LASERTAGUNG
November 20–21, 2014, Jena, Germany; Conference on beam sources, laser methods and applications in material processing http://www.lasertagung-jena.de

CONCEPTS



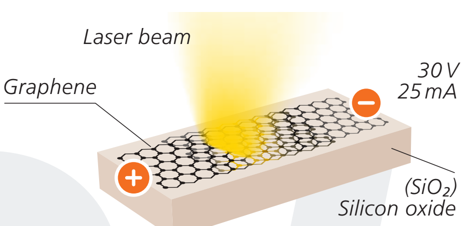
-- PCD LASER MACHINING

A laser polishing method can replace mechanical machining of cutting tools made of polycrystalline diamond. A measurement system ensures that the parts and the laser tool are correctly positioned to achieve the required degree of finishing without causing thermal damage. *www.ipt.fraunhofer.de*



-- WELDING 50 MM WITH 5 KW

This new method takes advantage of the high beam quality of modern solid-state lasers. It uses an extremely narrow beam to weld deep, narrow gaps from bottom to top in multiple passes with a weld seam nearly parallel to the flanks. *www.iws.fraunhofer.de*



-- WELDING GRAPHENE

Graphene is a two-dimensional lattice of carbon atoms and an extremely interesting option for many future applications. The CO_2 laser heats the welding point and is supported by an electrical voltage. The atomic lattices thus join. *http://bit.ly/LC-Joining-Graphene*

Laser headlights (right) turn night into day. LED headlight technology is shown on left for comparison.

Clear view ahead with laser light

Lasers could soon replace LEDs — BMW introduces laser headlights

In the fall of 2014, BMW will become the first automaker in the world to offer innovative laser headlights in a production vehicle. Thanks to laser technology for its high beams, the BMW i8 hybrid sports car lets drivers see as far as 600 meters. That's double the range offered by LEDs and uses up to 30 percent less electricity. Several high-powered laser diodes emit tightly focused laser beams which are directed through special optics onto a yellow phosphorus-filled lens inside the headlight assembly. This fluorescent phosphor material transforms the beams into white light 10 times brighter than conventional light sources. *www.press.bmwgroup.com*

The ultimate detector

Terahertz spectrometer detects hazardous mail without opening it

The Hübner technology company won plaudits at the 2014 Prism Awards for Photonic Innovation. Praise went to its T-Cognition terahertz spectrometer, which received first prize in the Defense and Security category. The T-Cognition system, which is approximately the size of a compact copier, uses laser waves to identify hidden drugs, explosives and other hazardous substances in letters and small packages. The system takes just seconds to scan each item, without even opening it. Hübner developed the T-Cognition spectrometer in collaboration with the Fraunhofer Institute for Physical Measurement Techniques (IPM) in Germany. "The T-Cognition system shows that no matter how new terahertz technology might be, it is already ready for use in industrial applications," says Professor Karsten M. Buse, who heads up the IPM. *www.ipt.fraunhofer.de*

Keeping letters private: The T-Cognition system need not open letters to detect drugs and explosives.

Hübner GmbH & Co. KG, BMW, rotwerk

Dr. Georg Kalss is responsible for materials technology at Haas Food Equipment GmbH. He and his team developed a laser-powered cleaner for commercial wafer baking systems.

"That tastes great"

There are many ways of cleaning commercial wafer forms, but none of them does the job well enough. So Dr. Georg Kalss from Haas Food Equipment decided to look for a new solution.

What kind of "dirt" are you faced with in producing pastry wafers, Mr. Kalss?

It's mostly fat and batter residue, which gradually are baked together into an extremely hard and stubborn layer on the plates. Our ovens are used to produce thousands of wafers a day. The giant baking trays are automatically filled and closed before being sent in sequence through the baking oven. When they emerge, the wafers are released – or sometimes not, if the plate isn't clean.

So how do you normally get rid of the residue?

You have to use really heavy-duty methods such as dry ice, chemicals or brushes, but each of those methods has one or more disadvantages. Dry ice is expensive, chemicals harm the environment, and cleaning with brushes is time-consuming and prone to error. You also risk scratching the surface of the baking trays, which ultimately means that you can't release the wafer layers even from clean baking plates. So we decided to look for a new tool.

The cleaning head between the baking plates. Their limited opening angle and the relief on the plate surface made for headaches.

… and that's when you hit on the idea of using a laser?

We delved into every available option in our search for a fast and reliable method that wouldn't damage the baking trays. A laser meets those requirements and is really very fast indeed. It can clean an average oven in just one or two shifts – a lot faster than cleaning with brushes or chemicals, which can take several days. The laser offers all the benefits of the other methods with none of their disadvantages. The results are really a sight for sore eyes!

How do you get the laser into the oven?

You don't. The baking trays come to the laser. The entire laser cleaning system is docked in a fixed position at the wafer baking oven and the trays are passed under the laser beam. That means the laser gets to clean all the trays, one after the other. The only challenge was getting the laser between the trays, since the waffle irons open to a maximum of 30 degrees. The relief on the surface also gave us something of a headache early on, because you can't constantly adjust the focus position. But we eventually solved that using an intelligent beam guide system.

Gallery showing the system and more about the solution: http://bit.ly/LC-Haas-en

Haas Food Equipment GmbH

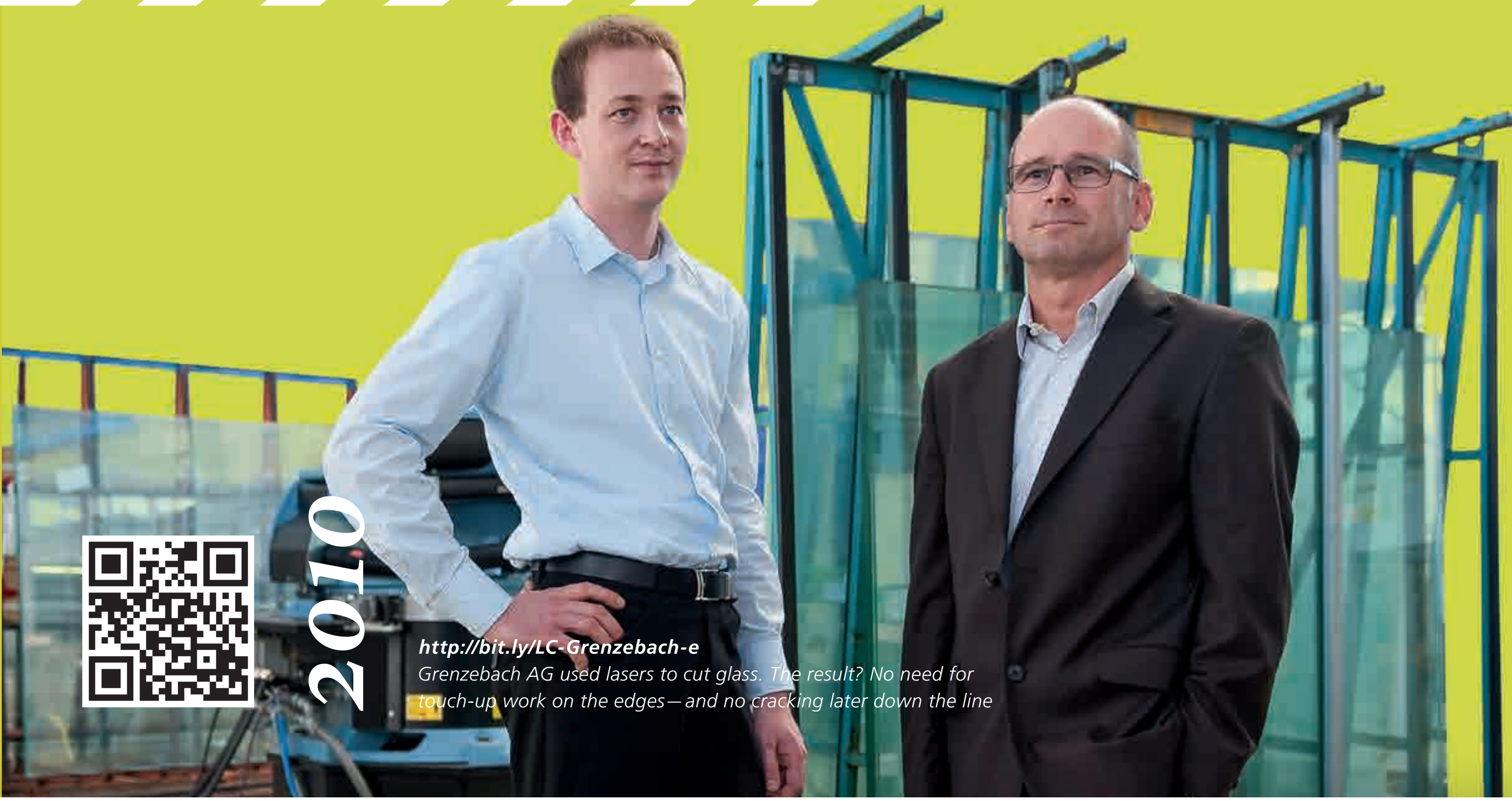
2008

http://bit.ly/LC-VanRob-en
VanRob substituted laser-welded steel structures for aluminum in GM trucks. The results: less weight, less energy use

We've written time and again about how lasers boost productivity, cut costs and reduce weight ...

http://bit.ly/LC-Laser-More-e
Laser & More welded lighting and other facade components for the Burj al Khalifa. Thinner sheets mean less material

2009



2010

http://bit.ly/LC-Grenzebach-e
Grenzebach AG used lasers to cut glass. The result? No need for touch-up work on the edges—and no cracking later down the line

