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Laser Community

THE LASER MAGAZINE FROM TRUMPF

Hot

What do electric stoves and cars have in common?

Sharp

The blade that craftsmen have always dreamed of

WWW.TRUMPF.COM

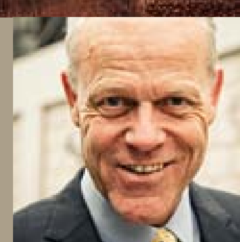
Well DONE

Quality, convenience & safety: The food industry delivers on its promises with laser light

MR. PHOTON

PROF. REINHART POPRAWE TALKS ABOUT HIS JOB AS A PHOTON ENTANGLER

→ Page 26



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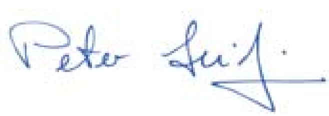
IMPRINT

Christian Reinhardt

In its role as a manufacturing tool, the laser has grown up and joined the mainstream. Whereas a decade or so ago it was still considered an outsider among the dozens of other more conventional options, today the laser is an established and indispensable feature of the automotive and solar-power industries. Other users are now following in the footsteps of the pioneers. One such company is AEG Electrolux in Rothenburg, which recently inaugurated its first fully automated laser cutting and welding line for the manufacture of baking ovens. Systems integrator FFT EDAG PS developed a solution that enables the white goods sector to benefit from a process already well-established in the automotive industry. The fully automated welding process creates perfectly airtight and burr-free joints at the rate of one per 12 seconds. Whereas back in 2005, laser applications such as marking apples or cheeses were treated as an esoteric sideline, we can now publish a feature article on the laser's importance to the food industry. The laser has meanwhile learnt to delicately crack eggs, peel tomatoes, create breathable packaging films, and cut and weld components for food containers and equipment for baking and cooking. The laser has become an indispensable feature of tomorrow's food industry.

Onward to new horizons!

To meet the needs of the world's growing and increasingly urbanized population — one of today's major megatrends — food has to be produced on an industrial scale and transported over greater distances from the producer to the consumer. Laser technology can help the food-processing industry to accomplish this huge challenge and at the same time meet the threefold requirement of maximizing product quality, manufacturing speed and cost efficiency. To provide an idea of the size of this market, sales of organically grown produce in Germany already amount to six billion euros. Other innovations made possible by laser technology are delivered directly to the consumer's hand, rather than to their dinner table. The ubiquitous black-and-yellow Stanley knife is equipped with sharp, laser-clad carbide blades that last between ten and twelve times longer than their conventionally manufactured predecessors. Each of these examples shows that the range of possible applications is far from exhausted — and that it only requires imagination and a pinch of courage to go much further.



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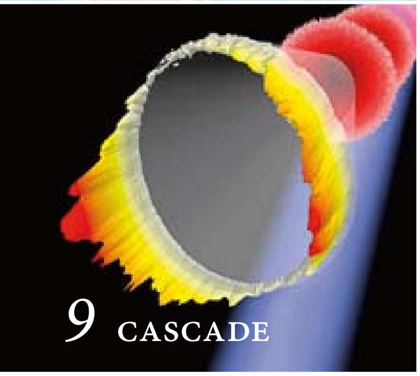

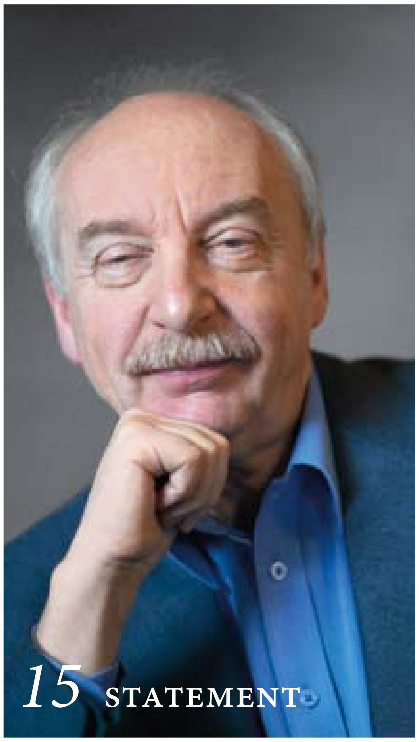

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COMMUNITY

Lasers and people at a glance PAGE 06

TOPIC

TOPIC

Super fresh

Stainless steel and convenience foods: How the food industry discovered the benefits of the laser. PAGE 10

Laserlight Dinner

Laser Community serves up five promising innovations. PAGE 12

STATEMENT

Follow your intuition

Less information often leads to better decisions, says Prof. Gerd Gigerenzer.
PAGE 15

16 MAGNA

18 ELECTROLUX

24 VACUUM TECHNOLOGY

22 STANLEY TOOLS

26 PROF. POPRAWE

2012

REPORT

"Laser means freedom"

Dr. Hongping Gu has his sights set on the future of laser applications. He tells us what he thinks lies ahead. PAGE 16

Oven-ready

An oven that comes in 500 different variants. If that reminds you of the auto industry, you're on the same wavelength as EDAG and Electrolux. PAGE 18

A cut above

A blade that never loses its edge? It may be black, but it's not magic. PAGE 22

SCIENCE

PROF. KLAUS DILGER

Pressure down

Performing laser welding in a vacuum can produce surprising results. PAGE 24

PEOPLE

"I don't like the term technology transfer"

Prof. Reinhart Poprawe explains why constantly losing good people to spin-offs is the best thing that could happen to him. PAGE 26

AND THERE'S MORE

Scan the QR code to access more images and videos on www.laser-community.com

S P O T

--- NUCLEAR FUSION
The National Ignition Facility in the USA has used the combined power of 192 UV lasers to produce a pulse of 2.03 megajoules of laser energy. This marks a key step towards the use of nuclear fusion to generate power.
lasers.llnl.gov

--- LASER MARKET
The market volume of laser systems for material processing grew by 28 percent in 2011, breaking through the 10 billion U.S. dollar barrier for the first time.
www.optech-consulting.com

--- WELD DEPTH
Physicists at Queen's University in Canada have developed an optical method of dynamically monitoring weld depth in industrial laser processes.
www.parteqinnovations.com

--- TRADE FAIR
The successful international laser fair LASER World of PHOTONICS has created a new offshoot in India, which will take place for the first time in September this year.
www.world-of-photonics.net

--- INVISIBLE
In an experiment, researchers at the DESY research institute fired a laser at iron atoms — and succeeded in making the iron invisible to X-rays. *www.desy.de*

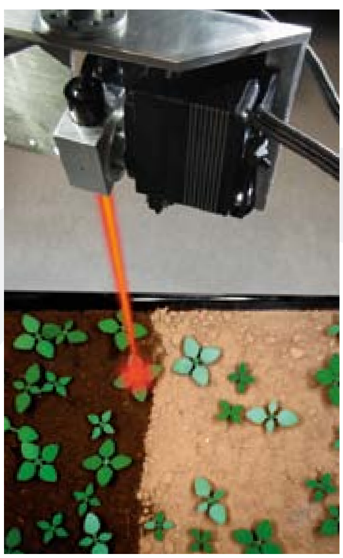
--- LASER COMB
American researchers are searching for life in space using a "laser comb": The tool makes precise comparisons of the light frequencies emitted by our Sun and other stars in order to track down similar solar systems. *www.nist.gov*

--- 3D NANOSTRUCTURES
A production process developed at the Harvard SEAS uses femtosecond lasers to create 3D nanostructures in materials. These could be used to create "invisibility cloaks" by bending light around objects as if nothing were there.
seas.harvard.edu

Windfall for innovation

EU announces funding for photonic technologies

The European Union intends to invest a total of 80 billion euros in research and innovation over the next eight years. Máire Geoghegan-Quinn, the EU Commissioner for Research and Innovation, announced the launch of the Horizon 2020 framework program at the end of November 2011. The program focuses more than ever on turning scientific breakthroughs into concrete, innovative products or services within the shortest possible time frames. A major portion of the budget — 17.9 billion euros — is earmarked for key industrial technologies, including photonics. But the EU Commissioner has promised more than just a huge injection of cash: Horizon 2020 will feature simplified rules and processes which will greatly facilitate access to the funding. *www.ec.europa.eu*



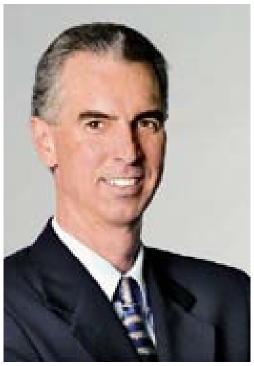
The scanner system reliably identifies unwanted plants.

Goodbye weeds

Laser flexes its green thumb

How can a laser be used to fight weeds at an early growth stage? Researchers from the Laser Zentrum Hannover e.V. (LZH) and the Biosystems and Horticultural Engineering Section at Leibniz Universität Hannover have been aiming their CO_2 laser at the unwanted plants' sensitive growth centers, known as meristems. Lab results have shown that a dose of around 35 Joules is enough to kill seedlings. By using a galvanometer scanner with a flexible mirror system, the laser beam can be moved quickly and accurately from plant to plant. The researchers employ a stereo camera system to differentiate crops from weeds by comparing the camera images with typical plant shapes. They plan to apply the method to large areas using field robots working in a stop-and-go mode. *www.lzh.de*

"I have shrunk by five centimeters — due to the pressure resulting from expectations for EUV!"



