Laser *Community*

THE LASER M[illegible]NE FROM TRUMPF

21/2015

From now to eternity

Continuous coil welding by THE

Happily united

Fronius joins sheet steel 200 millimeters thick

METAL KISSES PLASTIC

Experts in lightweight engineering are seeking feasible ways to join aluminum, CFRP and other promising materials

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#21

November 2015

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

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REPRODUCTION Reprotechnik Herzog GmbH, Stuttgart / Germany

PRINTED BY frechdruck GmbH, Stuttgart / Germany

Cover illustration: Gernot Walter, based on Auguste Rodin's sculpture The Kiss

Modern lightweight engineering is transforming the world of manufacturing by using familiar materials such as high-strength steels, light alloys, composites and plastics in new ways and in new combinations. The task now is to develop harmonious, efficient and effective ways of machining and joining these materials. Frankly, it seems unlikely that we will see a "silver bullet" for the entire field of weight-reducing design. There are so many variations in applications, load situations and structural requirements that custom solutions will be the order of the day when it comes to selecting and combining materials. The same is true of machining and joining them.

That poses a challenge, because it requires both in-depth and wide-ranging skills and expertise. Which materials are best suited to a particular material mix? What's the best method of machining those materials? Which joining process will provide a level of quality that meets industrial standards? And how do we make the best use of the materials in terms of structures and loads, while keeping costs to a minimum?

Much of this obviously applies to many other contemporary products, as well. Systems competence has become a key area of knowledge. Ultimately you can create technically feasible and successful products only if you understand how to dovetail broad-based knowledge with individual in-depth skills. That prompts two crucial questions: In which skills do we want and need to achieve excellence as a manufacturer? And which skills should we bring on board through our partners? Tackling these questions makes the surge in complexity more manageable.

Systems competence is decisive

Success comes from combining in-house systems competence and expertise with the skills of partners who are leaders in their field. That is essential to success for highly sophisticated products requiring in-depth expertise in a range of different areas. So, at the end of the day, what really counts is our ability to create and nurture stable partnerships. That's what some people refer to as network competence, and I think TRUMPF is already well positioned in that respect, both in regard to our own products and as a partner in our customer network. Drawing on clearly formulated and carefully applied knowledge, we are constantly casting a critical eye on what we should do ourselves and what we should bring in from the outside. And as a partner in our customer network we are open and reliable, guaranteeing innovations and industry-ready solutions.

Aluminum and CFRP are the two great hopes in lightweight engineering. Their kiss on the cover of this issue is an adaptation of Rodin's famous work *The Kiss*. It seemed fitting to us to illustrate the contemporary era of lightweight construction with the work of someone widely regarded as one of the pioneers of modern sculpture.

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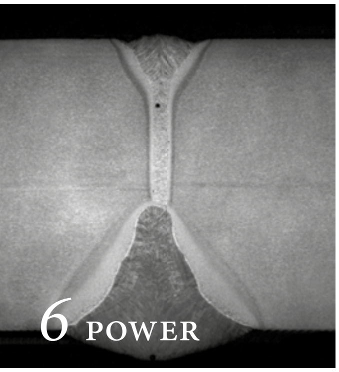
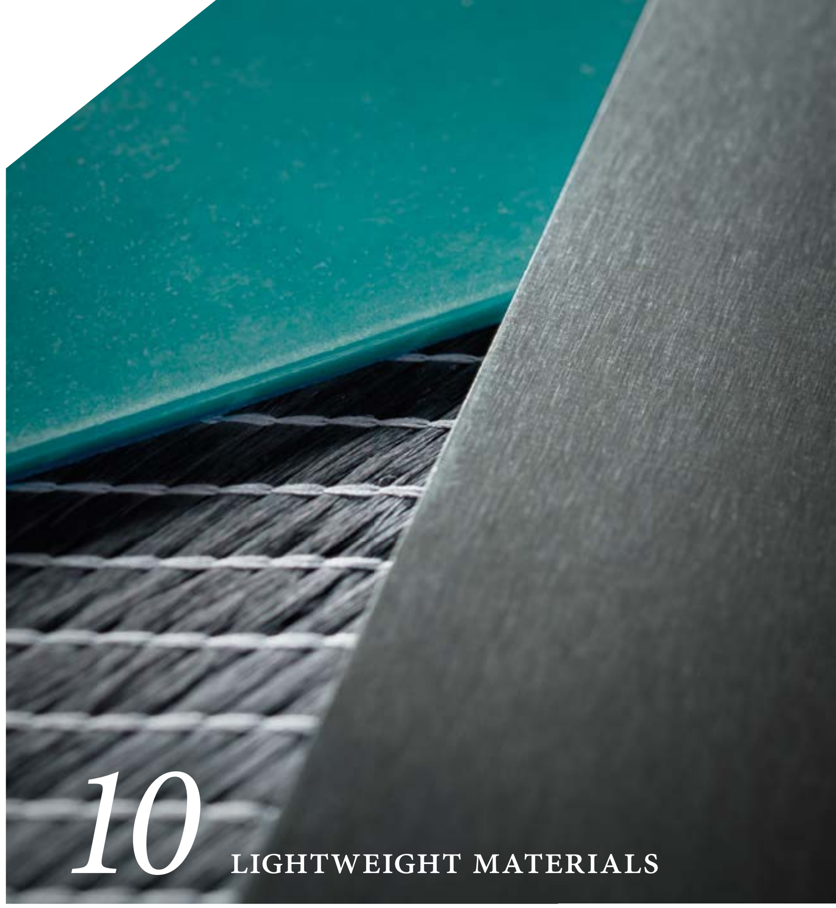