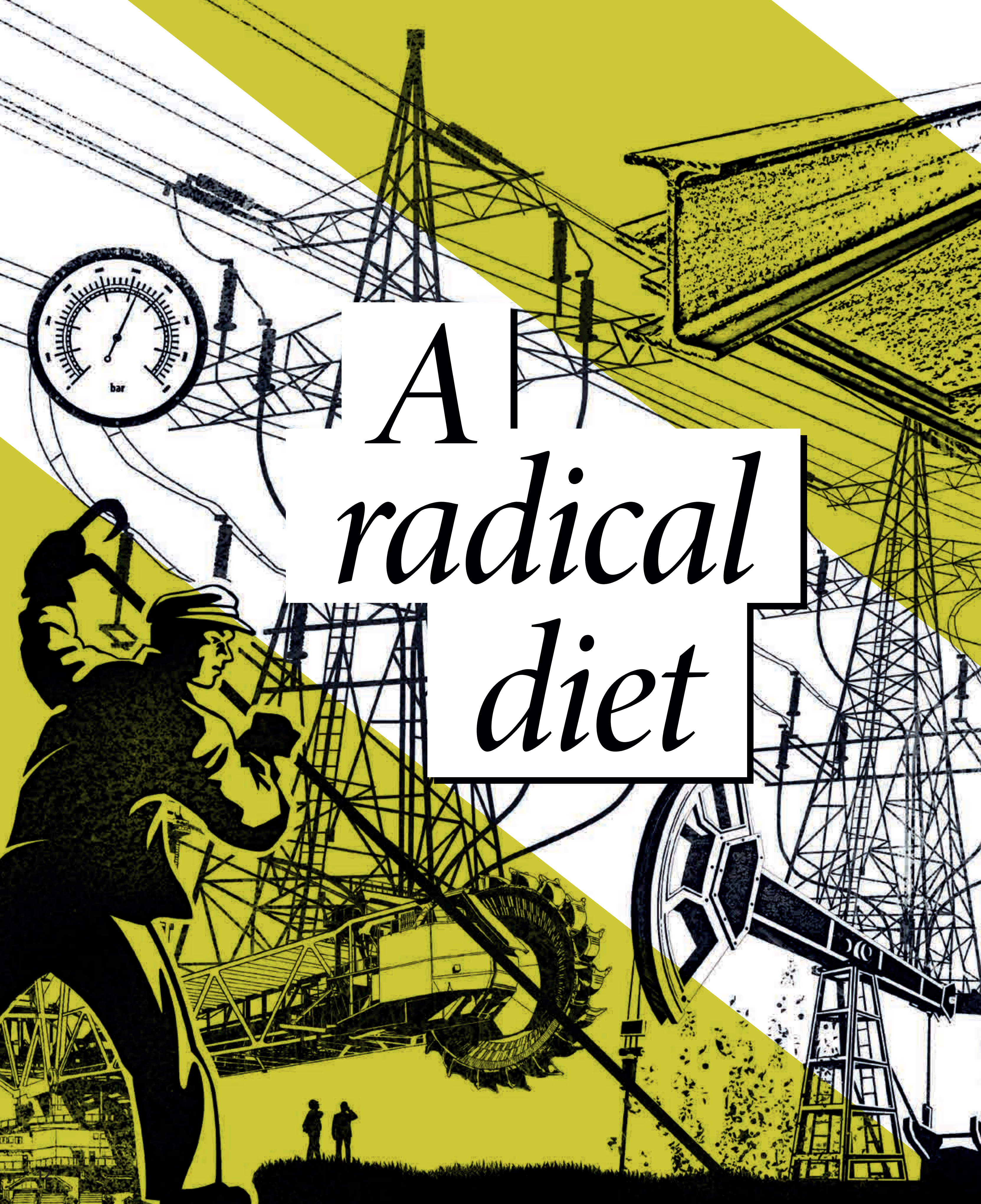
What's new, however, is that the lasers' ability to help reduce consumption of energy and resources is taking on importance in its own right.

2012

http://bit.ly/lc_ESAB-e
ESAB is making major inroads with highly productive laser hybrid welding, making for lighter structures and less energy consumed for deep welds

KD Busch; Simon Koy; Peter Oppenländer; Paul Zoeller

A radical diet



Expectations on the part of consumers and politicians are clear: Manufacturing processes are to consume less energy and fewer resources.

The ability of suppliers to help slash energy and resource consumption in the overall manufacturing process is becoming an increasingly key issue in the supply chain.

It may sound obvious, but Marko Pfeifer argues that sometimes people need to be reminded of an inescapable fact: "Zero consumption is not a feasible option. If you want to make something, you have to use energy and resources." As an expert working on the Green Car Body project at the Fraunhofer Institute for Machine Tools and Forming Technology (IWU), Pfeifer knows what he's talking about. The project's goal was to find ways of cutting the amount of energy and resources required to build cars. Pfeifer coordinated the InnoCaT4 sub-project, which investigated the savings potentials in car body production. "But the same process could be applied to a refrigerator or cell phone," says Pfeifer. The processes might vary somewhat, he explains, but one key finding would, in all likelihood, be the same. "It will only work if the suppliers cooperate," he emphasizes.

Many companies have direct control over less than half of the energy and resources that go into their final products. As a result, making responsible use of resources inevitably becomes an issue that affects the entire supply chain. The automotive industry is far from being the only example, but it is certainly a context that makes this fact clear at an early stage. That's because the automotive sector is a key global industry and an early adopter when it comes to embracing new processes and methods. If automakers decide something is important, the shifts in behavior and technological decisions which follow will affect approaches and investments in companies all over the world.

The significance of energy and resource efficiency as a key issue in the industry is illustrated by a presentation given by Ingrid Paulus, senior manager for Green Production at Audi AG in Ingolstadt. She spoke to 270 guests in the auditorium at TRUMPF, an Audi supplier. "We gather data on everything that consumes energy in our production process to see where potentials for improvement lie," said Paulus. She then listed a number of measures to achieve savings, most of which require the cooperation of suppliers. For example, the body manufacturing facility for the new Audi A3 has combined the welding controller and the welding gun control system into a single unit in order to cut the capital and running costs and to shrink the machine's footprint. The Audi production engineers have also carefully studied how their robots move and determined that gentle, curved motions require far less energy than abrupt, angular ones. Paulus also sees significant potential in smart lighting systems: "Robots don't need light. Only when humans have to intervene is there a need for illumination," she says. At the same time, intelligent shut-down concepts for both short and long interruptions in the work are playing an increasingly important role in reducing the consumption of energy and consumables. All in all, these methods can save hundreds of megawatts.

"We gather data on every user of energy, to find potentials for improvement."

Ingrid Paulus, Audi AG

All these approaches appear in reports issued as part of the Green Car Body project and none of them is specific to any one product. But they inevitably prompt suppliers to find new solutions, some of which will subsequently emerge in other industries. In 2012, *Laser Community* published an article on the manufacturing of ovens at Electrolux. EDAG AG developed a laser welding and cutting line for the manufacturer, drawing on its experience with production lines for car makers. This shows clearly that an oven is just another kind of body shell, incorporating a baking cavity.

In fact, many job shops are expanding their business using exactly this realization. It is often dependable and substantial order volumes from the automotive industry that make it possible for firms to invest in modern manufacturing technologies such as 3D laser cutting systems. Once this equipment is installed, the job shop can start to offer laser processing to other customers as well, thus manufacturing their products more efficiently. This process is reinforced by rules laid down by the automakers. For example, VW insists that agreements with its suppliers incorporate the company's own standards — intended to minimize environmental impact, promote re-

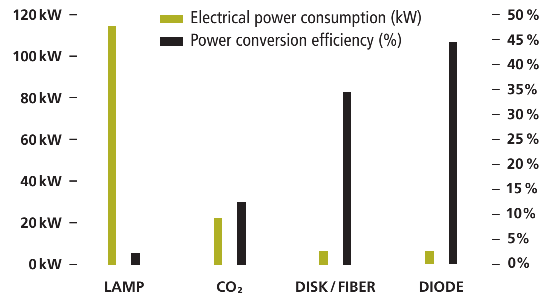
Markus Weißenhorn (shutterstock.com); Ingrid Paulus

cyclability and eliminate certain materials. In addition, the VW Group also requires its main suppliers to operate a certified environmental management system in accordance with ISO 14001.

As a result, closely controlled energy and resource consumption is steadily becoming more prevalent among automotive suppliers. Michelfelder Automotive is a good example of this trend. The company's primary products are stainless steel components for exhaust systems. Executive director Peter Sohmer explains how they meet repeated customer calls for efficiency increases: "We optimize the systems we use and carefully plan our manufacturing process to optimize machine utilization. We and our customers also agree on tolerance samples to avoid wasting materials. Along with the energy saving concept we have introduced, we have an internal CIP which regularly highlights potential for improvement," he explains. "We also turn to our suppliers and partners to identify further potential for savings."

LESS CREATES MORE

Relevance of system efficiency at 4 kW power level



Source: TRUMPF

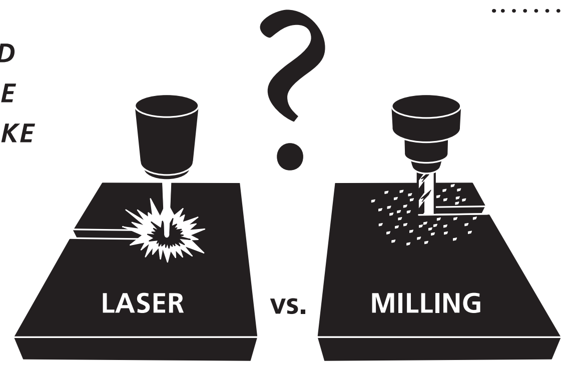
The laser boosts efficiency and reduces power consumption, but its greatest strength lies in its ability to increase productivity.

The findings and ideas that emerge from this process are then passed along to other companies within the Michelfelder Group, many of which have little or nothing to do with the automotive industry. One of these companies is Michelfelder Metall & Lasertechnik, where the Group's laser expertise is concentrated. Working as a job shop, it offers its expertise to customers from a wide range of other industries, too. Another example is Michelfelder Edelstahltechnik. It utilizes the Group's experience in stainless steel to offer solutions in other industrial sectors such as clean room technology, the food industry, mechanical engineering, and building technology. Werner Huprich, one of the company's two managing directors, explains their approach: "The automotive industry has no monopoly on high-pressure competition, major technological advances, and customers with very high expectations. We respond by increasing the level of automation and eliminating as many post-processing and finishing steps as we can. That's why laser processing, and laser welding in particular, are playing an increasingly important role in our business."

The fact that laser welding has become one of the key technologies for energy-efficient design is confirmed by welding engineer Holger Fischer. He explains how Volkswagen AG improved the production process for its differential and double clutch assemblies: "The first step we took was to eliminate the screws and rivets we previously used for fastening, replacing them with laser welding using CO_2 lasers and filler material. That reduced component weight by approximately one kilogram," says Fischer. "In the second stage we switched to disk lasers. These offer almost twice the efficiency and significantly increase process speed." Fischer's second example, the double clutch assembly, has nine joins, all of which are laser welded. All but two of these are butt joints, doing away with the need for flanges and additional material. VW also makes particularly efficient use of its disk lasers, as Fisher explains: "We use laser light guides so that a single beam source can supply multiple welding stations. That cuts out most of the non-productive stand-by time."