Bob Akins

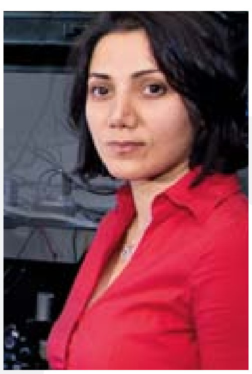
Cymer, a manufacturer of lithography light sources for the semiconductor industry, is opening up a whole new field of application for CO_2 lasers: The company is working together with TRUMPF to develop extreme ultraviolet (EUV) light sources. CO_2 laser pulses are aimed at tiny droplets of tin to produce a tin plasma. The highly ionized plasma then emits EUV radiation. The end customer, ASML, is working to a tight schedule, but Cymer CEO Akins is confident they will complete the development project by the end of the year. *www.cymer.com*

"This appointment puts Dr. Rethfeld firmly among the ranks of Germany's scientific elite."

Dr. Bärbel Rethfeld

Physicist Dr. Bärbel Rethfeld from the University of Kaiserslautern has been awarded a Heisenberg Professorship by the German Research Foundation (DFG) for her work on applied theoretical physics. She is one of the few women ever to have received this award. Rethfeld's research focuses on computer simulations of physical processes while working material with with laser beams. She develops models to predict the behavior of electrons on ultrashort timescales. These models are designed to describe the processes involved — from energy absorption to melting and material removal. *www.uni-kl.de*

"No photon left behind."



Dr. Mercedeh Khajavikhan

Together with her team at the University of California in San Diego, Dr. Khajavikhan developed a new type of laser. The highly efficient, "thresholdless" nanolaser funnels all its photons into lasing, with no losses. Thanks to the use of quantum electrodynamic effects, the new laser requires relatively low pump power to operate. This is a major breakthrough that makes the nanolaser an attractive option for future optical circuits packed onto tiny computer chips. *www.ucsd.edu*

European Union; Laser Zentrum Hannover LZH; Cymer; de Sousa; University of California

SAVE THE DATE

AMS CONFERENCE CHINA
June 28–30, 2012, Shanghai, China; International automotive manufacturing conference with regional focus
http://china.amsconferences.com

TOUCH TAIWAN
August 29 – September 1, 2012, Taipei, Taiwan; Conference for touchscreen technology
www.touchtaiwan.com/en

AMS CONFERENCE BRAZIL
September 10–12, 2012, São Paulo, Brazil; International automotive manufacturing conference with regional focus
http://southamerica.amsconferences.com

MSV
September 10–14, 2012, Brno, Czech Republic; International engineering fair
www.bvv.cz

IMTS
September 10–15, 2012, Chicago, USA; Leading U.S. trade fair for manufacturing technologies
www.imts.com

ICALEO
September 23–27, 2012, Anaheim, USA; International congress on applications of lasers and electro-optics
www.icaleo.org

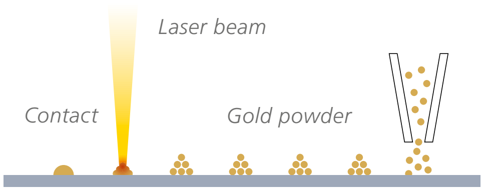
EU PVSEC
September 24–28, 2012, Frankfurt, Germany; European photovoltaic solar energy conference and exhibition
www.photovoltaic-conference.com

TUBE CHINA
September 25–27, 2012, Shanghai, China; International tube and pipe industry trade fair
www.tubechina.net/en/index.html

VIENNA-TEC
October 9–12, 2012, Vienna, Austria; International manufacturing technology fair for industry and trade
www.vienna-tec.at

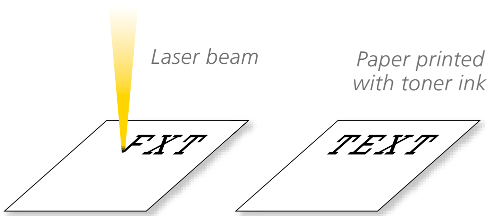
EUROBLECH
October 23–27, 2012, Hannover, Germany; International sheet metal working technology exhibition
www.euroblech.com

CONCEPTS



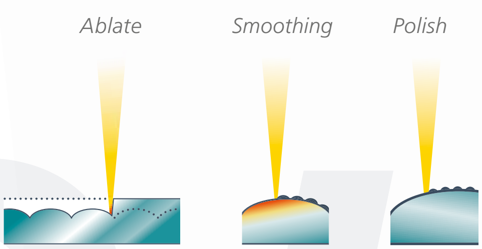
-- GOLD CONTACTS

Fraunhofer ILT has developed a new method for producing gold contacts, which cuts the amount of gold used by up to 90 percent. A laser beam is used to weld on the valuable metal as small contact spots instead of a large, thin layer. *www.ilt.fraunhofer.de*



-- LASER ERASER

A team from the University of Cambridge has used green laser light to remove the toner ink from conventional paper. This method reduces the energy required for standard recycling by at least 50 percent. *www.cam.ac.uk*



-- SHAPING GLASS

Fraunhofer ILT uses three CO_2 laser processes to create non-spherical lenses. The first beam ablates material to produce the required geometry, the second beam uses heat to polish the surface, and the third beam removes any remaining roughness. *www.ilt.fraunhofer.de*

Periodic structure of semiconductor layers in the new quantum cascade laser.

Cascade power

The new power of quantum cascade lasers

The Institute of Electron Technology in Warsaw has developed the technology required to produce extraordinarily powerful versions of a special type of semiconductor laser known as a quantum cascade laser. With a peak pulse power three times greater than their essentially experimental predecessors, the new cascade lasers could now become a viable option for industrial and medical applications. The researchers used aluminum-doped gallium arsenide to emit pulses of infrared radiation. At room temperature, the power of these pulses can reach up to several dozen milliwatts and, under cryogenic (i.e. extremely cold) conditions, up to as much as five watts. *www.ite.waw.pl*

Flash cleaning

Short-pulse laser takes on full-time position as cleaner

Functional coatings often create problems for the welding process. This typically leads to turbulent processes, spatter and material inclusions. An added problem is that the coating process often takes place in a melting bath, resulting in variations in the layer thickness from one batch to another. Whereas this might not affect the functionality of the components, it does require constant readjustments to the welding laser parameters. But now an efficient solution has been found, based on the local laser ablation of the coating material at the joining points. Short-pulse lasers are responsible for this increased efficiency, especially when working on thin films. At BMW's Dingolfing plant, for example, TRUMPF laser workstations, which are equipped as standard with high-precision scanner systems and control software, have helped to stabilize the welding line for differential gears. The process has already been tested using separate workstations and it is hoped that the integration phase will now further enhance series production efficiency.

Differential crown gear with prepared joining point

ITE; Gernot Walter

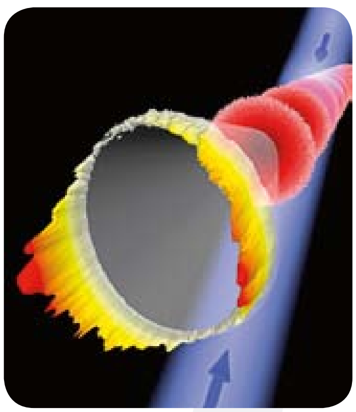
Light from the cold

Physicists from the University of Tübingen managed to create a laser using only gas and light. Dr. William Guerin explains why this laser is different from all others.

Dr. William Guerin experiments with optical gratings made of cold atoms at the Eberhard Karl University in Tübingen, Germany.

Gas lasers are nothing new. What is special about the laser your team generated?

The novelty of our work is that we have built a laser only from cold-atom vapor — a medium that nobody used for that sort of things before. Our laser relies on distributed feedback (DFB), which means it doesn't need mirrors, because feedback is spatially distributed inside the gain medium itself. The trick is to add a spatial modulation of the refractive index into the gain medium. The modulation forms a grating made of many atomic layers which function as partially-reflective mirrors creating multiple so-called Bragg reflections. This grating provides the feedback. Such lasers have been recognized since the 70s and widely used for their interesting properties: compactness, stability and single-mode operation.



Atoms are trapped to form an optical grating (red). Pumping them with another laser (blue) generates a cone-shaped laser beam (yellow circle).

How did you manage to create a DFB laser only from atomic vapor?

A gaseous gain medium doesn't seem appropriate to create DFB lasers. Gas is a disordered medium whereas DFB lasers rely on ordered structure. Moreover, the refractive index of a gas is very low so that it seems hard to make a modulation that is large enough to create feedback. And at normal temperature atoms move at 500 meters per second — too fast to catch them with optical traps. However, physicists are now able to laser-cool atoms to extremely low temperatures, to slow them down to 0.1 meter per second. If you now create an optical trap from a stationary wave, cold atoms can be trapped in an ordered fashion. They form extremely thin, broad layers, like a stack of pancakes.

And what about the laser?