ISSUE

COMMUNITY

POWER:
The best footprint
PAGE 6

GLORY:
Narrowest focus
PAGE 7

AHEAD:
Thinnest fiber
PAGE 8

FURTHER READING:
Latest research
PAGE 30

TECHNOLOGY

Lighter with lasers

An overview of laser joining and cutting methods for lightweight materials. **PAGE 14**

“We’re getting down to the atomic level”

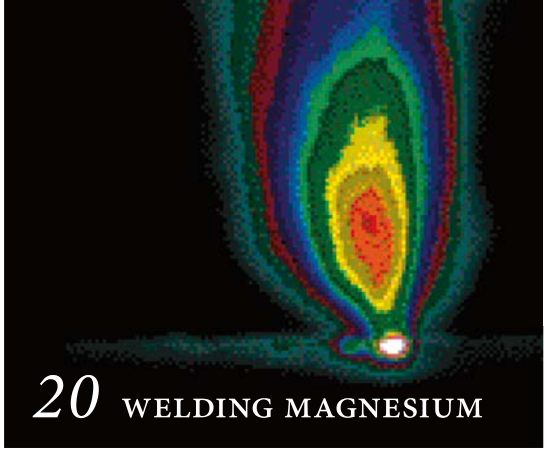
VW’s head of materials research and manufacturing processes, Oliver Schauerte, explains how automakers will be using innovative materials in the future. **PAGE 16**

Battle against the pores

Welding magnesium is tricky, but things are looking up thanks to a researcher and three laser techniques. **PAGE 20**

BAM, Ulf Quentin, Viola Schuetz / Baden-Württemberg-Stiftung, Gernot Walter

LIGHTWEIGHT FUTURE 16



20 WELDING MAGNESIUM

26 HYBRID WELDING

22 STATEMENT

24 WELDING COILS

21/2015

OPINION

The big three

Aluminum, CFRP and other plastics offer enormous potential. Three experts argue the case for three materials. **PAGE 10**

What happened to the flying DeLorean?

When will cars be light enough to take off? A plea for the future. **PAGE 22**

APPLICATION

Welcome to infinity

Coil welding equipment from THE Machines promises truly continuous production. **PAGE 24**

The big weld

Eight millimeter deep welds in sheets up to 200 millimeters thick? Fully automatic welding? "We can do it," said the Fronius engineers. **PAGE 26**

FOCUS ON LIGHTWEIGHT MATERIALS

POWER

A WIN ON POINTS: LAHW/GMAW WELDING TOPS LIFE-CYCLE ANALYSIS STUDY

It's an inescapable fact that as metal sheets get thicker, the time, material and energy required to join them rises disproportionally. So when does this process become environmentally unsustainable? That was what Gunther Sproesser and his colleagues decided to investigate at the Technical University of Berlin.

Sustainability and the efficient use of resources in manufacturing have long been key concerns — even before the Ecodesign Directive (2009/125/EC) came into force. Sproesser and his colleagues found themselves in uncharted territory. Although they found plenty of data on the environmental impact of various cutting techniques used in production, it seemed that nobody had investigated the environmental sustainability of fusion welding.

The Berlin-based researchers used the Life Cycle Assessment (LCA) method to examine the environmental impact of four welding processes: manual metal arc welding (MMAW), laser arc hybrid welding (LAHW), and gas metal arc welding (GMAW) in both the standard and modified versions. They compared how the processes fared in butt welding of low-alloy structural steels 20 millimeters thick. The results are clear. Manual metal arc welding has by far the biggest potential environmental impact in the fields of climate change, acidification, eutrophication and photochemical formation of ozone. The best results were achieved by LAHW/GMAW welding, followed by GMAW welding with a modified spray arc and reduced flange angle.

The research team also identified the drawbacks of each method. Manual metal arc welding's LCA score is diminished by the rutile coating of the electrode. The biggest drawback of laser arc hybrid welding in LCA terms is its high energy consumption, while in GMAW welding the filler material is the culprit. ■

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FULL ARTICLE:
www.laser-community.com/en/6053

The study was carried out at the Technical University of Berlin. The authors are:

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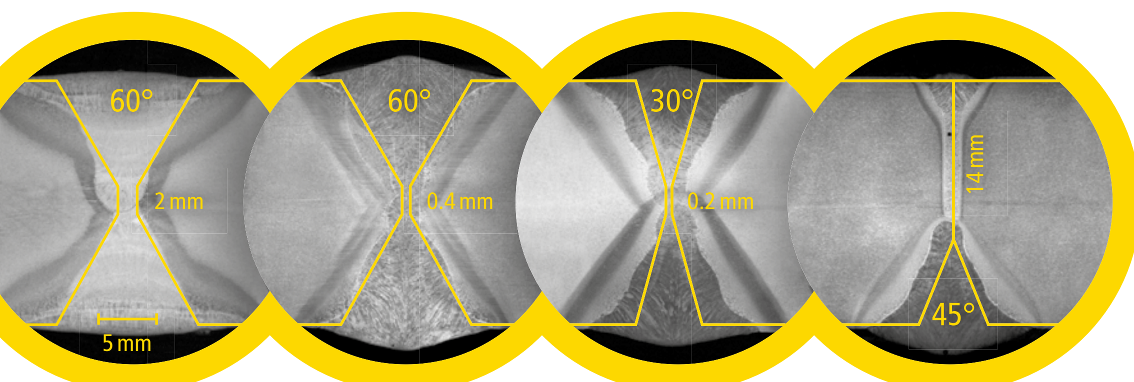
Michael Rethmeier