Making efficient use of the beam source is just one of the many techniques that more than compensate for the laser's high power consumption, which can initially appear to be something of a handicap when compared to other methods. This becomes even clearer in comparisons that take account of the entire process. For example, Frank Riedel from the Fraunhofer IWU has been working on thermal joining processes in the Green Car Body project. Right from the outset, he rejected the idea of using parameters such as

WHICH METHOD REQUIRES MORE ENERGY TO MAKE A ONE-METER CUT IN FIVE-MILLIMETER SHEET STEEL?



The answer:

LASER *(with a power consumption of 20 kW)*
CUTTING: 12 sec, 0.144 kWh
MATERIAL LOSS: 0.078 kWh in the kerf

MILLING *(with a power consumption of 0.4 kW)*
CUTTING: 14 min, 2.043 kWh
MATERIAL LOSS: 1.95 kWh in the chips

See the calculations at: http://bit.ly/LC_LaserxMilling

Markus Weißenhorn; Michelfelder Group; Joining Technologies power consumption or line energy as a sole measures of comparison. "That approach leaves too many factors out of the equation. So we decided to look at the joining processes as a 'black box.' We packed into that box everything you need to join two workpieces over a length of one meter. That included direct energy consumption, the indirect consumption required to prepare the process, post-processing and finishing, process duration, material consumption, space requirements, and so on." The team then compared scenarios using different joining processes. Riedel explains what they found: "If you're looking for the maximum energy efficiency for a particular assembly, then the ideal results will generally be a mix of methods that includes the laser." Yet this runs counter to a key trend in manufacturing: "Current thinking is that we should be using a smaller number of methods, but more flexibly," says Riedel. That means there is still plenty of scope for the role of the ultra-flexible laser to evolve.

Even when viewed from the energy and resource consumption perspectives, Riedel argues that the laser has clear advantages over other welding methods. "Obviously you have to melt the material too, but the narrow focus of energy means that the volume fused is extremely small," he says. That explains why the laser comes out on top in many scenarios even though its wall-plug efficiency lags far behind other processes. The laser applies its energy to the workpiece extremely efficiently, heating and melting only a minimal, near-ideal volume. And that's not all, as Riedel explains: "You no longer need to waste energy needed to prepare and close large gaps, to eliminate warping and stress, for straightening or grinding down parts — and in many cases that's enough to beat other methods when it comes to overall energy efficiency."

If the laser seams or the laser cuts — depending on the application — serve to create more stable structures from less material, then that boosts the laser's efficiency rating even higher. This has been confirmed recently in the automotive industry — in the power train, for instance, but also in the high-strength steels used in car body construction. The thinner sheet metal for the specially designed body components significantly reduces the weight — or the mass — of the materials. This has been made possible by highly productive laser machines which can easily handle this tough material even when dealing with enormous quantities. At the same time, automakers' efforts to reduce weight and material have opened up new business opportunities for job shops in the sheet steel process chain.

Similar benefits emerge when lasers are used to extend the service life of components manufactured using large amounts of energy and materials. Repair welding has evolved into a business line in its own right — and Michael Francoeur has been part of this growing trend since the beginning. In 2005 the American entrepreneur decided to seek maintenance contracts from the aeronautics and aerospace industry for Joining Technologies — his job shop. Cost savings were in the limelight, because this industry uses many high-precision components that are very expensive to produce. Using welding to repair damage, wear, and manufacturing flaws is often considerably cheaper than replacing components completely. Francoeur's business partner and CEO of Joining Technologies, Dave Hudson, also points out the sustainable, resource-friendly aspects of his work: "Even though this still isn't a high priority for many of our customers, it's worth noting that we generally use only a fraction of the energy and material that would otherwise be required to make a new component." Turbine blades and impellers are the most commonly cited examples for this type of repair. But solid shafts and cylinders from large marine diesel engines are also worthwhile candidates which require far more energy and materials to replace than to repair.

Whichever way you look at it, rethinking energy and resource requirements and the determination to make savings in the use of energy and raw materials are already very prevalent, especially in the intensely cost-conscious automotive industry. "We were originally hoping for potential energy savings of nearly 50 percent," says Pfeifer. "We didn't quite achieve that in every research project. But in the end everyone agreed that the savings potentials we had found should be put into practice. It changed the way a lot of people think." Many suppliers are noticing that change, too — and a growing number are building their futures on it.

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"Energy-saving concepts, CIP, reducing material waste … we work hard to improve what we do – and we pass on those expectations to our suppliers."

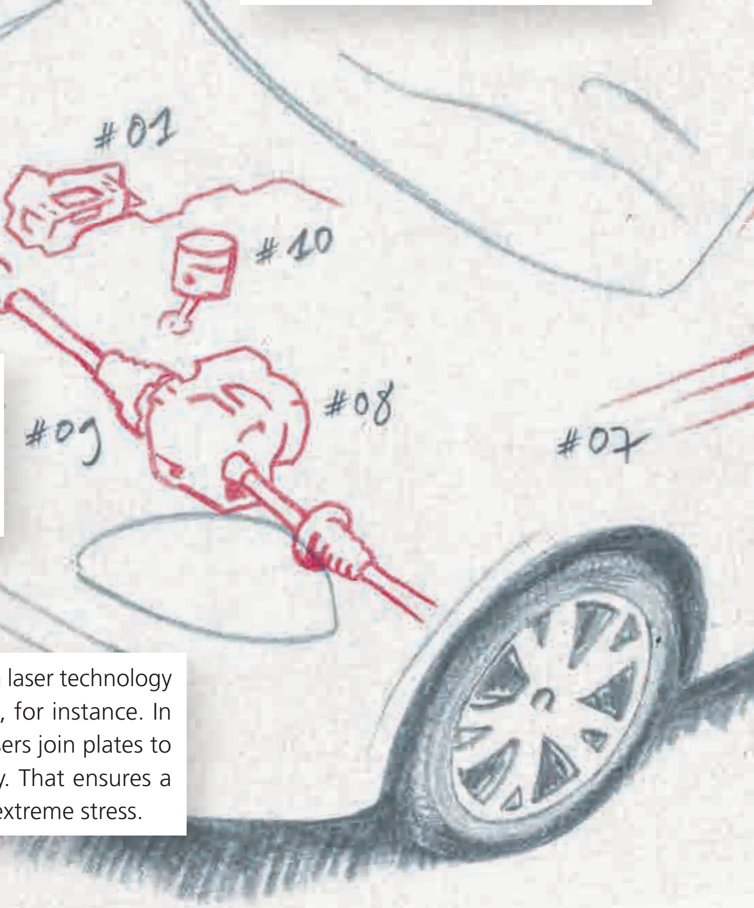
Peter Sohmer, Michelfelder Automotive

"In most cases we can repair components using a fraction of the energy and raw materials that a new part would have required."

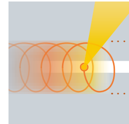
Dave Hudson, Joining Technologies

At the turning point

Tomorrow's new models will be lighter than their predecessors. Not only will that boost mileage, but also reduce weight and the amount of material used. This is due primarily to the increased use of laser light.



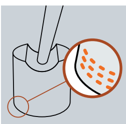
#01



Any additional material means additional weight — and that even applies to welding rod. A new technique known as laser stir welding moves the laser beam in a spiral motion along the joint gap. This motion causes the beam to melt material to the right and left of the gap, widening the melt pool and making it possible to bridge even large gaps. Examples are welding sub-assemblies such as seat supports and mounting blocks for engines and power trains.

www.laser-community.com/3448

#10

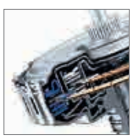


Less friction means higher mileage. Texturing components such as pistons using short-pulse lasers improves engine efficiency. The result: reduced CO_2 emissions — good for the environment and sustainability.

#09

Laser-welded seams can support extreme loads. That makes it possible to reduce weight in the power train. To make sure that no cracks or brittle spots form in the deep laser seams, the joints — and only the joints — are pre-heated using an extremely energy-efficient induction process. *www.laser-community.com/3462*

#08



Automotive suppliers also benefit from laser technology — when constructing the dual clutch, for instance. In contrast to conventional methods, lasers join plates to the hub without injecting any energy. That ensures a lasting connection even at high speeds and under extreme stress.

#07

Substructures, side panels, and seat brackets are manufactured using highly productive remote welding systems that reduce robot motion. This method welds three to four laser seams a second. New 3D scanner optics now also move the laser in the third dimension, so the robot arm no longer has to follow every step to maintain the focus.

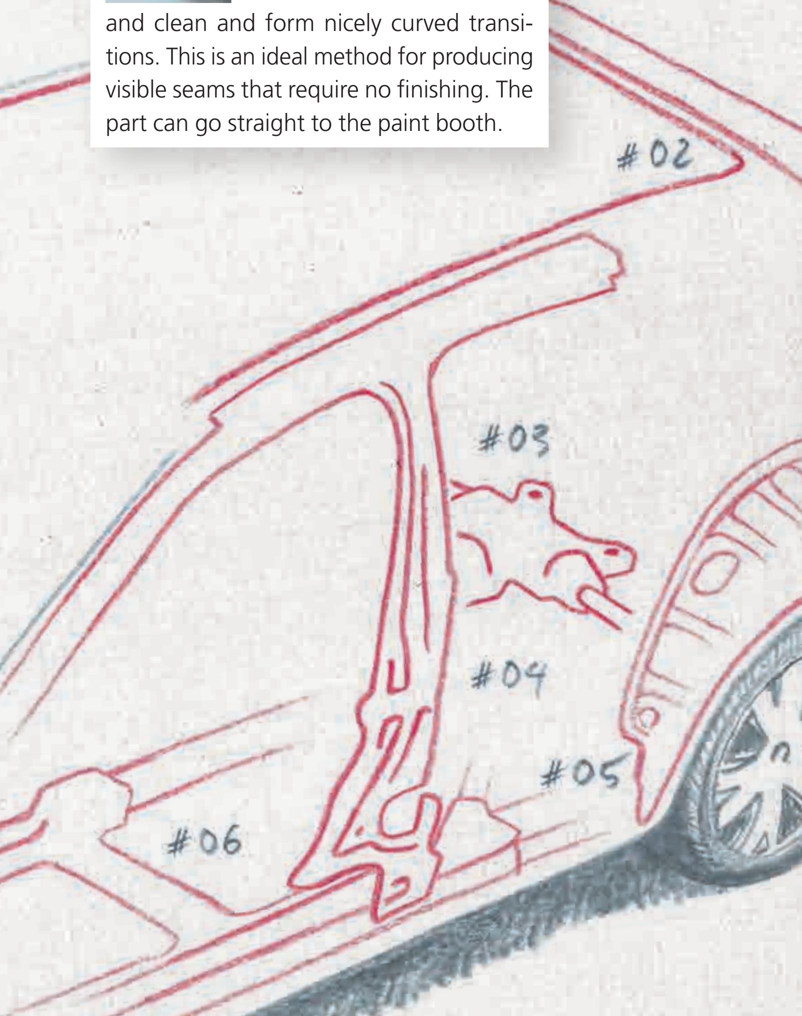
www.laser-community.com/3980

#02

Tailgates and car roofs contain soldered joints created by lasers. The surfaces of these soldered seams are smooth and clean and form nicely curved transitions. This is an ideal method for producing visible seams that require no finishing. The part can go straight to the paint booth.