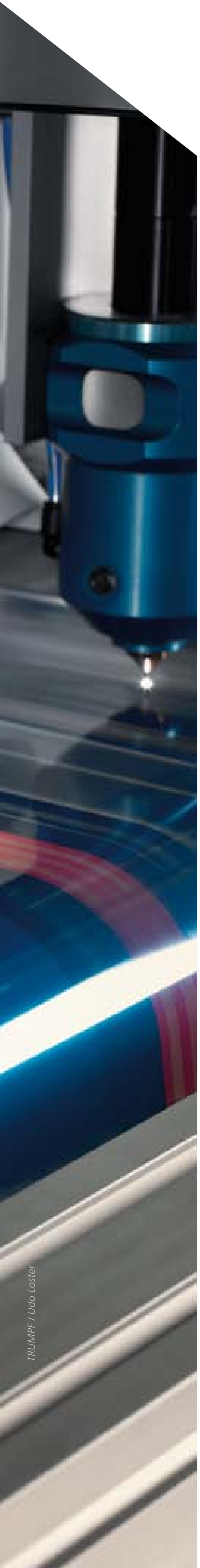
We demonstrated recently that such an atomic sample of dilute rubidium gas can reflect 80 percent of an incoming probe beam. It was possible because we compensated for the low atomic density by using about 10,000 layers. Then we just needed to add the second ingredient: gain. As in many other lasers, this is done by using a pump laser and the properties of rubidium atoms.

What options for applications do you see for your DFB laser?

It's still basic research. But, for example, our DFB laser emits an original cone-shaped beam that comes from the very sharp atomic resonance. Somebody else may find a concrete application based on this property. Maybe one of your readers!

Microperforated packaging, cooking films, blown stainless steel walls, decorated sushi: The meeting of laser technology and the food industry has really borne fruit.

MICROPERFORATION CO_2 laser machines by Lang Laser create tiny steam vents or easy-opening perforations in films for food packaging at up to 500 meters per minute.



TRUMPF / Udo Loster

SUPER *fresh*

The food industry wouldn't be the same without the laser.

The food industry is rapidly changing, and these changes are being driven by the global trend toward urbanization. Cities are growing and, as a result, more and more people are shopping for groceries in supermarkets. Many of them would surely be surprised to learn of the role laser technology plays in bringing food to their table. Slow food or convenience food — industry is responding to the ever-growing demand for mass-produced food products. New and innovative processes have been employed in the food-processing industry for quite some time now. It has to perform a balancing act to meet the threefold requirements of product quality, manufacturing speed and cost efficiency. A challenge that only the laser meet; hence its essential role in almost every stage of the production process.

More than just packaging The example of a frozen dish illustrates the extent to which lasers have revolutionized food packaging. Its most remarkable aspect is the plastic film in which the product is wrapped. It still fulfills the original purpose of packaging films, namely to preserve the freshness of the packaged food. But when the tray is placed in a microwave oven, the plastic film also speeds up the cooking process, while a clever invention prevents the pressure of the rising steam from splitting the container open: In the fraction of a second a precisely focused laser beam cuts 36 round little holes to serve as steam vents. If the packaging is placed in the microwave oven and the pressure increases, the right amount of steam escapes while taste and vitamins are conserved. The same technique is also used for thicker packaging materials to produce precise slits in screw-topped milk cartons, which enable the carton to be opened without effort. Whether thick compound materials, cardboard packaging or thermoforming film the diffusion-cooled TruCoax CO_2 lasers are capable of creating precisely the right contour cuts. Because the tool does not come into contact with the material, there is no risk of damage. And it is not necessary to add another step to the manufacturing process. The compact laser and scanner systems can be integrated at any suitable point in the roll winder or reel slitters, where they are capable of operating "on the fly" at a up to 500 meters per minute.

These are just a few examples of the immense diversity of laser applications in the packaging industry. Wherever there is a need for ultraprecise, high-speed processing, the laser is the answer for cutting, marking and texturing. It also opens up a wealth of new possibilities for product designers. Consumers can easily be persuaded to spend a three cents more for a product in a functional packaging. The potential for boosting profit margins can be illustrated by a simple example: just imagine the difference three cents make on all the bags of potato chips sold in stores in a single day.

But packaging is merely the last link in an often long chain of processing steps. When dealing with perishable, easily contaminated consumer products such as food and beverages, manufacturers have to be sure of maintaining the very highest standards of process reliability and hygiene.

→ *Continue on page 14*

OVEN-FRESH Grain mills, dough kneaders, commercial ovens: Many of the machines used to produce this loaf of bread were manufactured using lasers. Following the example of their colleagues in other industries, these companies have gained a strong competitive advantage by introducing laser-based manufacturing processes.

Direct link to the article on laser scribing applications for the packaging industry at www.laser-community.com/?p=1595

CRISP AND HEALTHY Consumers always look for freshness when buying salad greens. Such produce is therefore packed in a breathable plastic film with tiny perforations, produced using a laser, This perforations regulate the transmission of oxygen and CO_2, ensuring the ideal conditions to keep the salad crisp and preserve its flavor and vitamin content. To manufacture this modified atmosphere packaging (MAP), machines built by the specialist company LANG LASER are used to pierce 140-micrometer slits in the protective plastic film.

GUARANTEED GERM-FREE Connoisseurs around the world delight in raw-meat dishes such as steak tartare, filet américain, or Hackepeter. But to avoid an upset stomach, the minced meat must be absolutely fresh and prepared under perfectly hygienic conditions. Manufacturers of meat-processing machines therefore favor germ-resistant stainless steel as the material of choice. They use lasers to cut and weld the component parts, which prevents the formation of porous oxide layers.

LASERLIGHT *Dinner*

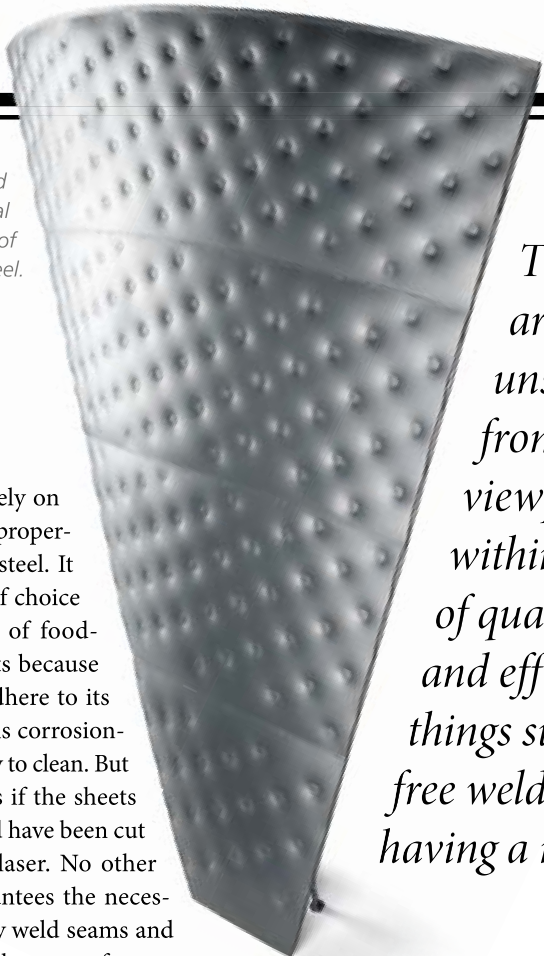
Christian Reinhardt

FINE BOUQUET Today, to enable premium wines to develop their full, complex aroma, they are matured in specially designed tanks made of stainless steel panels formed using a special laser-based process. This inert material does not alter the taste of the wine and guarantees an intact aroma.

MARK OF QUALITY Flexible marking lasers are the ideal tool for labeling products with use-by dates or customized brand logos. Often, the product itself can be marked in this way without suffering any damage — as in the case of whole cheeses, where the non-contact process can be used to mark the rind without putting any pressure on the dairy product itself.

5x

A full spread: Our five examples illustrate the use of lasers in the food industry for marking, welding, cutting and drilling.



"Laser quilted" and inflated functional panel made of stainless steel.

The applications are often unspectacular from a technical viewpoint. But within the triangle of quality, safety and efficiency, minor things such as pore-free welding end up having a major impact.

→ They therefore rely on the "wondrous" properties of stainless steel. It is the material of choice in the majority of food-processing plants because germs do not adhere to its surface while it is corrosion-resistant and easy to clean. But this only applies if the sheets and profiles used have been cut and welded by laser. No other technique guarantees the necessary high-quality weld seams and prevents the development of porous oxide films that constitute a risk to hygiene. Another advantage of stainless steel is that it allows the manufacturers of food-processing equipment and machinery to process steel sheets of different thicknesses or made from different alloys using a single laser system, thanks to the flexibility with which the working parameters can be set. This makes it easy for them to manufacture different types of meat grinders, dough mixers and transport tanks.