Welding preparation and the weld seams produced by the different processes. Laser arc hybrid welding requires that the least amount of material be removed during seam preparation, reducing the need for filler material.



Manual metal arc welding — *GMAW welding (standard version)* — *GMAW welding (modified version)* — *Laser arc-hybrid welding*

PUSHING THE BOUNDARIES

Dr. Ulf Quentin uses ultra-short pulsed lasers to produce surface structures at a nanometer scale. He recently received an award for his work from the German Scientific Laser Society.

According to the laws of physics, you cannot focus a laser beam to a width narrower than its wavelength. That's why researchers are constantly looking for ways to loosen up the way they interpret these laws. Dr. Ulf Quentin, assistant to the Management Board at TRUMPF, is no exception. He has succeeded in focusing laser light with a wavelength of 500 nanometers on a tiny spot measuring just 100 nanometers, used when structuring the surface of the substrate.

The trick he uses is to place a tiny glass sphere, one micron in diameter, on the substrate surface. He bombards this tiny sphere with ultra-short laser pulses, creating what is known as an "optical near field" underneath the sphere. He explains: "An optical near field always occurs at an interface where light is transferred from one medium into another — in this case from the glass particle to the ambient medium close to the substrate surface." In the optical near field, the beam of light "re-forms" itself and has different properties at the interface than it does in the "normal" far field. "I exploit this effect to narrow the focus of the beam more than would normally be possible. That allows me to ablate an area one fifth of the wavelength of the laser light," Quentin explains.

As well as introducing small points into the substrate, Quentin also uses this method to ablate lines and areas. He does this by using a second, continuous laser beam as optical tweezers, guiding the tiny sphere over the substrate.

"In the future, people might use this technique to carve prototype circuits for microchips or gently cut open living cells in order to manipulate them," says Quentin. "It's another way for us to increase the already impressive precision of laser machining." ■

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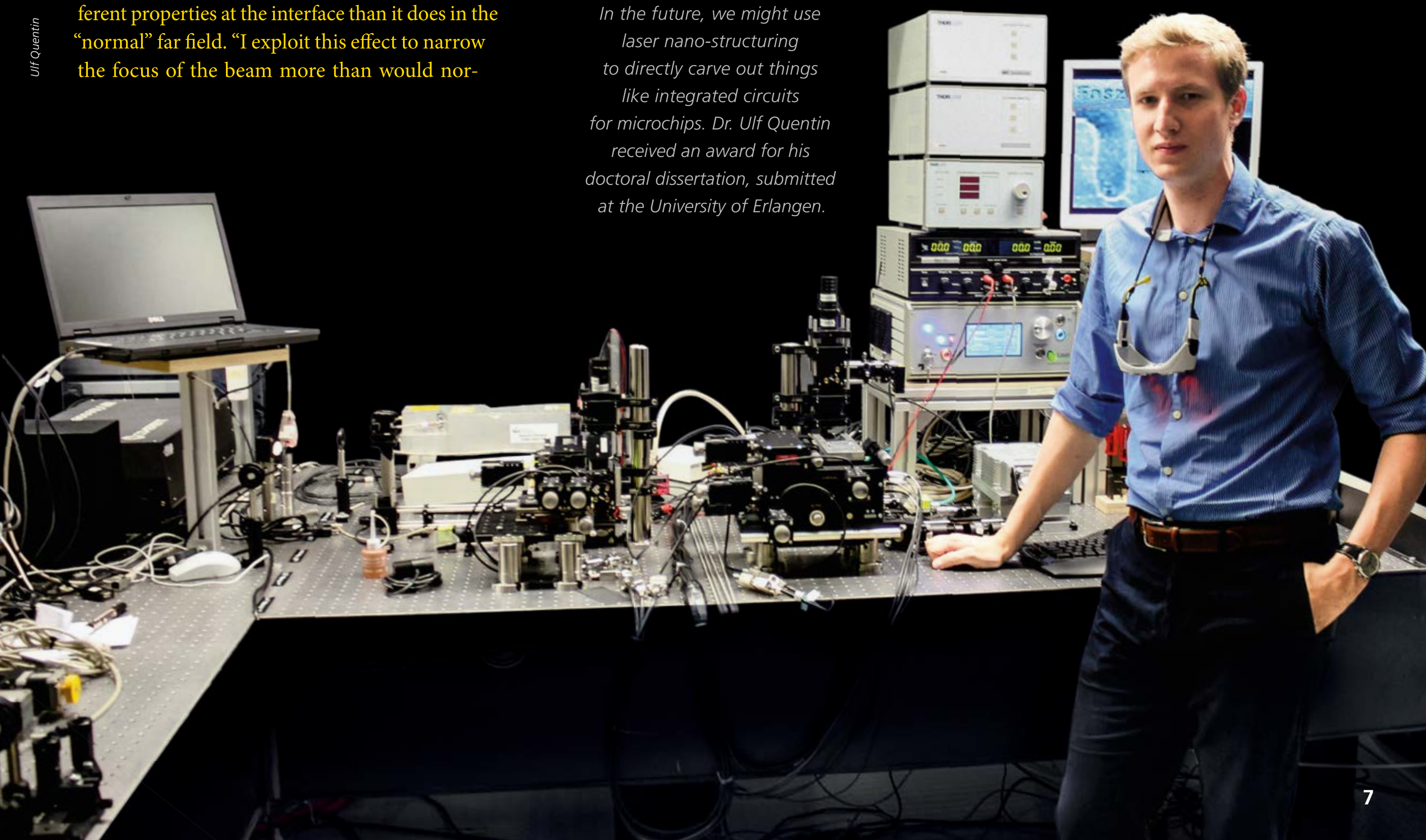
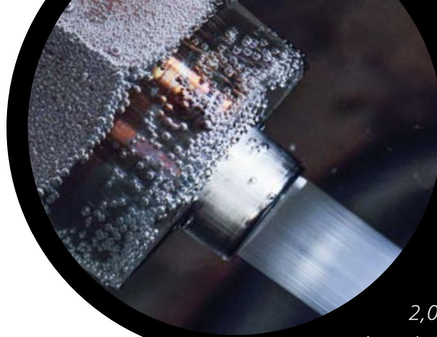