#03

The crown wheel and casing for differentials have long been joined using lasers. Nowadays, short-pulse lasers are also used to ablate phosphate layers, grease, and corrosion protection compounds to ensure that the welding process is smooth and spatter-free. *www.laser-community.com/2277*



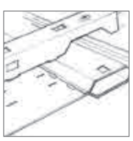
#04

When press-hardening assemblies such as the B-pillar, lasers cut the blanks prior to pressing. But that's not all. With user-programmable 3D machines, lasers also add holes and perforations and trim the outside edges of the formed parts. That eliminates tools and reduces the material and energy consumption required to produce and repair them. *www.laser-community.com/3472*

#05

Hot-worked steel grades such as Usibor® are 30 to 50 percent lighter than conventional cold-formed alloys. They are the base material for tailor-welded blanks. Lasers weld these blanks — but not before a short-pulse laser has removed the aluminum-silicon coating at the joint at an extremely high ablation rate.

#06



Unitized steel bodies can be made lighter by using profiles instead of drawn components and flanged connections. To do this, a sheet — significantly thinner than what was previously used — is reinforced with half-profiles. A laser welds them with a series of short fillet welds. It may also join, on the back of the sheet, the tabs of the half-sections sticking through the sheet. During these processes, heat input remains so low that no thermal distortion arises, in spite of the large surface areas.
www.laser-community.com/1481

Lasers have long been an irreplaceable tool in the auto industry — for applying materials, texturing, cutting, and welding — and an integral part of the drive toward lightweight construction.

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Illustration: Gernot Walter; TRUMPF

“The *only* way to remain competitive”

It’s all about precision: Keeping pace with the requirements of the automotive industry puts efficiency front and center—and that includes the manufacture of seat components. This is why Dr. Hur Yoon-Ho, Vice President of Daewon Precision, favors using high-tech laser technology.

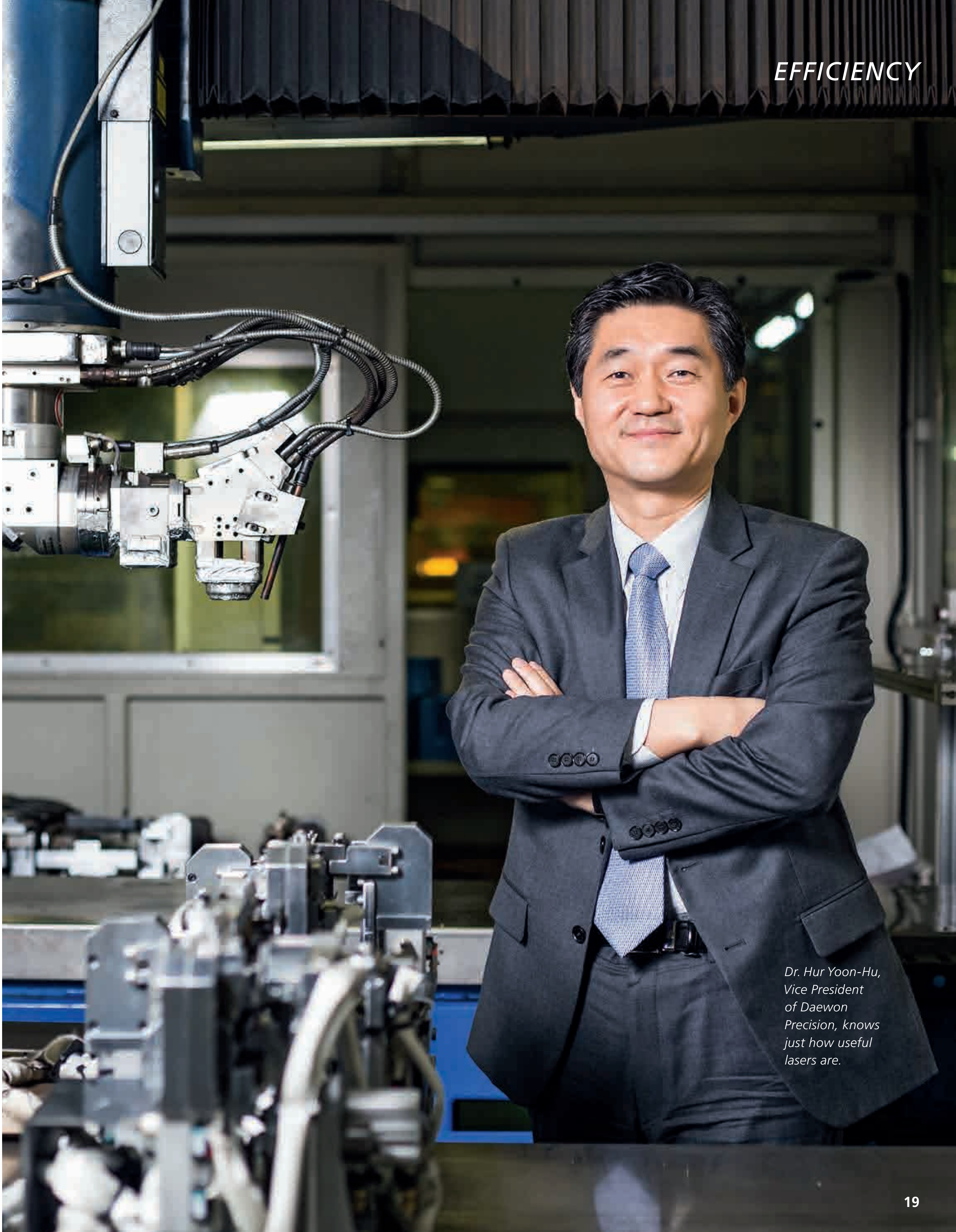
Dr. Hur, your company manufactures all kinds of components for automotive seating. Given that many of them may not be what we first see when we look at a car, is there actually anything that drives innovation for standard parts such as seat rails or adjustment mechanisms?
Indeed there is and I would like to stress this point. Industry-wide megatrends affect us as well. Keeping pace with developments in the automotive market means that cars have to become ever more efficient. But it’s not enough just to fine-tune the engine or to manufacture a lightweight body. Each and every component deserves a trip back to the drawing board.

And in what ways is it worthwhile to take a fresh look at your products?
That’s a complex issue. Our customers are calling for car seats that are increasingly smaller and lighter. Every gram counts, but obviously nobody wants to pay a higher price for this. Amid all the calculations, we must never lose sight of quality—because at the end of the day, our products play a major role in road safety. A detached seat rail can have fatal consequences in a crash. But in everyday driving, too, owners have very high expectations. It’s especially awkward for manufacturers to receive complaints about what their customers see as simple, functional parts—things like seat adjusters. All this greatly affects how we manufacture our products. In order to achieve the right balance of efficiency, quality and price, we purposely seek out high-tech solutions such as lasers. That way we know we’re equipped for the future.

So you see yourselves very much as a high-tech manufacturer?
Absolutely. Since our company was founded in 1983, it has changed incredibly quickly—most notably in how we manufacture. In order to keep pace with the market requirements I just mentioned, we had to develop and adapt a whole range of new technologies. In doing so, what we want is to get an edge on our competitors or extend our lead over them. Unlike others in our sector, we introduced techniques such as laser welding quite early on. We’d already started using lasers on a seat rail production line back in 2008, and now we’re using laser welding machines to manufacture five parts for three types of vehicle. Furthermore, we are considering a different item and technology on the new type of vehicle we recently landed the contract for. One part suitable for laser welding is the seat rail. Welded to it by laser are brackets linking it with the frame for the cushion. Another example is the seat adjuster. It was previously manufactured by flanging together the upper and lower covers. Laser welding eliminates this flanging operation and saves on materials. This is one small step toward weight reduction. Now we are evaluating laser welding for the side member of the back seat frame and adjuster.

What alternatives are there to laser welding, and why did you decide against them?
Some of our competitors join parts using mechanical techniques, such as bolts or rivets. Although they’re cheaper than welding, these joins result in a bulkier final product and as such contradict the trend toward miniaturization. What’s more, such techniques add extra material to the assembly. But our automotive customers expect us to be efficient with resources, so we’d rather shave material than add it. That means the only other techniques we might consider would be CO_2 welding and MAG welding. Welded seams for rails or adjusters have to be really strong to function perfectly throughout the vehicle’s service life. So what we need is an efficient technique for producing extremely strong and inconspicuous weld seams while reducing and not increasing product weight—and the only technique that’s up to the task is laser welding. Following market demands for weight reduction, we have used high tensile strength steels for seat rails for three years, now. To achieve

Daewon uses laser welding in the manufacture of many parts including headrests, seat rails and adjustment mechanisms. This technology maintains the company’s competitive edge.



Dr. Hur Yoon-Hu, Vice President of Daewon Precision, knows just how useful lasers are.

Daewon Precision; Yon Je-Seung / Studio Africa

A boltless welded part used to attach a car's seats to its body. Laser welding is the only way to achieve welds that are strong enough.

This retainer holds the release lever to slide the seat back and forth. It is produced using spot and seam welding.

Quality assurance on Daewon's state-of-the-art production line, making it possible to conduct non-destructive monitoring of this part's weld depth.

this, we have rapidly improved press technology and joining technology. We have installed a high-precision press and have started to use the laser. The trend is to use more and more high-tensile steels in new vehicle models.