Smooth flow The exceptional chemical stability of stainless steel makes it ideally suited for the beverage industry, where it allows liquids to be fed without acquiring an unpleasant metallic taste. The storage tanks in which wine and beer mature are now commonly made of stainless steel. The walls of these tanks often contain cooling circuits filled with a heat-transfer agent that precisely controls the temperature inside the tank and thus regulates the fermentation process. The same principle is used to control numerous other temperature-dependent processes, such as the refrigeration of transport containers. The design of modern tanks differs from that of its predecessors, in which pipes or welded ribs were incorporated for this purpose. Instead they are constructed by welding together flat sheets of stainless steel, one over the other, with parallel weld seams. At the end of the welding process this structure is inflated by introducing compressed air — rather like blowing up an air mattress. The resulting hollow panels can then be welded together to create the finished tank, in most cases using a laser. The butt joints produced in this way are gas-tight, have a high load-bearing capacity, and are resistant to microbial attack. Moreover, due to the low heat input, the large surface of the stainless steel panels is only minimally deformed despite the considerable number of weld seams.

Competitive advantage Lasers rarely come into direct contact with the actual product. Nobody has yet invented the laser-sliced cream cake or the laser-prebaked pizza. Such ideas are unrealistic because the energy input would be too high. But there are a few niche applications in which the laser can be useful, especially if they require a non-contact solution. Cracking eggshells without damaging the content of the egg is a prime example. This process was originally developed for the pharmaceutical industry, but could be easily used for applications in the food industry. A more practical example is peeling tomatoes. The laser only heats the flesh directly below the skin, enabling the latter to be peeled off to reveal a perfectly skinned tomato. Hardly any vitamins are lost because far less heat penetrates through to the center of the fruit.

There is another food-industry application in which lasers have already achieved a breakthrough, namely the laser marking of food products. It is common practice for cheese makers to use lasers to imprint the use-by date in the rind of the cheese. In this way, manufacturers of dairy products can reduce their labeling costs and avoid the otherwise inevitable pressure marks that spoil the appearance of their products. Apples are another grocery product that can be brand-marked with laser-inscribed company logos or slogans. A UV laser oxidizes the pigments in the skin of the apple, leaving behind a paler-colored marking. In an era in which consumers are increasingly brand-aware, such marketing devices represent a genuine competitive advantage. There is no limit to the opportunities this provides. Bakers are already using the new technology to deliver bread rolls bearing their company logo, and sushi kitchens are using lasers to texture the sheets of seaweed wrapped around their products and transform them into veritable works of art.

For packaging, processing and labeling, the laser has become an indispensable feature of the food industry and is here to stay. And as the world population rises, the demand for efficient laser applications will no doubt increase further.

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Oliver Graf

Gerd Gigerenzer is the Director of the Center for Adaptive Behavior and Cognition at the Max Planck Institute for Human Development.

Follow your *intuition*

Should you use your head, or go with your gut? Psychologist Professor Gerd Gigerenzer argues that "sometimes having less information can actually lead to better results."

Picture yourself in a television studio. You are on a quiz show, sitting on a stylish chair that seems to be designed to be uncomfortable. The presenter fires the next question at you: "Which city has more inhabitants: Detroit or Milwaukee?" Disaster! Geography has never been one of your strong points. You feel yourself starting to sweat. You don't know the answer and you can't use logic to work it out — so all you can do is guess. You desperately search your mind for clues: Detroit, Detroit… the car industry! Maybe you even hit upon the Motown record label or the Detroit Red Wings. And Milwaukee? Maybe you have heard the name once (in a song?), but no more than that. So you decide to go with Detroit — and it's the right answer! When Daniel Goldstein and I posed this question to American students on a college course, they were split fairly evenly, with 40 percent choosing Milwaukee and the rest choosing Detroit. But when we asked German students, virtually all of them chose the correct answer. Does that mean Germans know more about American geography then Americans do? Absolutely not. In fact, they knew hardly anything at all about the two cities, and that is precisely why they trusted their intuition, which led them to choose the right answer. The American students actually knew too much about the two cities — and this excess of facts clouded their judgment.

We see intelligence as a carefully considered process, a conscious activity that follows the laws of logic. Yet much of our mental life is unconscious and has little to do with logic. We constantly resort to intuition for everything from choosing our friends to making everyday consumer decisions such as which toothpaste to buy. Consumer organizations and management consultants often advise people to "keep a cool head and analyze all the options carefully; weigh up the pros and cons of each alternative." But, in reality, that's not how people work. As shown in the example above, we often choose to rely on our gut instincts and seem to get surprisingly good results.

If, when you hear "Detroit", all you can think of is cars and the Red Wings, then you're more likely to guess the city's size correctly.

Intelligence adapts and makes the best of the resources it has at its disposal by relying on subconscious processes, rules of thumb and evolved capabilities. Our brain picks out the most important information and pushes the rest to one side — a strategy that often helps us to rapidly take the best course of action. My feeling is that we should view human intelligence as an adaptive toolbox that contains genetic, cultural, and individually created and communicated rules of thumb. In this toolbox, logic is just one of many useful tools that our mind can access. In many cases, our gut instincts will produce better results than logic. That's because logic is simply unable to offer satisfactory solutions to certain problems. For example: Which stocks should I buy? Should I leave my partner or not? Should I accept this job offer or the other one? Everyone knows that feeling of suddenly knowing that something is right — choosing to act in a certain way even though we couldn't possibly articulate the deeper reasons behind our choice of action. The particular intelligence of our subconscious lies in the fact that it knows without thinking which rule is likely to work in any given situation. "If you are given the names of two cities and you have only heard of one of them — then that is likely to be the bigger of the two." ■

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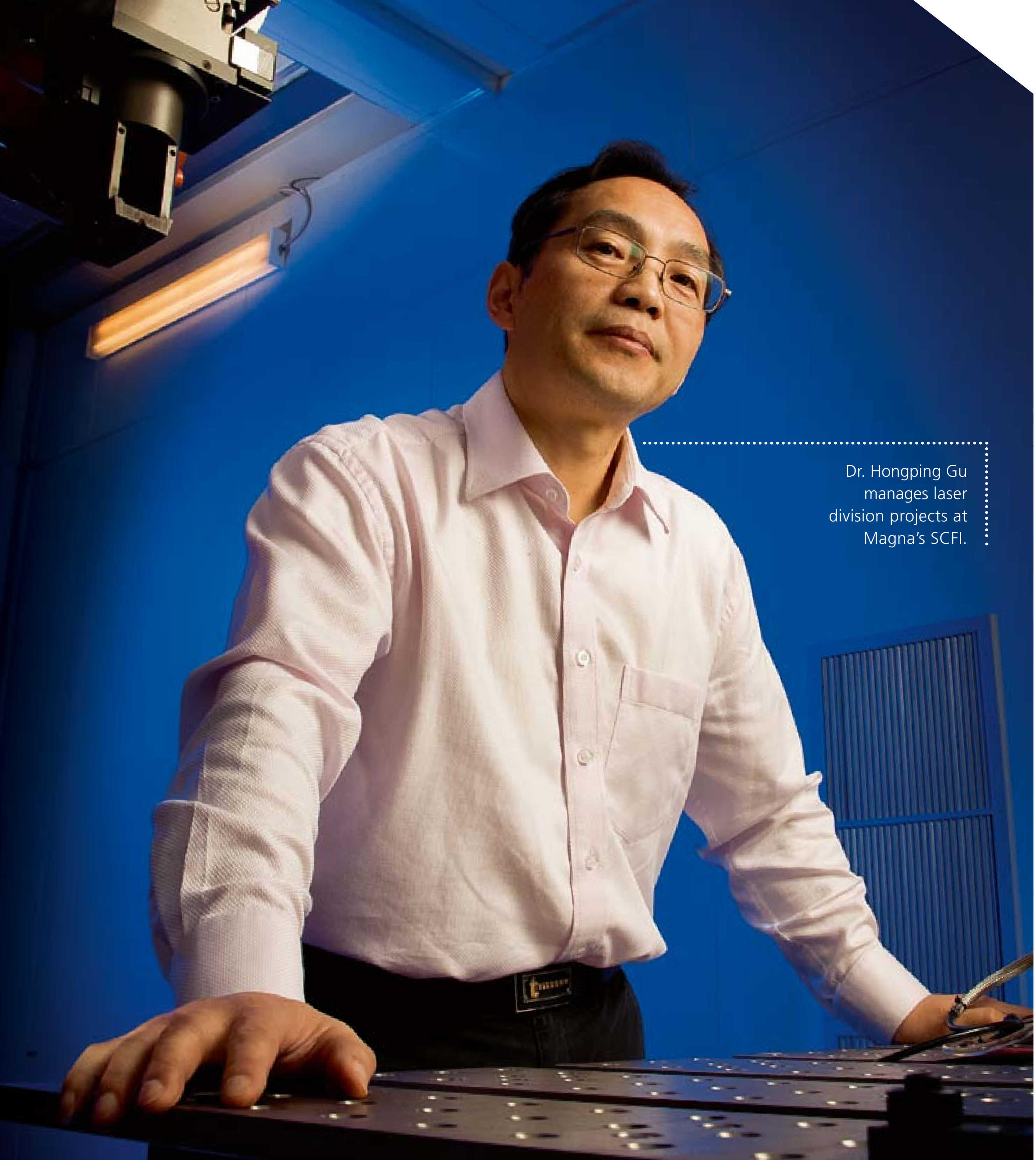
Dietmar Gust, Gernot Walter



Dr. Hongping Gu manages laser division projects at Magna's SCFI.