In the future, we might use laser nano-structuring to directly carve out things like integrated circuits for microchips. Dr. Ulf Quentin received an award for his doctoral dissertation, submitted at the University of Erlangen.

Ulf Quentin



"PERFECT HOLES FOR PERFECT FIBERS"

Microfibers are small, but supermicrofibers are miniscule. Anne Feuer used an ultra-short pulsed laser to pave the way for the longest and finest cellulose fibers in the world.

2,000 cellulose-based supermicrofibers are extruded into a spinning bath to harden (above). Anne Feuer presents the thinnest cellulose-based fiber bundle in the world: ten kilometers of fiber weigh 0.3 grams (below).

I already have a microfiber cloth and a microfiber running shirt at home, Ms. Feuer. So what extra benefits do supermicrofibers offer? A supermicrofiber cloth would be able to capture more dust and absorb more moisture than your microfiber dust cloth, thanks to its significantly larger surface area. And supermicrofibers would do a better job of soaking up perspiration! Supermicrofibers are also a good choice for air filters in motor vehicles and for sanitary products such as tampons.

But if supermicrofibers are so much better, why did they make my running shirt from microfibers? Because until recently we didn't have a suitable method for producing long, well-arranged, cellulose-based fibers. At present, the fibers in the resulting weave point wildly in all different directions. To make long, fine fibers, we need spinnerets that are impossible to produce by conventional means.

Why is that? The direct spinning method involves pressing the raw material — a warm cellulose solution — through a sieve, a bit like pushing spaghetti dough through the holes in a pasta making machine. To get perfectly aligned fibers, you need perfect holes that are round, smooth, vertical and, above all, long. In other words, holes with a diameter of just 25 microns, but a length of 300 microns, and something like 2,000 holes in just half a square centimeter. You can imagine how hard that is to punch!

So a laser was the only realistic option. Was an ultra-short pulsed laser the sole choice? Effectively, yes. We need two things to produce our micro-holes. First, ultra-short laser pulses that have as little effect as possible on the material around the hole, so you get smooth walls without any burrs or indentations. The only way of achieving that is with "cold machining". Secondly, we use a method called helical drilling. In other words, we focus the beam to slightly more than half the hole diameter and move it in circles. The laser spirals its way through the workpiece, removing and vaporizing the material as it goes.

So when will I be able to replace my running shirt with one that's more absorbent? It's going to take a few years before this new technique becomes commercially viable. A couple of companies have already experimented with a few products as part of the project, but a full-fledged industrial application is still a long way off.

MORE ABOUT THIS PROJECT: *Anne Feuer took charge of the "Top Spin" research project following the departure of Martin Kraus, the engineer who initiated the project at the Institute for Beam Tools (IFSW). Together with the Institute of Textile Chemistry and Chemical Fibers (ITCF) in Denkendorf, the team came up with a method able to manufacture cellulose-based supermicrofibers. Their work was sponsored by the Baden-Württemberg Foundation.*

ITCF Denkendorf, Viola Schütz / Baden-Württemberg-Stiftung

One thing's for sure: lightweight engineering and multi-material mixes are steadily gaining ground. What's not so clear is how we'll be machining all these materials in the future. This article provides some answers.

Light → work

IN SEARCH OF THE PERFECT MATERIAL

That's what drives the makers of aluminum, CFRPs and plastics.

PAGE 10

LASERS FOR LIGHT-WEIGHT MATERIALS

How to cut and join lightweight materials using lasers. An overview.

PAGE 14

THOUGHTS FROM A MATERIALS RESEARCHER

Oliver Schauerte from Volkswagen discusses trends in lightweight engineering.