Is this approach also cost effective?
All our products are produced in vast quantities, and this is where I think lasers really prove their worth. Since lasers can help achieve high throughput rates, using them definitely pays off for us. What's more, they are dependable. We're proud of being able to call ourselves a zero-defect company and that claim relies heavily on laser welding's excellent process reliability. Since we don't produce any rejects, we use less energy and fewer resources. Taking such a high-tech approach allows us to meet our customers' needs and stay ahead of the competition.

You were able to introduce lasers without any problems, then?
Programming the lasers to achieve the required welding precision did present us with a number of challenges. Our expertise in industrial processes is based largely on experience during recent years. Since there are many different geometries, material thicknesses and material types, we must identify proper welding parameters, including laser power, welding speed, focal point and sequence of welding positions. We are optimizing this procedure for the best quality with minimal distortion. There were also changes to be made outside the welding process itself. As the tolerances of our pressed parts were too great for lasers at the time, we had to revise our processes to make them laser compatible. We expanded our quality assurance activities to include non-destructive techniques and real-time monitoring of the welding procedure. Each of these measures helps us maintain our current zero-defect status, which lets us assume a very favorable position in the marketplace.

What importance do you see for lasers in the years to come?
Lasers play an indispensable part in how we can remain competitive. We're currently considering switching to laser welding for two further product lines. The fact that we've been working with lasers for several years is a key advantage. That made it easy for us to adapt to the trend toward more lightweight vehicles, because we were in a position to offer solutions straight away. And this is something we're looking to maintain — always looking into what we could do next. This is how we achieve lasting success. ■

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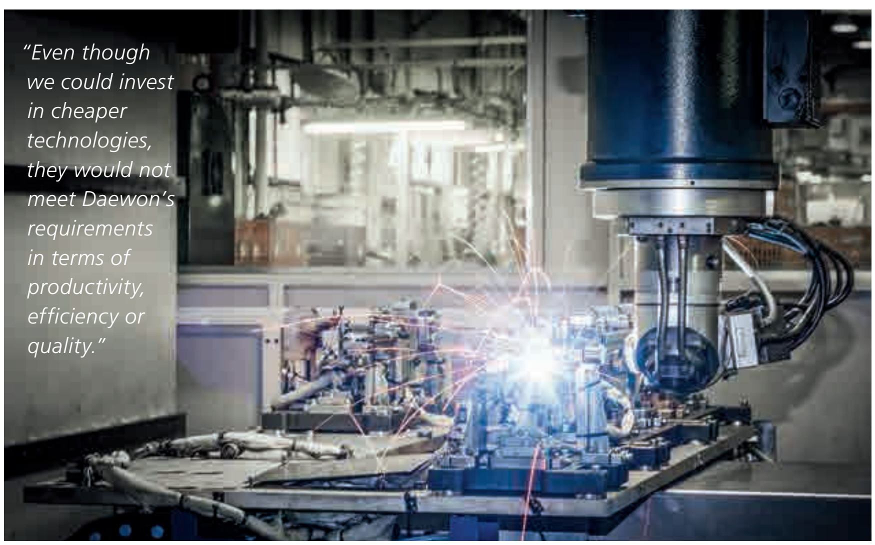
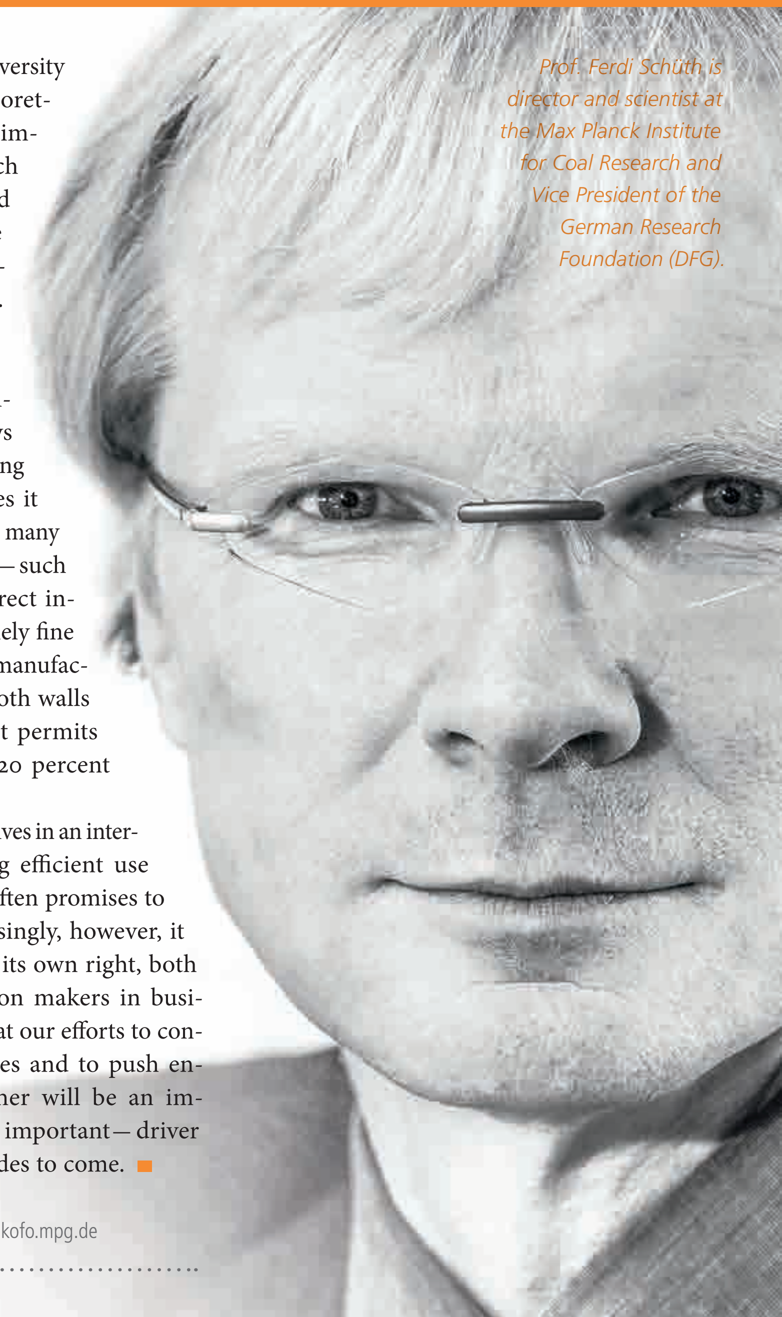
"We've been working with lasers for years, and that gives us a decisive competitive edge."



Yon Je-Seung / Studio Africa

The inventor's hour

Prof. Ferdi Schüth, jury chairman for the German Future Prize, is convinced that the push for resource efficiency will become industry's new innovation driver.



Prof. Ferdi Schüth is director and scientist at the Max Planck Institute for Coal Research and Vice President of the German Research Foundation (DFG).

"Save, save!" That's often what it sounds like when politicians or environmental groups urge efficiency and further reductions in resource consumption. In our mind's eye we can see their raised index finger. But there's also a completely different take on efficiency: "Forward, forward!" Because as we move toward using ever fewer resources, curiosity is a much more effective driver than austerity, and "smart" products will be more readily accepted than puritanism.

There's no denying we're under pressure. Demand for raw materials is rising while supplies are dwindling, with the result that they are getting more expensive. The world economic crisis that started in 2008 only briefly slowed the long-term trend toward higher prices for things like crude oil. So now it's not just individual entrepreneurs but in fact entire economies that are striving to free themselves from the dominion of commodity prices.

From a global perspective, a critical challenge facing humanity is figuring out how to secure supplies of energy in the future. The issue is multi-facetted: How much energy do we need? How can we assure mobility? Which energy sources can we use? How do we adjust our energy infrastructure to accommodate them?

While we can only begin to guess at the answers today, we do at least know where the answers will come from. If we want to solve humanity's energy problems, there are two things we will need more than anything else: researchers' eager spirit of discovery and engineers' patient will to come up with new and useful products.

A case in point is the collaborative development of the industrial ultra-short pulse laser, which we honored by awarding it the 2013 German Future Prize. The University of Jena delivered the theoretical models and the preliminary experiments, Bosch developed the process, and TRUMPF implemented the requirements for an industrial-strength beam source. With this product, resource consumption is reduced in two ways: first, the ultra-short pulse laser allows highly precise "cold" working of materials, which makes it extremely efficient. Second, many resource-saving products—such as innovative gasoline direct injection valves with extremely fine spray holes—couldn't be manufactured without it; the smooth walls and custom geometries it permits ensure that engines use 20 percent less fuel.

Currently we find ourselves in an interesting transition. Making efficient use of resources and energy often promises to bring down costs. Increasingly, however, it is being seen as a goal in its own right, both by society and by decision makers in business. There is no doubt that our efforts to consume ever fewer resources and to push energy efficiency ever higher will be an important—if not the most important—driver of innovation in the decades to come. ■

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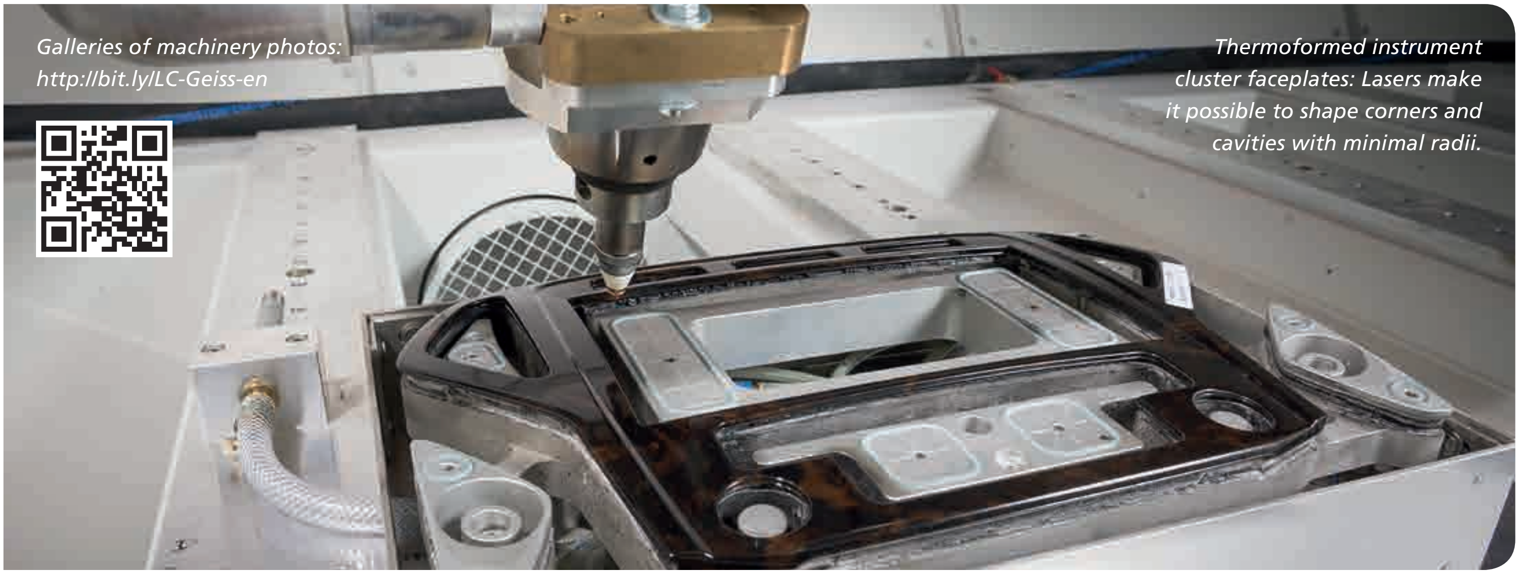
Deutscher Zukunftspreis / Ansgar Pudenz



Galleries of machinery photos: http://bit.ly/LC-Geiss-en

Thermoformed instrument cluster faceplates: Lasers make it possible to shape corners and cavities with minimal radii.