Dwight Cendrowski

THE SCFI
A research branch of Magna International, the Stronach Centre for Innovation offers the resources to develop innovative ideas while simultaneously cultivating Magna's next generation of innovative leaders.

THE MAN
25 years ago, Hongping Gu attended one of China's first scientific laser research institutes and moved to Canada to study lasers for material processing. He joined the SCFI shortly after it opened in 2009.

THE JOB
Dr. Gu is Manager of Advanced Laser Applications at the SCFI. He manages the Centre's laser division projects and performs experimental research to bring innovative ideas to reality.

"Use your freedom"

What advice does automotive laser expert Hongping Gu have for future manufacturers? "Don't be limited by machine capabilities. Lasers can give you freedom for new designs."

Last year the North American automotive industry sold fewer vehicles, but reported higher profits. Dr. Gu, what role are lasers playing in this changing market?
The auto industry today isn't like it was seven years ago — one particular model, very high volume, and not much variety. Now you see many different models and parts. Using mechanical methods, you need many different machines to produce so many shapes. Using lasers, you just change the program. Lasers help the whole process in terms of better quality and reduced cost.

How will laser technology influence future automotive process chains?
Lasers don't affect the overall process chain. When you're using laser technology efficiently, you simplify the procedure and reduce the complexity. If you have one machine that can do all the things that used to require lots of machinery, investment is lower and you can save floor space.

Do you think this will change car design?
Manufacturers can design a greater variety of cars and meet a larger variety of people's requirements using lasers. Before, automotive manufacturers needed a certain volume. How could they get returns if they had to invest a huge amount of money in machines that only produced a few parts for a few cars? Lasers are much more flexible and can be used for many different components.

What effect do lasers have on automotive safety and fuel consumption?
To reduce weight, you have to use stronger material in lighter gauges. Cutting high-strength steel is very difficult for traditional tools. Also, to achieve higher energy efficiency, designs usually need modification — which can create problems in the various machining channels. With the laser, you can free your mind to break the part into different components, use different materials, and then join them together.

In your opinion, what laser processes look the most promising for automotive use?
Laser heat treatment is the next big thing. Two areas in which you can reduce costs are parts manufacturing and tooling. To make tooling last longer, you must be able to repair or maintain it. With the help of the laser, it could be possible to use a lower grade material and add different materials in key areas that wear out or are damaged to help tools last longer. Specific heat treatment for components is not new, but using the laser for localized strengthening or weakening of materials isn't fully developed yet.

Do you see any laser applications moving from the lab to manufacturing?
We're trying to promote laser heat treatment of parts, such as power train components, into the production environment. Many such components have a very small area needing heat treatment. Using the laser, you can focus the heat treatment and achieve high strength in a localized area. You don't need to harden the whole part, which reduces costs.

What laser trends do you find most exciting?
Fiber beam delivery. It is more convenient to manipulate the beams. The process is simpler to implement and maintain. These systems are gradually being employed in automotive for cutting and welding for every component. Fiber and disk lasers make it easier for manufacturers to make the switch to laser technology. The initial costs are similar to other laser options, but the process costs are lower due to lower maintenance and overall cost per part. I'm also excited about increased available output power and more variety in terms of pulse shape, pulse duration, and peak power. Greater variety of lasers — such as fiber and diode — with different wavelengths offer the ability to process a wider variety of different, lighter alloys more efficiently.

What potential do you see for laser technology in nonmetal applications?
Larger size components could be possible in nonmetals. We already see increased interest in laser welding plastic components, such as headlight or taillight housings. Unlike mechanical cutting, the laser could allow processing of nonmetal materials in complicated shapes without problems. The laser can move to any spot and it's very easy to change from one part to another by just changing the program. In addition, lasers will play an important role in processing brittle materials, such as glass or ceramic. Unlike conventional laser processing of metals where melting and evaporation take place, laser cutting of glass is done via the controlled thermal stress cleavage of the materials. This may create demand for a new type of laser in the future.

What's on your "wish list" for laser technology?
I'd like to have an articulated system that can separate the beam and direct it into different locations simultaneously. You could use the entire capacity of the laser to meet the different power level needs of different applications simultaneously. I'd also like to see increased energy efficiency and more easily scalable laser power for the ability to expand in the future. And lower cost — this will make it possible for more manufacturers to make a change to laser technology. ■

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Oven-ready

Remote laser welding and cutting are not typically used to produce ovens. Electrolux decided to break with tradition — and the result was a big step forward in quality.

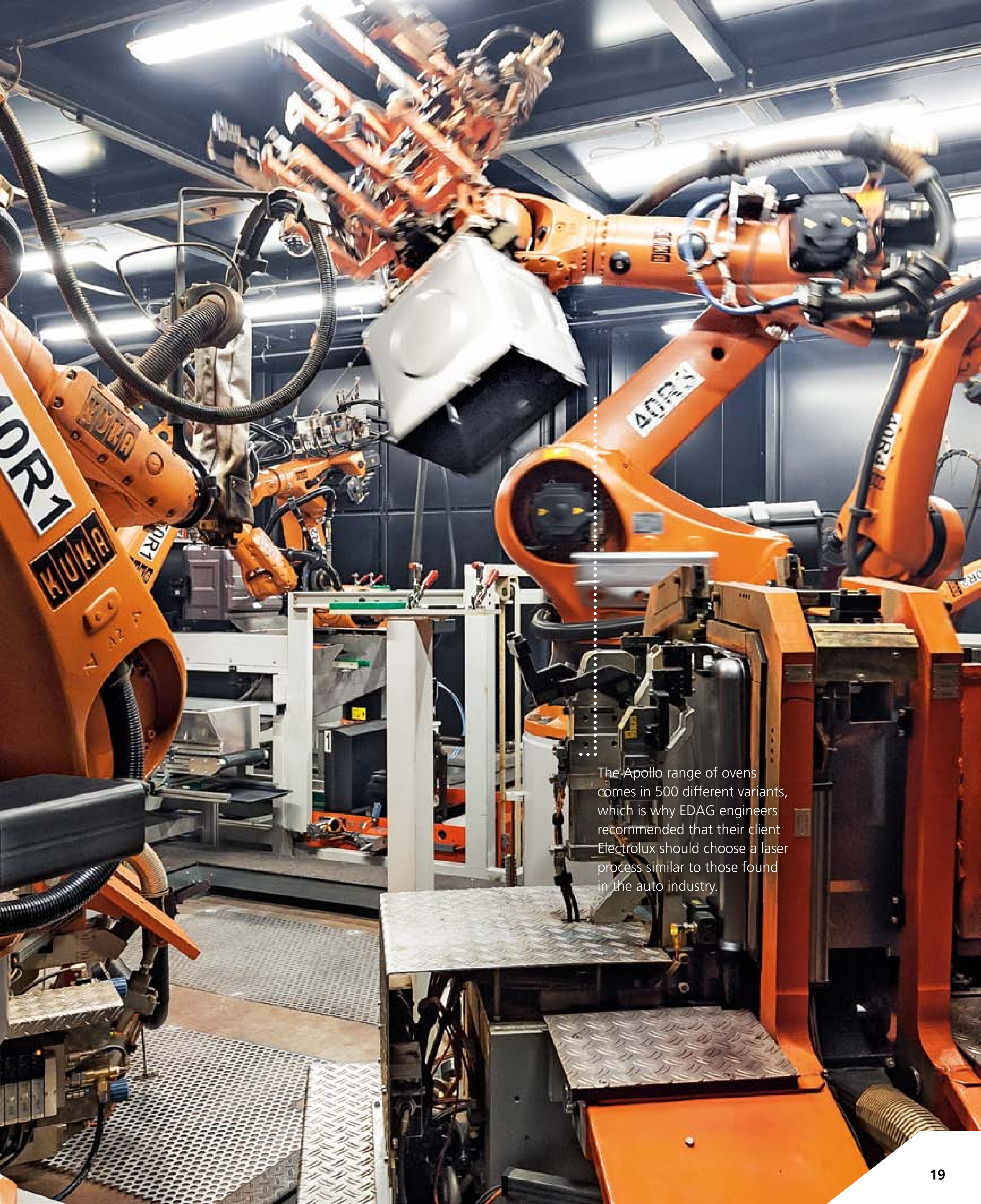
Three welded metal sheets and an enamel coating — surely that's all you really need to produce an oven? Bernd Ebert, Director, Global Manufacturing Engineering at Electrolux, laughs: "If it's that simple, why is the Electrolux plant in Rothenburg one of the most advanced household appliance factories in Europe? An oven cavity may look like a fairly basic box, but producing it involves many processes — from clamping and welding to enameling and baking." The Rothenburg plant produces some 700,000 built-in ovens each year for markets around the globe. In 2009, the company switched to the latest generation of Apollo ovens. The quality standards required for these ovens led to the development of a fully automated laser welding and cutting line — the first of its kind in the oven manufacturing industry.