PAGE 16

IT WORKS WITH MAGNESIUM, TOO

Three different laser welding processes that solve the perennial pore problem.

PAGE 20

OPINION

The big 3

Aluminum, CFRPs and plastics are tomorrow's most promising candidates for lightweight design. But what plans and visions do their makers have? Read on to find out.

Gernot Walter

ALUMINUM / *Team spirit in lightweight design*

Aluminum has a long history of use in the automotive industry. Now experts are trying to develop alloys that will let auto makers use highly automated joining techniques. Corrado Bassi from Novelis believes that remote laser welding is the method that shows the most promise.

Cars and cans are the biggest drivers of growth in the aluminum market. Weight and stability play a key role in both applications. But in the packaging industry, the main focus isn't really on the material, but rather on the coating solutions we develop in collaboration with our partners and customers. That's not the case in the automotive industry There the material itself is constantly pushing our developers to work harder on areas such as plasticity, strength and joining techniques.

Obviously we're delighted with every car built solely from aluminum, and of course we want to increase the share of aluminum used in car making. But the future lies in composite construction—deploying different materials in the right places to make the best use of each of their strengths. Thanks to hot forming, steel has taken on a key role in lightweight construction and is generally the manufacturers' preferred choice when it comes to structural components. But plastics and fiber-reinforced composites such as CFRP are now coming into their own as load-bearing materials. And aluminum has clearly demonstrated that it's a good choice for exterior components such as the hood, trunk lid and doors.

Our job as material manufacturers is to improve how our products work together. When you use lots of different materials, things obviously get far more complex in regard to joining processes, corrosion problems and painting. One thing that's very important is to find solutions making it possible to use highly automated joining processes. Unlike steel, these lightweight materials cannot even be welded to themselves, and they inevitably require some kind of filler metal.

When it comes to welding tools for aluminum, I'm particularly interested in lasers, specifically remote laser welding. The great distance between the optics and the workpiece makes the technology very flexible, letting users weld many different seams, even in hard-to-reach places. That's a big advantage particularly in automotive engineering, because component rigidity is a key criteria that depends in part on the joining process. But especially in remote welding you have to work without filler wire and shielding gas. So that's why we've developed a special kind of sheet aluminum that makes this possible. We call this innovation "fusion", and it involves casting two different alloys in a slab. After rolling, we end up with a core made of the standard 6000 series alloy used in car manufacturing and, on the outside, a layer of aluminum-silicon alloy that can be laser welded without filler.

We believe that laser welding and aluminum are a combination that offers plenty of potential. That's why I'm confident that developments of this type will become increasingly important. ■

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Corrado Bassi is the auto development manager for Novelis at the company's Sierre location in Switzerland. Novelis is a global market leader in rolled aluminum products. Headquartered in Atlanta, Georgia, USA, Novelis operates 25 manufacturing plants and recycling centers in 11 countries and employs almost 11,000.

The Eiffel Tower comprises 7,300 tons of wrought iron. If it were to be built today using aluminum, it would weigh only 5,110 tons.

An Eiffel Tower made of CFRP would weigh just 1,460 tons instead of 7,300. Of course, at today's prices, it would cost 50 times more than the iron version.

Andreas Wüllner heads up the SGL Group's composite materials business. SGL is one of the world's leading manufacturers of carbon-fiber-based products and materials, operating 42 production facilities worldwide. The company is headquartered in Wiesbaden and employs some 6,300 people.

CFRP / *Lightness for everyone!*

High rigidity combined with very low weight. These are the prominent features of carbon-fiber-reinforced plastic—CFRP. Unfortunately, it is also expensive, leading to higher component costs than when using other lightweight materials. Andreas Wüllner from the SGL Group argues that innovative production methods will change all this—with the effect that we'll soon be seeing a lot more CFRP and the like in everyday products.

Fiber-reinforced plastics are usually finished using conventional techniques such as milling and water jet cutting. Another method that holds great promise for the future is the laser, especially when it comes to high volumes, repairs and preparation for adhesive bonding. As a manufacturer of fiber-reinforced plastics, however, we don't favor any one particular method.

What matters most to us is strengthening this material's position in the market. We do this by working with our customers to develop and promote new and innovative applications and optimized production methods. In the past, CFRP and similar composites were used primarily in industries such as the aircraft and wind power sectors, as well as in sports cars and Formula One racing. Those are generally areas where you're looking at comparatively short production runs and longer manufacturing cycles. As a rule, the components are made by baking layers of CFRP in an autoclave, and this is a time-consuming process. What's new is that we're now seeing composite materials entering mass production to an ever greater extent. One example is the auto industry. One prominent example is the inclusion of CFRP as a standard material in the body of the new BMW 7 series. These kinds of applications obviously involve high volumes, and that's making the production methods better and more innovative in terms of lead times and the whole approach to component manufacturing. And of course that ultimately reduces the cost per part.

As a material manufacturer, we support this process in a number of ways, for example by optimizing the weave of the mats and the orientation and weight of the carbon fibers. That makes the resin flow faster through the fibers, achieving optimum distribution within the part. And we also support our customers and advise them how to keep scrap rates as low as possible, for example by using tools that are very close to the final shape.