Manfred Geiss uses light to cut thermoformed components.

Plastics professionals

Contours and cut-outs typically have to be added to thermoformed components after vacuum-forming is complete. Geiss AG is the only company of its kind worldwide to use the laser as a tool to machine contours.

No machine goes to the customer without a powerful extraction and filter unit (shown at left).

KD Busch

The Geiss AG, a mechanical engineering company in the northern Bavarian town of Sesslach, builds machines that cover the whole spectrum of thermoplastics, composites and polyolefins. The company is a pioneer in thermoforming—a rival to injection molding and similar in some respects to deep-drawing for sheet metal. The thermoforming process applies a vacuum to shape preheated thermoplastic sheets or films. Subsequently, the formed parts have to be removed from the sheet, which is usually rectangular in shape, once it has re-hardened. To help its customers carry out this work, Geiss has offered CNC units to cut along curves since 1984. Milling and cutting techniques using ultrasound, hot and cold blades, and occasionally even water jets are the classic methods for machining curves. Manfred Geiss, owner of Geiss AG, was unique in recognizing the potentials of the laser. “We’d been using lasers to cut structural and stainless steel here in our sheet metal fabrication operations for years. So why not use lasers to cut plastics too?”

As machine builders with a strong focus on plastics, numerous factors played a role in the company’s deliberations. Lasers are free of wear and, unlike water jet cutting, do not require the use of abrasives. They are flexible, fast, dry, and maintenance free. They achieve extreme precision at consistently high quality. All they require is a fume hood to extract the hydrocarbon vapors generated during the cutting process. Only PVCs and other halogenated plastics are beyond the range of laser cutting because of the hydrochlorides produced; they combine in the exhaust toform toxic dioxins.

Whether for clean contours or hair-thin perforations: Lasers and composite materials are a perfect match.

Manfred Geiss sums up: “ABS, acrylics, carbon fibers, PET, and polycarbonates are all suitable for laser processing. Fiberglass-reinforced plastics need more laser power. Laminates with a foam filling won’t work at all. And blades are more effective when cutting very thin materials.”

> *“Lasers can also be used for cutting operations inside clean rooms.”*
>
> Manfred Geiss

To supplement traditional methods, Geiss developed its own portable laser cutting machine, with TRUMPF’s assistance. The machine uses Cartesian coordinates and features a compact, built-in TruCoax CO_2 laser generating 1,000 watts of power. All the optical components were supplied by TRUMPF, while the CNC machine itself is a one-of-a-kind Geiss design. Thanks to their elaborate parametrics, all the Geiss three- and five-axis CNC machines can be equipped with a laser cutting option.

Better absorption Specifically matched to processing plastics, the CO_2 laser works with a wavelength of 9.3 microns instead of the usual 10.6 microns. This improves the absorption and thus cutting speed for many plastics by around ten percent. In addition, laser technology has many advantages over other tools. The cutting tool never makes contact during laser processing, meaning that no drag forces are produced—a real virtue given current trends toward ever thinner materials. And, since simple part clamps are sufficient, there is also a cost benefit.

“Lasers also reach contours and cutouts that are completely inaccessible to milling spindles,” Geiss adds. “Corners and cutouts with very small radii are also possible, as are hair-fine holes through composite materials.” This obviates finishing work in many applications. When processing acrylics, for example, the cut edges look flame-polished. Laser cutting is also the method of choice when clean rooms must remain free of dust and chips. And finally, whereas traditional methods reach their physical limits with polyamide fibers—milling causes the fibers to fray and blades bunch up the material in front of them—lasers cut cleanly through the material without any fraying or bunching.

Feasibility tests Using a demonstration machine installed on Geiss premises, the mechanical engineers conduct tests to determine whether a laser would be the most suitable tool for the customer’s purposes and to find out which parameters deliver the best cutting results. This is augmented by certified emissions tests by a leading inspection authority—TÜV Süd. As an example, the shell of a freshly manufactured suitcase consists of polycarbonate, one millimeter thick. The length of the curved seam is 2,480 millimeters; 16 holes have to be drilled. At an advancing rate of 9,000 millimeters a minute and laser power of 500 watts, the cutting cycle lasts 69 seconds. The firm’s own sled design is made of ABS four millimeters thick, using PMMA (polymethyl methacrylate). The cutting length is 2,580 millimeters and there are two holes to be drilled. The laser completes the job in 49 seconds. Similarly, the laser cuts an air grille made of ABS and acrylic in just 260 seconds in the high-speed mode, even though the grille includes 168 rectangular cutouts, six holes, and a cutting length of 860 millimeters.

Laser applications are many and varied and include plastics for headlamps, cladding, and floorings in cars, sun visors in trucks, and films for the furniture-making, construction and packaging industries. Geiss believes in the success of laser cutting. “Two mega-trends are driving its growing popularity. One is the shift toward lightness; vehicles today have weight-optimized designs with thinner walls, for instance. The other is the triumph of the composites. For materials such as glass- and carbon-fiber reinforced plastics, lasers are just the ticket.” ■

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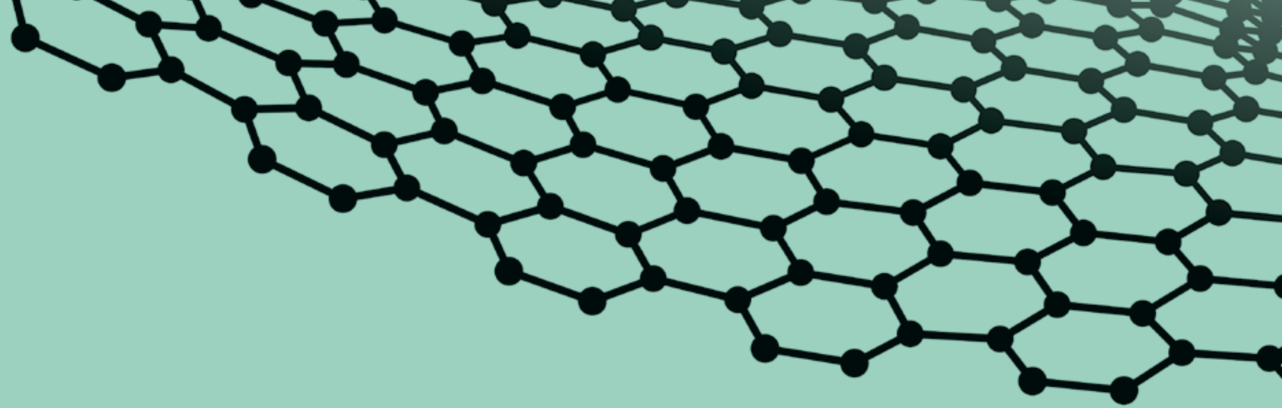


Prof. Minlin Zhong

Atomic fence

Imagine the possibilities … an anti-corrosion coating made of graphene no more than four atoms thick, realized using industrial solid-state lasers.