The specifications called for an oven with a volume of 65 liters, available in various heights, that could be equipped with standardized components such as a heating element and oven lamp. "The Apollo range of ovens comprises 500 models, including features such as steam cooking and pyrolytic self-clean functions," says Ebert, an engineer and business economist. "Our vision was to feed just one type of each basic component into the system. At that point the process steps should define which variant is to be produced." The team was also planning a big step forward in quality, aiming to eliminate the annoying edges that typically appear on the enameled surface. This was one of the main reasons for breaking with tradition: to use laser welding instead of resistance welding and laser cutting instead of punching. This new approach threw tried-and-tested processes into question and plenty of people within the company harbored reservations about the new technology, but Electrolux was determined to press on. The project involved the three European Electrolux production sites as well as integration experts called in from the company FFT EDAG Produktionssysteme (PS).

Automated to the max The Rothenburg plant took on a pioneering role when it started using the new process for mass production in February 2010. The automated assembly line produces oven cavities at a rate of one every 12 seconds, with the top, bottom and cavity wrapper components being fabricated from 0.6 mm-thick, low carbon steel. The cavity wrapper is formed into a C-shape in a bending unit and transferred to a pallet conveyor. The top and bottom panels then enter the line via a "paternoster" and are also transferred to the pallet conveyor, at which point everything disappears through the tunnel into the welding booth.

"We use an electronic Kanban procedure that shows the machine operator which ovens are required and forwards the production program to the system. The plant control system displays all the active and ongoing production orders," says Christian Ehninger, an engineer who works closely with Ebert. A steerable camera zooms in to reveal the complex inner workings of the welding booth. It contains two welding robots, each of which is equipped with a TRUMPF TruDisk 5302, and four cutting robots, each of which features a TRUMPF TruFiber 400. In the initial step, high-precision clamping chucks are used to hold the components together on the tool rack. The Z-edge

Jens Oswald



The Apollo range of ovens comes in 500 different variants, which is why EDAG engineers recommended that their client Electrolux should choose a laser process similar to those found in the auto industry.

1

2

3

4

RECIPE FOR SUCCESS

1 Computer-controlled accumulating conveyors move oven components into the automated assembly line. **2** Robots position the top, bottom and cavity wrapper components, which are made from 0.6 mm-thick steel, on the pallet conveyor. **3** Joining takes place in the welding booth. A three-meter-long weld seam joins the three parts together. Cutting lasers produce the complex, model-specific hole patterns. **4** The ovens then continue to the degreasing and enameling stage at a rate of one every 12 seconds.

For more pictures, visit www.laser-community.com/?p=1593

Jens Oswald

of the top and bottom panels serves as a limit stop. It must be at exactly the same level all the way round so that the overlapping part of the wrapper can be pushed up against it. Two small angle brackets are welded on, followed by a three-meter-long weld seam. Next, the oven cavities are picked up by six-axis robots and placed in the cutting pallets where the TRUMPF cutting lasers produce the complex hole patterns using special optically controlled cutting techniques. The ovens then pass through a cleaning stage before being powder coated with a fog-like spray to create an enameled surface which is between 120 and 150 micrometers thick. Finally, the ovens are baked at over 800 degrees Celsius, carefully inspected, and then placed in a holding bay ready to enter one of the nine final assembly lines. A three-hour buffer gives the necessary leeway to cope with any machine downtime.

Ebert attributes the success of the project to an iterative approach and their conviction that they were on the right track. He also credits the open tendering process. The team used a matrix to measure up the welding concepts and processes against the required oven specifications. "The tender specifications cited the three-meter-long weld seam — plus the fact that it had to be invisible under the enamel coating — as a key challenge, but we deliberately avoided specifying a particular process," explains Ebert. The machine suppliers bidding for the contract produced prototypes using a range of different methods which Electrolux then subjected to intensive testing in Rothenberg. FFT EDAG PS was the only provider to recommend laser technology. "Roll seam welding would generally be the standard choice in this context," admits Jean Heussner, project manager at FFT EDAG PS. "But using seam welding in this particular application caused problems in the corners — and it would have required multiple machines to meet Electrolux's 12-second output rate." FFT EDAG PS drew on its experience with joining processes in the automotive industry, and Ebert says that the test results clearly supported their final choice: "The critical weld seam is perfectly burr-free."

"We want to create all the variants within the system itself."

Bernd Ebert, Director, Global Manufacturing Engeneering, Electrolux Rothenburg

From laboratory to factory

A vibration-free foundation was laid in preparation for the installation of the welding cell, next to the basement area containing the power generator. The building modifications were worthwhile, because they allowed the operator to achieve a new level of process excellence. With their ability to handle flexible welding parameters and geometries, the TRUMPF laser systems only needed minor adjustments to fit in with the process requirements.

Before delivering the new production system to the end customer, FFT EDAG PS and TRUMPF jointly ran a series of laboratory trials to define the equipment and validate the processes. "We had no difficulty integrating the machines in the production line", reports Jean Heussner of FFT EDAG PS. The major emphasis lay on end-to-end process validation, including defining the geometries, testing for accessibility, and process reliability testing — "essential prerequisites for reproducible quality in a series-production environment."

The integration of cutting and welding processes in a single production system has two tangible benefits. Firstly, there is no interruption in the flow of data at the transfer points between different components — a factor that leads to greater process stability. And secondly, it enables new variants and product modifications to be implemented rapidly and cheaply. Changes to cutting and welding geometries can be user programmed in a single operation for both machining stages, because lasers produce the cutouts and drill the holes. There is no need to produce and modify new punching tools — another factor that saves time and money. Moreover, the results fulfill the main objective of a product (in this case a baking oven) that fully meets the customer's criteria for visual and haptic quality.

The Electrolux Group's experience of the new manufacturing system at its Rothenburg plant in Germany was transferred to other European sites in 2011. It is currently being introduced at the Electrolux appliance plants in Forlì, Italy, and Swidnica, Poland. The laser welding and cutting cells for these plants were also supplied by FFT EDAG PS. Meanwhile, the Electrolux plant in the United States has also expressed an interest, which gives confidence to Ebert and his team: "We are proud of this exciting project — and the advanced know-how it has generated secures Rothenburg's future in the international group." ■

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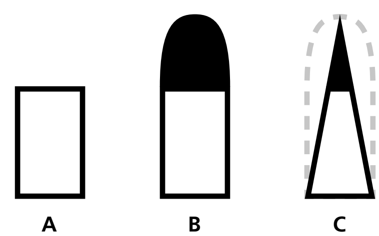
"Our batch size nowadays is 12 or a multiple of 12."

Christian Ehninger, Central Manufacturing Engineering, Electrolux Rothenburg

A cut above

Powder deposition by laser is setting new standards in knife blade technology at Stanley, where sharper for longer is the new mantra.

It's the black edge that makes all the difference — in terms of cutting as well as in terms of marketing.



A continously fed strip of blade steel (A) accepts a fine bead of welded carbide (B), which is then ground into shape (C).

For the more pictures of the process, visit www.laser-community.com/?p=1597

Running unmanned and continuously for three days, the application at Stanley Black & Decker is now the longest, uninterrupted, single-run laser deposition process in the world. But as amazing as this may seem, it's little more than a first step for this progressive manufacturing company. The Stanley brand is synonymous with workplace utility knives. Professional plasterers, carpet fitters and decorators at construction sites around the world have used Stanley knives throughout their careers. Add to this multiple applications in markets such as packaging and handicrafts, and few will have escaped exposure to this iconic product.

The blade itself is remarkably simple, selling in two major formats: trapezoid blades preferred by UK and US customers; and snap-off segmental blades for European markets. Both are housed in Stanley's instantly recognisable yellow and black retractable-blade handles. In fact, so distinguished is the brand that evolution and new development is no mean feat, but this is the challenge being met head-on by R & D staff at Stanley Black & Decker, as the company is today known following a merger in 2010.

An edge of dust

"Carbide" is the next generation of Stanley knife blade. This fusion of product innovation, process technology, and marketing skill is about to take utility knife operations to a whole new level. And at its core is a high-performance TRUMPF laser solution depositing a carbide powder to the blade edge. The first sales and marketing giveaways of Carbide have already taken place following a series of recent "soft launches" around the world. "The soft launches are deliberate to test the market: too much, too quickly will leave us unable to meet demand at this stage," says R & D Manager, Peter Culf. This revolutionary technology was developed and installed at the Stanley Black & Decker UK facility near Sheffield, and adds to existing "conventional" knife blade manufacturing capacity.

At present, Carbide blades are manufactured using six inline, purpose-built application centers. Essentially these house TRUMPF laser deposition head and camera systems with coiled strips of blades fed automatically below the nozzle. TRUMPF TruDisk technology provides the laser source, while TRUMPF TruMark laser marking stations are integrated into each center. The blades are subsequently ground in a separate operation to produce the required edge angles. Stanley Black & Decker's application centers deposit a carbide powder on the cutting edge of each blade. The result is knife blade technology redefined. "Our alliance with TRUMPF came about because they are clearly the market leader at the premium end of the laser market," says Culf. "If we didn't have TRUMPF on board, our precision deposition process wouldn't have got off the ground." This is a process that boosts hardness from 800 Vickers Hardness for a standard blade, to 1200 Vickers Hardness. "Using an industry standard CATRA testing machine, Carbide blades show up as virtually indestructible," says Culf. Surprisingly, this caused something of a dilemma for the marketing department. "Our market research showed that claims of any blade offering 10 or 12 times the life of our standard blades would not be believed," he states. "However, because of Stanley's reputation, five times greater life was deemed conceivable. As a result, this is what our marketing materials reflect despite the reality that life expectancy is far, far greater."