By constantly enhancing the material, we also open up access to new applications. One example of a new product line introduced by the SGL Group are the fiber-reinforced thermoplastics that achieve especially short cycle times and can be welded, repaired and recycled. We also actively seek out collaborative projects and put significant resources into basic research and issues that affect the industry. For example, we work in partnership with the chair of Carbon Composites at the Technical University of Munich and we are co-founders of an industry association—Carbon Composites e.V. (CCeV).

Our goal is to get to the stage where fiber-reinforced plastics are no longer a luxury application but rather an integral part of many everyday products. ■

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PLASTIC / “Work together!”

Production experts say that producing producing components made from plastics and metals is no easy task. Dr. Harald Ott from Albis Plastic GmbH agrees, and adds, “But that’s where the best opportunities are found.”

Plastics are nothing new in the world of lightweight construction. Virtually all the components used in car interiors, for example, are made at least partly from plastic, from the dashboard and switches to the interior trim. Even in areas where metals have traditionally reigned supreme — such as the engine compartment and chassis — we are beginning to see the use of highly reinforced polyamides and high-performance plastics as mounting systems for engines and transmissions. And engineers are increasingly using specially fabricated compounds for car body components such as bumpers, fenders and glazing. This trend is likely to continue, largely because it offers considerable potential to reduce a vehicle’s overall weight. Another exciting development is the move toward making components more multifunctional, adapting the materials they contain or their design or manufacturing processes to let them perform a wider range of functions. This approach can help cut costs and reduce manufacturing complexity.

Yet for all these developments, I think that much of the potential inherent to metals and plastics themselves has now been exhausted. Now, the task for engineers and technicians is to focus more on the bigger picture, using new combinations of materials and processes to develop innovative products. To do that, they need to involve the suppliers of the relevant material groups early on. We support our customers by helping them design finished parts and tools in a way that makes the best use of a material’s properties, as well as by offering custom development of the required plastic components.

When it comes to innovative manufacturing methods, the laser plays a crucial role. Some of the key processes used for plastics — along with using lasers in additive manufacturing (3D printing) — are laser structuring, marking and welding. Another method used for bonding plastic parts is laser transmission welding, a process in which the laser passes through an upper transparent piece of material and only heats the laser-absorbing piece of material below, creating a highly defined joining zone. We offer a wide range of solutions to meet all kinds of needs and we can also modify those solutions for custom applications. In plastic-metal hybrid manufacturing, for example, we first use suitable lasers to structure the surface of the metal. Then we inject a plastic component and create a secure bond between the two. Keeping up with our customers’ changing demands is essential, so we work closely with partners in business and industry and participate in research projects. That’s the only way to provide our customers with the professional support they need to develop new and innovative products. ■

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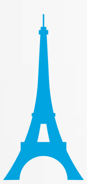
Dr. Harald Ott works as senior manager for product development at Albis Plastic GmbH in Hamburg. The company represents leading European brands and manufacturers as a distributor of thermoplastic products. It also works in the field of compounding, creating its own highly specialized compounds for a broad range of applications.



An Eiffel Tower made of polyamide would be completely weatherproof and resistant to UV light. Paris would no longer have to apply some 60 tons of special paint to the tower every seven years.

Gernot Walter, Julia Knop

LIGHTER W

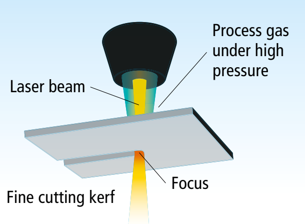
Work that is highly amenable to automation, needing no contact with the material, imparting of forming without tools. The classic arguments for using lasers make a convincing case

SEPARATING

ALUMINUM

ON REFLECTION, YES

The high thermal conductivity and reflectivity of aluminum make it necessary to cut more slowly and with higher energy input than for steel. For this reason, using lasers to cut aluminum was, for many years, seldom a profitable option. However, the wavelengths and beam quality of modern solid-state lasers have made possible highly productive industrial cutting applications, such as the deburring of die castings.

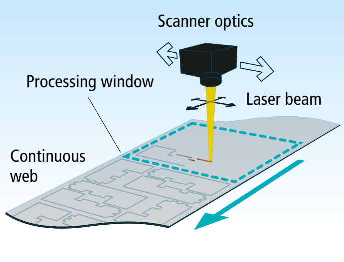


Narrow beam and fine focus, positioned to eject the melt. This is how to inject the most energy into the process.

PLASTIC

TRUSTY HELPER

Laser processing of plastics with a wide variety of beam sources has become standard industrial practice. Lasers not only separate parts, but also score and perforate workpieces in order to create features such as breaking points, air cavities, and transparency effects. Ultra-short pulsed lasers separate and perforate even ultra-thin, high-performance plastics such as Kapton films.

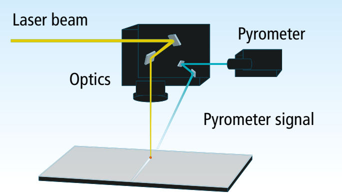


High cutting speeds and low energy input facilitate highly efficient, scanner-controlled cutting on the fly.

CFRP

FIBER-FRIENDLY

Differing light coupling behaviors in fibers and matrix materials were long thought to impede using laser cutting for fiber-reinforced composites. This seemed to counteract the advantages over mechanical methods, even though the latter also struggled with the fibers. But in the meantime the zone affected by the heat can be controlled precisely or reduced to a few microns through "cold processing".