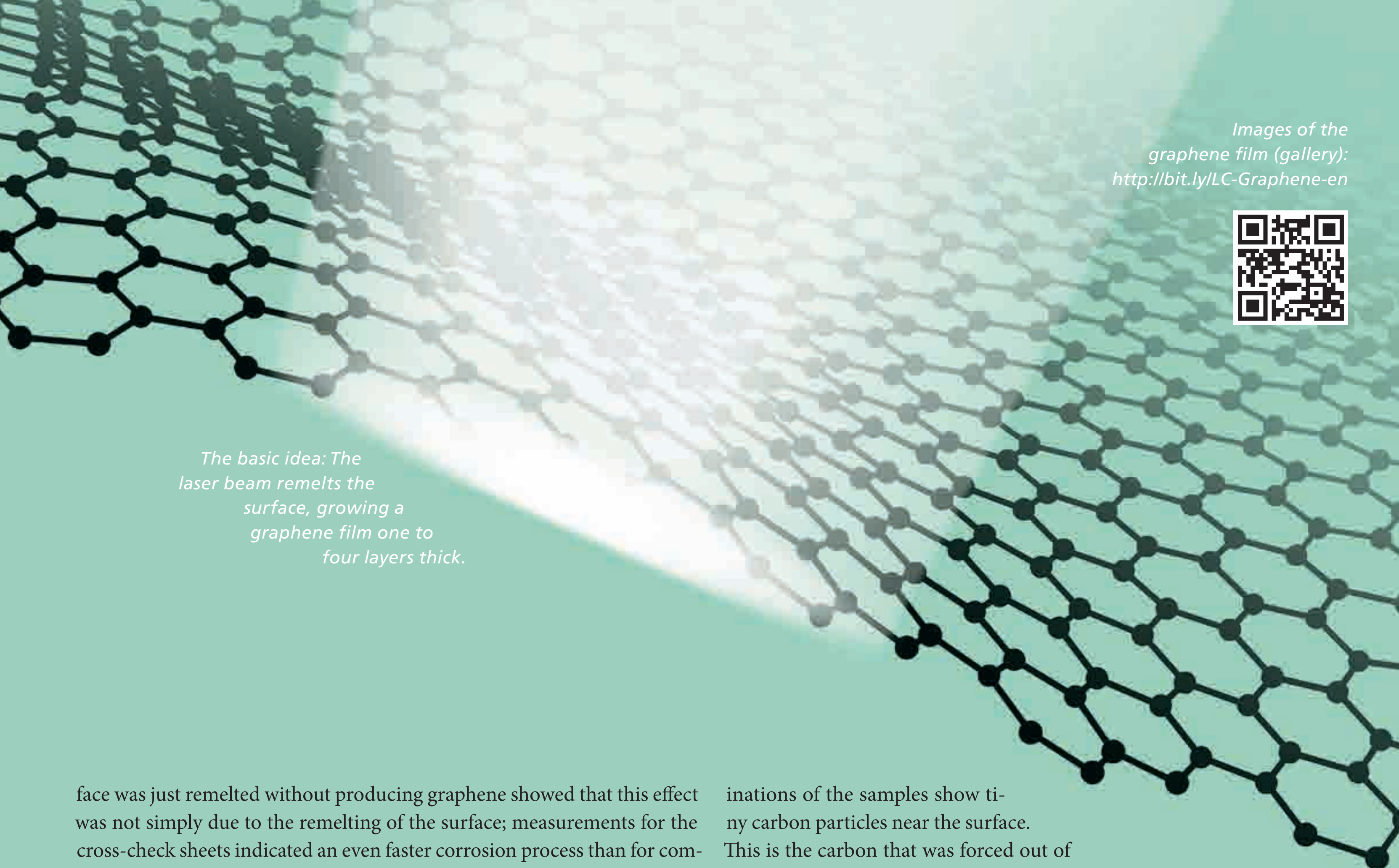
One of the hottest wonders in current research, graphene forms monoatomic layers of carbon atoms tightly packed into a two-dimensional honeycomb structure. To help you visualize that, imagine chicken wire with a hexagonal mesh and a carbon atom at each corner of the mesh. This "chicken wire" has a lot of interesting properties that make it extremely interesting for electronics applications. But that is not all: Its high mechanical and thermal stability and chemical inertness practically cry out for it to be used as an extremely thin anti-corrosion coating.

Intensive research into graphene over the past few years has led to the development of a variety of coating methods. When it comes to larger areas, the principal approaches are CVD (chemical vapor deposition) and various laser-assisted processes that combine laser energy with chemical processes. Although all these methods have their individual strong points, it would be good to have a method for practical applications that fulfills all the main requirements: one that grows graphene directly, coats large areas quickly, allows user-programmable patterns, works under normal ambient conditions, does not use or release hazardous substances, and employs tried-and-tested industrial tools. We set off to achieve just this.

The goal of our experiments was to fabricate graphene layers directly on a workpiece, functioning as an anti-corrosion coating. Earlier experiments had shown that graphene made directly on the surface of a workpiece is many times more effective than transferred graphene layers. High-power industrial lasers were used to produce the graphene. The experiments were carried out on polycrystalline nickel sheets. A paste made of graphite nanoparticles suspended in ethanol and evenly spread into a 20-micrometer-thick layer served as the carbon source. This solid carbon source is less hazardous than the gaseous sources often used in CVD. Next, the surface of the nickel sheets was irradiated with laser light: a diode laser with a flat-top beam profile and a wavelength of 0.98 micrometers was employed to evenly remelt larger areas. In order to remelt only those parts of the surface corresponding to CAD-programmed patterns, the team used a fiber laser with a round beam, a Gaussian beam profile, and a wavelength of 1.06 micrometers.

The diode laser irradiated the workpieces with a 16-millimeter-wide and one-millimeter-long beam profile at a process speed of 18 centimeters a minute. This remelted the surface to a depth of almost 0.3 millimeters, and graphene formed on the fresh surface at the rate of 28.8 square centimeters a minute. During the experiments to produce user-programmed patterns, the solid-state laser irradiated the sheets, following two pre-programmed patterns. The first was a spiral, which the laser melted into the surface with a beam diameter of three millimeters and a scanning rate of 24 centimeters a minute. The second was a maze, which the laser executed with a beam diameter of one millimeter and a scanning rate of 60 centimeters a minute. Of course, any other patterns are possible. Examinations using optical and electron microscopy and various spectroscopic methods revealed that the entire irradiated surface in all experiments was covered by a one- to four-layer graphene film. Three- to four-layer graphene up almost a third of the entire film area. However, it was not concentrated in one region, but covered the entire surface in an even, meshed pattern.

Although just a few layers thick, these graphene films provide extremely effective anti-corrosion protection, as anticipated. This was demonstrated by measuring the corrosion current densities and potentials of various samples in a NaCl solution. The rate of corrosion and initial resistance to a corrosive environment can be derived from these measurements. The initial resistance of the nickel sheets with a closed graphene film turned out to be significantly higher and the corrosion rate a thousand times slower than for unprotected samples. A cross-check using sheets whose sur-



Images of the graphene film (gallery): http://bit.ly/LC-Graphene-en

The basic idea: The laser beam remelts the surface, growing a graphene film one to four layers thick.

face was just remelted without producing graphene showed that this effect was not simply due to the remelting of the surface; measurements for the cross-check sheets indicated an even faster corrosion process than for completely untreated sheets. Conversely, a graphene film covering only fifty percent of the surface already achieves a considerable reduction in the corrosion current measurements. In short, the graphene produced by this method exhibits the desired properties.

At the same time, the experiments indicate that the number of graphene layers in the film can be influenced to a certain degree. The formation and number of layers are strongly dependent on the cooling rate, a relationship that earlier experiments had already shown and this series of experiments confirmed. Extremely fast cooling of the surface following heat treatment produces the thin film of one to four layers, described above. Slower cooling leads to a thicker film with many layers. Very slow cooling processes — in an oven, for instance — produce no graphene at all. The reason for these differences is carbon's behavior in solution with solid nickel.

As anticipated, the graphene films provide extremely effective anti-corrosion protection.

Under the heat of the laser beam, carbon atoms separate from the graphite nanoparticles in the molten nickel. However, because solid nickel permits only a maximum 2.7 percent carbon solution according to the Ni-C binary alloy phase diagram, and the carbon solution rate decreases when the nickel cools down, the excess carbon atoms diffuse out of the solid solution and to the surface, where they meet and form two-dimensional graphene meshes. As the sample is melted only approx. 0.3 millimeter deep at room temperature, it solidifies very quickly and many of the carbon atoms lose their mobility before they reach the surface. Accordingly, examinations of the samples show tiny carbon particles near the surface. This is the carbon that was forced out of the solution but did not get as far as the surface. Slower cooling means that more carbon reaches the surface and forms more graphene layers.

The series of experiments therefore lays the foundations for a new process to coat workpieces with thin graphene layers over large areas, protecting it very effectively against corrosion. The laser method uses common industrial solid-state and high-power diode lasers and works under normal ambient conditions. It can produce not only closed layers but also layers in arbitrary, user-programmable patterns. This is achieved in just a single process step, without using chemicals or chemical processes that are potentially harmful to human health or the environment. We hope that this work will offer industry a productive way to benefit from the fascinating properties of graphene films in the near future. ■

Dr. Minlin Zhong is a professor and head of the Laser Materials Processing Research Center at the School of Materials Science and Engineering, Tsinghua University, Beijing China. He focuses on laser micro and nanofabrication, laser surface engineering, laser additive manufacturing and novel material development. Dr. Zhong is a Fellow of the Laser Institute of America. E-mail: zhml@tsinghua.edu.cn

Illustration: Gernot Walter; Prof. Minlin Zhong

“Everyone said I was completely crazy”

Bold audacity—and the ability to see the forest in spite of the trees. Laser pioneer Paul Seiler recalls his experiences in the wild years of the 60s and 70s, when the laser era dawned.

You've devoted fifty years of your life to lasers. How could a handful of photons hold your attention over the course of half a century?
I've always had a passion for lasers and the opportunities they offer. And over the years I've often recaptured that feeling of excitement and enthusiasm that thrilled me from the start. I certainly had to overcome plenty of difficulties and setbacks along the way, but that never diminished my passion. If anything, it increased it! Because ultimately it's the challenges that keep you focused on an idea, even after fifty years.

And yet your first contact with lasers came about quite by chance …
When I finished engineering college in Karlsruhe I started my career at Carl Zeiss in Oberkochen. That's where, in 1963, I encountered a laser for the very first time while conducting preliminary tests for a range-finding system for tanks. We were already familiar with Q-switched lasers from America. The intensity of the light pulse made it possible to conduct time-of-flight measurements over greater distances in the field. As a lab engineer I was given the task of putting together a test setup with a ruby laser and Q-switching using Kerr cell shutters.

And was when you got hooked?
The test setup filled a whole room, and it took lots of adjustments before the first pulses finally bathed the room in a deep red light. When we saw the emitted and reflected pulses on the oscilloscope screen, it just made our success even sweeter. Making the speed of light visible was a fascinating and defining experience.

You mentioned that it was difficult to get hold of laser-active media in good quality. What other difficulties did you face in the early years of the laser?
The Americans were already far ahead of us in the 1960s. That meant we already knew virtually everything about lasers, at least in theory, but in fact there were still plenty of unresolved details: resonators for suitable laser-active media, pump configurations including the power supply, measurement techniques for the intensive laser light. Even the stability of the optical components was still unknown at that time. The advantage was that I learned everything there was to know about lasers — and did so very quickly.

And you employed that knowledge to develop your first laser "tool?"
That's right. It was a microscope laser device and it had all the functions needed to use the laser as a tool. As much as possible, we tried to use components from the Zeiss range of equipment, such as a photomicroscope stand or the zoom lens from a movie camera. The laser-active medium came from Schott, a company affiliated with Zeiss. At that time, Schott was supplying neodymium-doped glass to Lawrence Livermore in the USA for experiments with nuclear fusion. This glass could be used to make long rods, and we were able to polish and coat the end surfaces at Zeiss. The resulting laser rod was therefore an active medium and resonator at the same time, just like the first laser developed by Theodore Maiman.

Then the Osram company, in the nearby town of Herbrechtingen, asked us if it would be possible to use the laser to drill the orifices in diamond drawing dies. We gave it a try — and it worked. Basically, we had found the right laser for an exciting application at just the right time. Sometimes everything falls into place!