Practically everyone's seen one: the characteristic black-and-yellow Stanley knife.

Working hand-in-hand with marketing has been a prevalent theme throughout the project. The Stanley Black & Decker marketing team was insistent on a product that "looked different" in the marketplace. The special look of the black edge created by the laser deposition process was just what marketing needed, and even though it could be removed by introducing more argon shielding gas, it was decided to retain this "black and hard as the devil" look, and even enhance it by laser marking the Carbide brand in stylish black lettering along the side of each blade.

The project demonstrates that laser deposition technology is not the sole reserve of high value parts produced in low volume, such as jet engine turbine blades for example, but can be applied to simple products manufactured for mass markets. "We are no different than any manufacturing company. Each expenditure has to be meticulously justified, but our driving motivation was that we wanted a superior blade," explains Culf. "Advanced technology of this type obviously carries a cost, but we believe that our customers will readily appreciate the performance benefits that result. According to our market research, life is the leading customer requirement, followed by first-cut sharpness, price, brand and safety. Ultimately Carbide is a prestige item that will become our 'hero' brand."

As demand ramps up, Culf says that installing more TRUMPF based application centers is very feasible. This move will of course help boost the company's global capacity, but there is still ground to cover. With this in mind, don't be surprised if Stanley Black & Decker make the process even sharper in the very near future. ■

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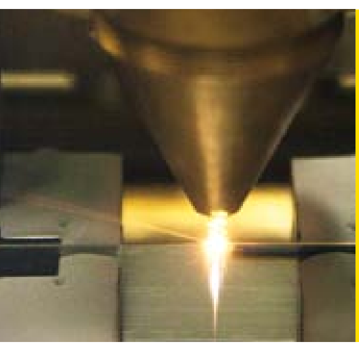

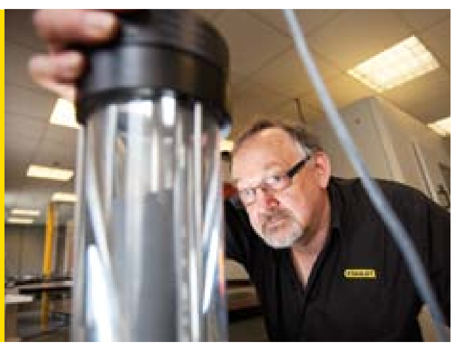

Left: *The nozzle deposits the metal powder on the steel.*

Right: *Peter Culf, Research & Development Manager at Stanley Tools, developed the process.*

Dean Smith (Camera Crew)

Prof. Klaus Dilger

Pressure down

Less spatter and neater seams. Who would have thought that combining the costly vacuum technology of electron beam welding with the lower-energy beam of a solid state laser could be so effective?

In conventional laser beam welding, the escaping metal vapor sometimes hits the molten layer at the capillary rear wall and causes weld spatter. Solid state lasers (SSLs) have a far greater tendency to generate spatter than CO_2 lasers in this process — and this tendency becomes more pronounced with increasing weld depth and feed rates. As a general rule, SSLs are therefore the preferred option for thin sheet applications, while CO_2 lasers are considered to be the superior choice for sheet thicknesses greater than four millimeters. Welding applications in certain fields such as gear manufacturing, in which the weld depth is far in excess of 10 millimeters, are completely out of reach for solid state lasers. Regardless, industry demand for SSLs continues to grow, largely in response to economic considerations, in particular the wish to boost energy efficiency and manufacturing flexibility.

In contrast, electron beam welding enables greater penetration depths and produces high-quality weld seams, but has the disadvantage of requiring a much lower working pressure of approximately 10^{-4} millibar. In many cases, however, this technique does not actually present a viable alternative. Part sizes are restricted because of the required vacuum chamber, and cycle times are higher due to the use of a vacuum pump and the need to move components in and out of the chamber. Further disadvantages include the X-rays generated by the process and the fact that capital costs typically tend to be higher.

This prompts the question of whether it might be possible to merge the advantages of both electron beam welding and solid state laser welding by bringing together aspects of both processes in a combined method. As part of a joint research project with TRUMPF Laser- und Systemtechnik GmbH and pro-beam AG & Co. KgaA — one of the leading German manufacturers of electron beam technology, the Institute of Joining and Welding (ifs) at Technische Universität Braunschweig is currently attempting to develop a novel combined technology of this kind, investigate its feasibility, and make it commercially available.

Pressure: A pivotal factor

One of the key advantages is the way in which SSLs can be flexibly integrated into production systems. Multiple processing stations and/or vacuum chambers can have access to a single laser beam source and use it for what is, in many cases, a broad range of different welding applications. One of the most significant results of reduced ambient pressure is that it changes the metal vapor plume that is typically seen in solid state laser welding.

Spatter formation diminishes as the pressure decreases, and the weld shape changes.

Institut für Füge- und Schweißtechnik der TU Braunschweig

Even a slight drop in pressure leads to a visibly narrower plume and a substantial reduction in the amount of weld spatter. A further drop in pressure to 100 millibar shrinks the metal vapor plume still further, reducing it exclusively to the joining zone and producing only isolated spatter. The plume and spatter formation disappear entirely once a pressure of 10 millibar is reached. The reduced pressure also yields weld seams that, in terms of quality, are on a par with seams produced by electron beam welding. Using a laser power of six kilowatts to weld 10-millimeter-thick mild steel at a feed rate of two meters a minute, the researchers were able to produce remarkably high quality penetration welds without any irregularities. Under atmospheric pressure, this level of quality could not be achieved even with a CO_2 laser.

New shape of seam

A reduction in ambient pressure also produces further characteristic features and properties regarding the quality of the weld seam. Using the same process parameters, a drop in pressure leads to an increase in weld depth and changes the shape of the seam cross section. At a laser power of six kilowatts, the researchers succeeded in producing a 25-millimeter-deep penetration weld under a vacuum of 10 millibar. Welds of this depth would be inconceivable under atmospheric conditions, especially in regard to the power used to produce them.

A micrograph of a weld seam produced under atmospheric pressure reveals a seam in the shape of a nail head with a relatively wide bead. Bead width decreases as the pressure drops, with melting principally occurring deeper in the material. At a pressure of 100 millibar, the weld seams have a high aspect ratio and parallel seam edges. Reducing the pressure by another power of 10 causes a striking change in the weld shape. The weld depth remains virtually unchanged, but micrographs show the seam taking on a vase-like shape. The key characteristics of this vase shape are the inward curve at the center of the seam and a convex broadening in the root area. It almost appears as if the caustic of the laser beam is “frozen” in the micrograph.

No cavities, no bead depression

The technique of laser beam welding at reduced pressure offers new potential for laser material processing. Particularly for thick metal sheets, it completely eliminates the problem of the weld seam collapsing during penetration welding. Despite a fourfold excess of energy, weld seams with a depth of 10 millimeters do not reveal any top bead depression or excess penetration bead — two problems that are inherently unavoidable in welding operations at atmospheric pressure due to the higher excess power. The use of reduced pressure also successfully prevents the undercut typically seen in the penetration welding of sheets with a thickness of three millimeters.

The specific features and characteristics of laser beam welding at reduced pressure demonstrate clear quality improvements in terms of spatter formation and weld shape. As a result, this process represents an opportunity to achieve significant efficiency growth in efficiency in existing markets and opens up multiple new fields of application. For applications where high weld seam quality is particularly important, such as powertrain manufacturing in the auto industry, this new process could very well be a viable option. In fact, researchers have still only scratched the surface of the potential offered by this new process: For example, it is conceivable that the process could have an equally positive effect on the formation of process pores in laser beam welding. ■

For the detailed results, visit www.laser-community.com/?P=1599

Prof. Klaus Dilger *is the Director of the Institute of Joining and Welding (ifs) at the Technische Universität Braunschweig. One of his areas of specialization is beam welding processes. He is currently conducting research into laser welding under vacuum.*
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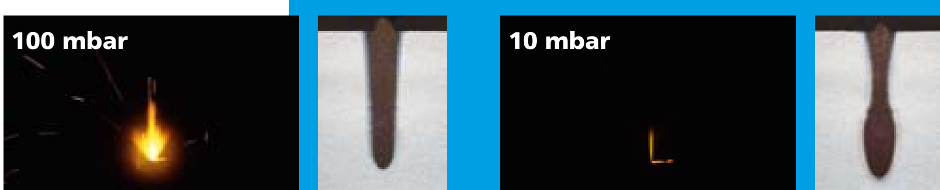
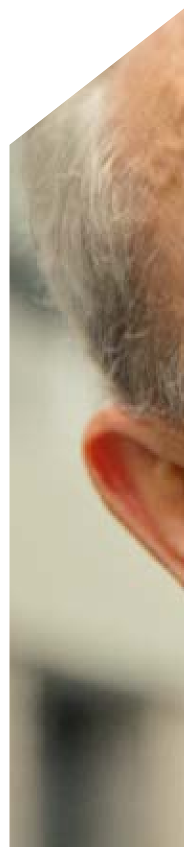


Under a low vacuum, solid state lasers can create welds that not even CO_2 lasers are able to produce.