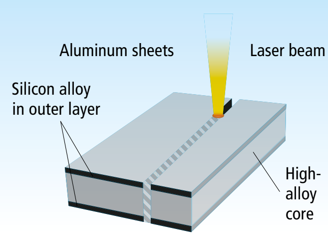
Concept developed at the Laser Center in Hannover for real time temperature control when using remote laser cutting for CFRPs.

JOINING

ALUMINUM + ALUMINUM

TWO'S COMPANY

When processing aluminum, laser-based methods also had to rely on filler materials. Currently there are two strategies to avoid using a third component in the process. One way is to use composite materials which incorporate the filler material as a coating, for example. The other is to influence the cooling behavior by manipulating the molten material with an oscillating beam.



For remote welding without wire: composite sheet metal, rolled from a slab that itself consists of two alloys.

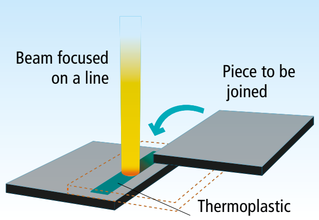
ITH LASER

no mechanical and low-to-minimal thermal stresses, and offering the flexibility even when it comes to the often unconventional world of lightweight materials.

CFRP + CFRP

FULL ADHESION

Two of the primary techniques for joining fiber-reinforced composites are bonding and taping. When bonding, high-performance nanosecond lasers – often in the UV spectrum – are increasingly being used to carefully clean the adhesion surface and carry out pre-structuring. When taping, on the other hand, lasers create the adhesive effect. Their light melts the "tape"— a thermoplastic film —directly before the join is made.

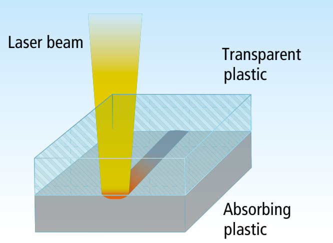


Taping CFRP components in a lap joint. Here the laser prepares for welding and carries out the joining process.

PLASTIC + PLASTIC

PASSING THROUGH

Here, lasers are increasingly taking care of preparations for bonding. What's more, laser transmission welding is becoming increasingly common when making housings for electronic components. In this process, the beam passes through the upper part, manufactured from a plastic that is transparent to the beam's wavelength, and melts the material in the lower part. Thermal stress is minimal and the surface is not affected.

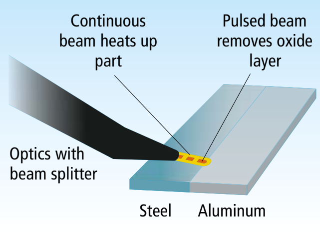


Laser transmission welding. Even though the upper part must be transparent for the laser's beam, it may be opaque to the human eye.

ALUMINUM + STEEL

JOINED, NOT WELDED

Aluminum and steel cannot be welded by conventional means. Using laser technology, however, makes it possible to create a solid lap joint. The laser fuses the steel in the focus of the beam, and the molten material heats up the aluminum beneath it. When it hardens, the steel forms a bond with the aluminum that is similar to brazing.

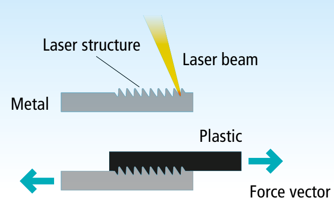


Alternative concept developed by Fraunhofer IPT for joining aluminum and steel using two interlaced laser beams.

PLASTIC + METAL

BOND AND LOCK

The laser again plays two roles. Acting as a "bonding agent," high-performance nanosecond lasers pre-structure even large-scale adhesion surfaces – creating undercuts, for instance, by raising areas before material is cast around the component or a thermoplastic is injection molded. As a joining tool, laser light can heat up the metallic part along the seam — directly or by the transmission method — so that the plastic part melts and sticks.



Using lasers, it is possible not only to roughen surfaces precisely in a certain area, but also to adapt them to the later force vector.

Gernot Walter

“A multi-material mix? Bring it on! But steel still has a great future ahead of it, too.”

"We're getting down to the atomic level"

Oliver Schauerte, head of materials research and manufacturing processes at the Volkswagen Group, discusses the latest trends in lightweight construction, gun licenses for production staff, and the next big thing among materials.

Mr. Schauerte, what materials will you be using to build the VW Golf in 2025?
Mostly steel, just like today's models. I personally believe that steel still has a long future ahead of it. It's hard to think of any group of materials that can boast such incredibly dynamic developments as steel. It's a very exciting field. In the past, the only way to strengthen steel was to increase the carbon content and sacrifice some of its plastic malleability or ductility. But nowadays we have steel alloys containing manganese, boron and silicon, the so-called TRIP and TWIP steels, as well as various other developments. So we no longer have to make that compromise. These new steels offer both high strength and great ductility, and that makes them particularly useful for building car bodies.