You had a secure job at Zeiss and clearly plenty of opportunities, but you decided to move to Haas in 1971. What prompted you to do that?
Everyone said I was crazy because I was planning to give up a secure job with a pension plan, even though I had four kids. But I did it anyway because I felt that Haas offered the opportunity to use lasers in industrial applications. I had a hunch that lasers would be particularly useful in manufacturing technology — it was certainly in a league of its own when it came to welding.

At Zeiss, people's interest in the laser as a tool petered out when my super-

Angelika Grossmann

visor and mentor Dr. Siegfried Panzer passed away. Lasers as tools simply had no place in the company's portfolio. I first met Dr. Wolfgang Müller, the head of development at Haas, at a lecture at Esslingen Technical Academy. Zeiss had already carried out successful experiments for Haas in welding flat spiral springs for watches. Dr. Müller told me that Haas was intending to commission the Battelle Memorial Institute with the development of a laser for this application. Right off the top of my head I said, "That's something I can do, too."

And so you did!
The first machine incorporating a built-in laser and intended to weld springs automatically was launched in 1973 and was a huge success. The weld was very strong and very precise at the same time, and the process was ten times faster. The machines had been used for adhesive bonding in the past and required only minor modifications, thanks to the laser components system (LCS) which we had developed. The LCS was designed for incorporation into machines, so we tried to sell the system to other companies, too.

You tried to? Weren't other industrial users virtually begging to use your new laser system?
Unfortunately not. The process was still entirely unknown, and in most cases was only cost-effective with the appropriate automation equipment. And, at least in the immediate "Federle-Haas" environment, nobody had approved a development of that kind. So it was very hard work. I gave presentations, put together brochures and sales materials, and gradually ended up turning into an entrepreneur in my own right.

When did your big breakthrough come?
AEG-Telefunken successfully used our system to automatically weld the cathode components in television picture tubes. The competitors took note of that, since color television was gaining steam and they knew it would be impossible to produce the required quantities without automation. Then the company Philips decided to introduce laser welding on a broader basis. That was a courageous step for the factory in Sittard, Netherlands. That was where all the assemblies for the CRT electron guns were manufactured, so the laser had to be 100 percent reliable. The management sat me down and asked me very seriously whether Haas could be confident of achieving that. My answer was an emphatic yes, and we immediately received an order for six laser systems. Now, that was a cause for celebration for both myself and the Haas laser team, which consisted of just ten people at that time, but it was also a huge challenge.

Philips was our biggest customer, and collaboration was fruitful in many ways, not just in terms of the ongoing technical development. Having such a high-profile customer gave our laser components system international prestige, and Haas Laser was suddenly a brand name.

Lasers in modern watchmaking: http://bit.ly/LC-Watch

The development of the laser light cable was a quantum leap for solid-state lasers. How did it come about?
As so often happens, we had another lucky break. On a trip to Japan, the Philips mechanical engineers discovered that scientists there were attempting to transmit laser light along glass fibers. It was clear this would offer a major advantage when integrating lasers into machines. Philips provided us with the first glass fibers and we used those to develop what we call the laser light cable. But of course this also meant that instead of needing three lasers to weld simultaneously at three points, you now only needed one laser with three laser light cables.

That might have hindered laser sales, but this factor ultimately proved to be a good thing, right?
Exactly. It turned out to be an advantage not only for Philips, but for us, too. Suddenly it was more economical to use laser systems, which gave them a significant boost in popularity.

With the emergence of solid-state lasers in the kilowatt range, laser light cable took on a whole new significance. That development came about through a joint research project run by the German Federal Ministry of Education and Research. At first we didn't believe that the solid-state laser stood a chance against the CO_2 laser in this power range. But when we presented a 2-kilowatt laser with a laser light cable at a 1991 trade show, the carmakers showed interest. The acquisition of Haas Laser by TRUMPF gave us the financial backing we needed to further these developments. If it weren't for the laser light cable, solid-state lasers would never be as important as they are now, in many areas of industrial manufacturing.

How would you personally sum up the first 50 years of the laser?
They were difficult but very rewarding years. Our personal lives often had to take a back seat, but everyone who has a passion for their work would probably say that. Even now, 11 years after retirement, I'm still just as fascinated by lasers. And when I see how far the laser has come, I'm proud that I always believed in its success. ■

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"Without the laser light cable, solid-state lasers would never be as important as they are now."

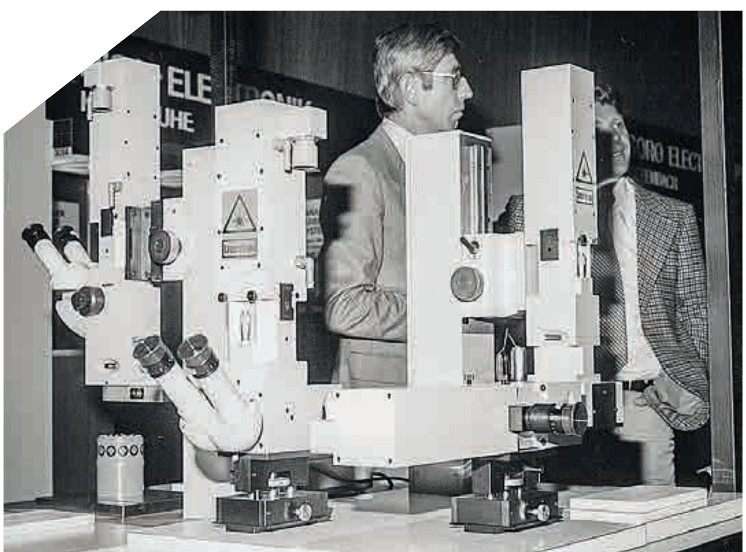
However far the goalposts might have shifted over the years, Dr. Paul Seiler had the determination and perseverance to stay true to his goal of putting lasers into industrial use.

To the right: *In the early years of the laser, Dr. Paul Seiler spent much of his time trying to convince people of its merits. This photo shows him at the Laser Exhibition in 1977 (lower left). There were many uses, even in the early years. Shown here are workstations for welding the filaments used in glow plugs in diesel engines (lower right).*

LIFE Born in 1938 in Bretten, Germany, Dr. Paul Seiler studied precision mechanics at the University of Applied Sciences in Karlsruhe. He is regarded as a pioneer in solid-state lasers for industrial use. From 1992 until 2003, Dr. Seiler was the managing director of TRUMPF Laser GmbH & Co. KG in Schramberg.

LASERS When the first laser made its debut on the world stage in 1960, Dr. Paul Seiler discovered a passion for laser technology. As of 1973, his systems of lasers and components were instrumental in combining lasers and machines.

LIFEWORK In 2003 Dr. Seiler was awarded the Baden-Württemberg Business Medal in recognition of his outstanding achievements. This marked the culmination of his professional career. In 2008 he received an honorary doctorate from the University of Stuttgart.



Angelika Grossmann; TRUMPF; Gernot Walter

www.laser-community.com

TRUMPF; Carl Zeiss Microscopy GmbH; IPTE Factory Automation; Haas Food Equipment GmbH

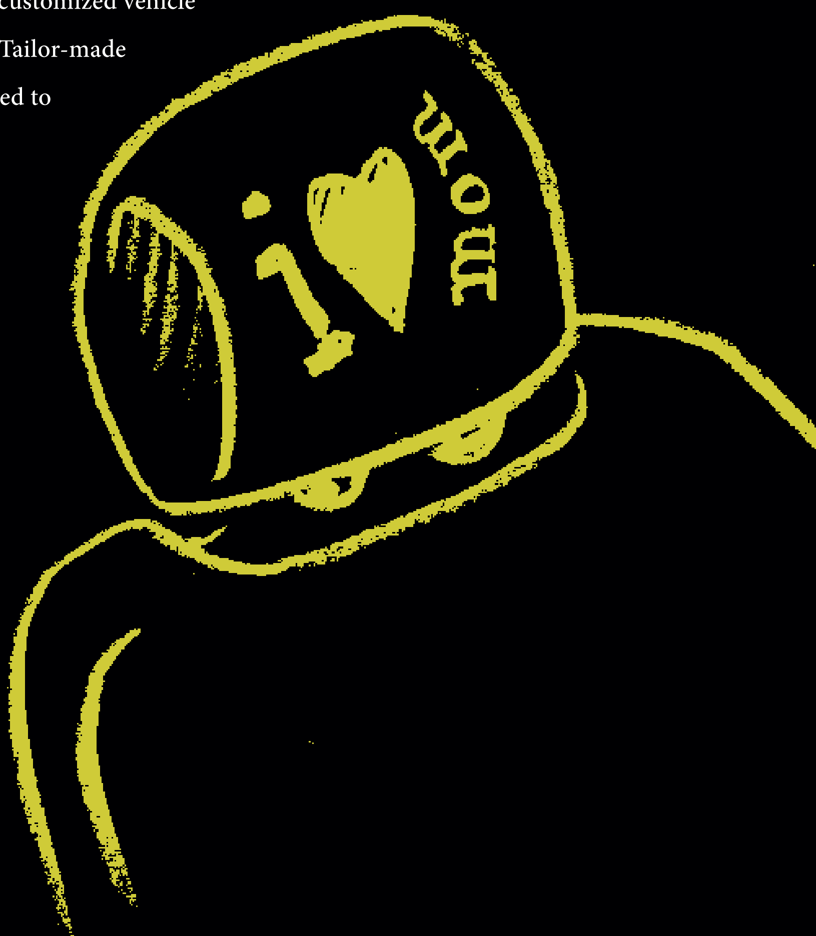
When it comes to laser applications, one key role is often overlooked, namely the "integrator", whose job it is to incorporate the idea and the laser into the manufacturing process. Read our special article on laser system manufacturing and take a journey through the world of laser integration — from microscopes to steel mills: **www.laser-community.com/laser-system-manufacturing**

ONLINE SPECIAL

BONUS TRACKS

Where's the laser?

In the personalized headrest. Today's motoring enthusiasts want more than just an ordinary, off-the-showroom-floor car. And now it's easier than ever for them to get what they want. Laser marking technology lets automakers offer their customers an increasing array of customized vehicle interior options to cater to each driver's individual taste. Tailor-made inscriptions and ornamentations can now be added to headrests, steering wheels, center consoles, floor mats, and even gas caps. Although these options have been available for some time, conventional methods such as printing, embroidering and embossing don't come cheap. But lasers make the process considerably more economical and can be used on virtually any material, including polymers and metallic surfaces, leather and textiles. And that means that motorists can rev up their ideas when it comes to personalized design!



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