Prof. Reinhart Poprawe calls himself a photon entangler.
We asked him to explain what that means.

"I don't like the term *technology transfer*"

Ralf Kreuels



Over the last 25 years, some 30 companies have been founded as spin-offs from the Institute. They employ about a thousand people and reach annual turnover of almost 100 million euros. What effect does all this have on your work?
Every spin-off ultimately means that we lose staff and orders — but we still support them! There are two reasons for that: First, they enhance the ILT's reputation and, secondly, the start-up companies they form give us a rich new source of industry partners. The fact is that people always start out thinking that they can make a success of their new technology on their own, but after one or two years they find that their competitors have already drawn level or even overtaken them. That's when the founders really start to appreciate the importance of collaborative research. Over the long term, spin-offs provide genuine benefits to our Institute.

How many of those start-ups survive the first few years?
All of them! But that's because our spin-offs generally grow very slowly. They are toward the beginning of the process chain and are not actually offering consumer products. But all that could change if laser manufacturing were to become an established technique for something like hearing aid housings, because that would be a huge market.

You have spent more than 30 years focusing on the future of German laser technology. How did you first become interested in lasers?
It all started with an excursion I took when I was studying at California State University in Fresno in 1976. We went on a trip to see the world's largest laser at Lawrence Livermore National Laboratory. It was a huge piece of equipment in a building as big as four gyms. I was absolutely fascinated by the whole thing. Once I got back from my year abroad I was determined to continue my physics degree at an institution that specialized in laser research.

What stage had Germany's laser research reached back then?
There were only a few researchers working on lasers back then, most of them working at the Max Planck Institute of Quantum Optics in Munich and in a team led by Professor Gerd Herziger at Darmstadt University. He was one of the first people to bring laser technology from the USA to Germany; and he ended up being my doctoral adviser.

Germany pulled ahead of the USA astonishingly quickly. How did it manage to make such rapid progress?
Laser research in the USA was primarily focused on nuclear fusion and military applications, neither of which were relevant issues in Germany at that time. The Darmstadt team had set itself the goal of utilizing the technology across a broad front for industrial manufacturing. They began by working on compact lasers in the kilowatt range for cutting, welding, soldering and drilling. This market might simply have been too small to interest the Americans. But the biggest reason for

Prof. Reinhart Poprawe feels just as comfortable working in industry as in research. As the director of the Fraunhofer Institute for Laser Technology ILT, he acts as a mediator between these two worlds.

"The laser materials processing market — in the 1970's — might have been to small to interest the Americans"

Germany's success was the practical focus that has traditionally been so pronounced in technical courses of study in this country. The close ties between the research community and industry are a huge advantage that Germany has always enjoyed over other countries.

So technology transfer is one of Germany's key strengths as a major industrial center?
Yes, but I'm not very keen on the term "technology transfer" because it sounds so one-sided. I see the research and business communities as partners. Just think of entangled photons if you want an example of how closely interlinked those two partners are! At the ILT, we need to know at the earliest possible stage what our industrial partners' requirements will be two or three years down the line. That enables us to work on targeted research issues that will produce relevant innovations. The practical benefits emerge in tandem with the progress we make on the research topics. This close link between the two communities is a core principle of the Fraunhofer institutes. The Fraunhofer Institute for Laser Technology ILT was founded in Aachen in 1985 with Gerd Herziger at the helm, and right from the start we worked closely with the German laser industry.

Later in your career you spent seven years running an industrial company (Thyssen Laser Technik GmbH). Why did you switch sides — and what made you ultimately return to the fold of the Fraunhofer ILT?
As a researcher, I was only involved in a project up to the point where the benefits of the innovation became tangible, and then the rest of the project would be carried out by the companies on their own. By becoming the head of a company I was finally able to get involved in that process of turning innovations into products. I never intended to return to the public sector, but then in 1996 I was given the opportunity to become the director of

Open invitation: The Fraunhofer ILT in Aachen has become a central hub of the laser user community.

LASER Prof. Reinhart Poprawe first encountered laser technology in 1976 while he was studying physics at California State University. That experience had a lasting impact — and his career has revolved around laser technology ever since.

LIFE After obtaining his doctorate, Poprawe started work as a department head at the Fraunhofer Institute for Laser Technology ILT. Four years later his career shifted to the world of business, but he remained firmly committed to laser technology, heading up the activities of the company Thyssen Laser-Technik GmbH from 1989 to 1996.

LIFEWORK Since 1996, Poprawe has held the Chair for Laser Technology at RWTH Aachen University and is director of the Fraunhofer Institute for Laser Technology ILT. One of his key tasks in this role is to foster cooperation between science and industry.

the ILT and occupy a chair at RWTH Aachen University. I saw my return to the Institute as an opportunity to increase the research community's cooperation with industry partners.

Does your Institute always receive the impetus for innovations from industry partners, or does it sometimes come from basic research?
Obviously the global development community is continuously generating new ideas which immediately get global exposure. But the real question is how to turn an invention into an innovation. Industry has a far better perspective on the market, and innovations are essentially produced in a market environment.

> "The real question is: How does an invention become an innovation? Industry has a far better perspective on the market, and innovations are produced in the marketplace."

You not only have close ties to companies; you also collaborate with RWTH Aachen University in a cluster of excellence: "Integrative Production Technology for High-Wage Countries." What benefits does that offer your Institute?
We work closely with economists and planning-oriented engineers in the Cluster and benefit from their different perspectives. Business and technical process chain analyses are very different things. Economists also have a different take on when a new technology might become relevant.

The Cluster's research topics aim to resolve many of the contradictions between "scale" and "scope", in other words between mass production and the maximum possible degree of product variability. Will laser-based additive manufacturing methods become more important in the future, even in large-scale production?
I believe that these technologies are the only way forward. One example is selective laser melting (SLM), which our Institute helped to develop. SLM makes it possible to produce parts without using any dies or tools: The more complex and individualized the parts, the more likely it is that SLM will be a good choice. The automotive industry has already started producing some components using SLM, so the concepts of scale and scope are already drawing closer together. The key benefits of SLM include weight reduction, lower material consumption, and complete freedom of design.

But those kinds of techniques are still extremely costly — might they become cheaper?
We are working hard to reduce the costs involved. It is already possible to achieve a volume build-up rate of one cubic centimeter of material per minute. I feel confident that SLM will eventually succeed in transforming mass production.

How can countries like South Korea, which is currently experiencing a boom in research, learn from the German development environment?
Germany is so well established in the field of manufacturing engineering and has achieved such high levels of expertise that it must be difficult for newcomers to find a way into these markets. But there are some areas where German dominance is not quite so pronounced, for example semiconductor diode lasers. That is a field that clearly has a promising future, and I think it offers an opportunity for those countries to gain a competitive edge. But, whatever happens, Germany will ultimately maintain its superiority in manufacturing engineering because it takes decades to build up the kinds of networks of researchers and companies that we have here.

How much work do you do with Asian researchers and companies?
I am the representative for China at RWTH Aachen University. One thing we offer is a double master's degree program in collaboration with Tsinghua University in Peking. Our work at the Institute also involves regular communication with the Asian customers and suppliers of our industry partners. We are currently working on a joint project to define standards for accepting components from China. If we can achieve that goal, it would be a win-win situation for everyone involved.

Will collaboration between the business and scientific communities become even more important in the future?
Without a doubt. As we always say, it used to be important to know where to look up the information you needed — but today you need to know who knows that information. And tomorrow the question will be: Where is that knowledge being generated? ■

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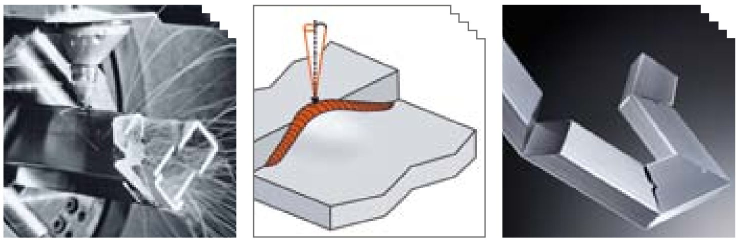

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BONUS TRACKS

Where's the laser?

ON WATCH DUTY: Watchmaking has long been a noble trade that achieves a fine balance between craftsmanship and art. But even the most exquisite timepieces eventually succumb to the ravages of time. In the past, watchmakers confronted with a broken gear tooth no bigger than a speck of dust in a watch movement would attempt to tinker up a solution, putting their faith in highly questionable elastic-band fixes or daredevil soldering work — often to no avail. In many cases, the more costly option is simply to replace worn pinions or wheels in their entirety. But that was before the YAG solid-state laser arrived on the scene. Today's watchmakers can carry out delicate repairs with a high-precision welding laser without heating up adjacent metal parts. The best way to get things ticking again!

Gernot Walter