What about the trend towards a greater mix of materials that everyone's talking about?
Well, that's certainly happening—but you asked me specifically about the VW Golf! New materials are generally introduced in models in the upmarket segments and then make their way down to midsize and smaller vehicles. Steel will continue to dominate in these price segments for a long time to come, though we will also see increasing use of aluminum and magnesium. But if you look at the Bugatti "Veyron", for example, you'll see that it already contains stainless steels, high-alloy aluminum, titanium, carbon-fiber-reinforced plastics and magnesium. The further you move down through the price range, the more steel you'll find. But whatever class of vehicle you look at, new models will always have a more diverse range of materials than their predecessors, and that applies to the Golf, too. So don't worry, the trend towards a multi-material mix is still going strong!

Why do new materials always start at the top and work their way down?
It's partly to do with the cost of lightweight materials themselves, and partly a question of the manufacturing methods that we tailor so carefully to each particular material. The effort and cost involved in introducing new materials is directly dependent on the number of units you're producing. The smaller that quantity and the lower the number of production sites, the more radical we can be in terms of lightweight construction. We have a unique situation in the Volkswagen Group because we offer such a broad array of

Daniel George

vehicles ranging from the Bugatti Veyron and Audi A6 to our high-volume Seat and Volkswagen cars. We transfer our material know-how from one brand to another.

In which assemblies will these materials be found in the future?
There will be more aluminum, but not necessarily where you'd expect it — not just in the car body, but also in areas like fittings and the transmission. There's also potential for using this material in the engine, auxiliary units and pipes. In terms of exterior components such as doors and trunk lids, I see good opportunities for magnesium and high-performance plastics over the long term. These components can generally be manufactured separately from the car body, so you can carry out paint spraying and rustproofing processes at differing temperatures.

And what does the future look like for fiber-reinforced plastics?
CFRP and similar materials perform so well that they can be used almost anywhere. I expect to see more glass fiber and carbon-fiber-reinforced composites in exterior components for sports cars. When it comes to components with large surface areas, fiber-reinforced plastics are the lightweight solution. Take a supercar such as the Lamborghini "Aventador", for example, and you'll see that the structural shell is made entirely of CFRP. For the majority of vehicles, however, CFRP will continue to be too pricey even over the long term, in part because CFRPs are either too difficult or even impossible to repair. CFRPs certainly spearheaded the lightweight construction boom, but they're not always the best solution when it comes to meeting other requirements. CFRP manufacturers have expanded the range of materials carmakers use, and that has actually encouraged innovation among traditional steel and aluminum manufacturers. That has really fired up the materials market!

"We want to design materials to our specifications."

"Aluminum? It's all about efficient production."

"Sandwich materials will be the trend of the future"

How will you join all of these materials together?
The joining techniques can basically be divided into three categories: mechanical, chemical (that's gluing), and thermal (or welding). We're carrying out comprehensive research into all these areas; we're not committed to just one of them. But I can say that friction stir welding is definitely something we will be using for steels of significantly different strengths. The combination of riveting and gluing also offers a whole number of advantages. One challenge, for example, is making sure to avoid heat distortion when you're joining something like CFRP to steel or aluminum. We've encountered a curious problem while riveting high-strength steels. As steels get stronger, we have to increase the setting speed for the rivets, and we actually ran into trouble with the firearms regulations! They insist on stringent safeguards for projectiles fired at more than 30 meters per second, so our research associates would have to have a gun license. That's not necessarily what you want on the factory floor.

What about laser processing?
Laser welding is a pioneering technique in our industry. I think we can expect to see greater efficiency in the manufacturing process, especially with the new opportunities offered by remote welding. And when it comes to gluing or the combination of riveting and gluing, we need lasers to pretreat the surfaces. And, of course, if the volume of CFRPs continues to increase, then lasers could be of interest to us as a good cutting tool.

What changes do you anticipate in the lightweight materials we use today?
As regards further developments for aluminum, we seem to be reaching our limits and any progress now is happening in small increments. Research efforts should really focus on the processing methods — for example investigating how we can manufacture components cost-efficiently and join them in composite structures without impairing their properties as materials. In the case of fiber-reinforced plastics, I'm hoping that manufacturers will be able to drive down the cost per part even further.

What's the focus of your research at the moment?
Well, we're taking a close look at the physics of the matter for a start. We're working on quantum mechanical simulations that model interactions between different metals on the atomic level. We want to discover the best ways to form alloys and metallic materials.

You mean you're actually looking at individual atoms?
Absolutely. What we have at the moment is an experience-based development process for materials. Put simply, that means you have an aluminum alloy and you add a little bit of element X and a little bit of element Y and watch what happens to the alloy. That's not precise enough for us. In the future we want to simulate in advance how the material's behavior will change if we mix in certain elements. But to do that we need to know how the atoms interact. Ul-

timately we really want to be designing materials to our specifications.

What materials can we expect to see in the future? What's the next big thing?

I'm confident that hybrid and sandwich materials will be a major trend in the future. Take metals, for example. When it comes to structural materials we only really have four basic elements to choose from in auto manufacturing: iron (actually steel), aluminum, magnesium and titanium. All the other elements are inferior to at least one of these elements. That's not a very wide choice, and even with alloying you can't really alter the physical properties of those four metals — such as their stiffness — to any great degree. If I could wish for one thing, then I would like to be able to modify the physical properties of these substances. That's something you can only achieve by teaming them up with other materials: aluminum with fiber-reinforced composites, steel with plastic, cast alloys with ceramic or silicon particles, and so on. Those are the new groups of materials I think we'll be seeing in the future.

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PROFILE

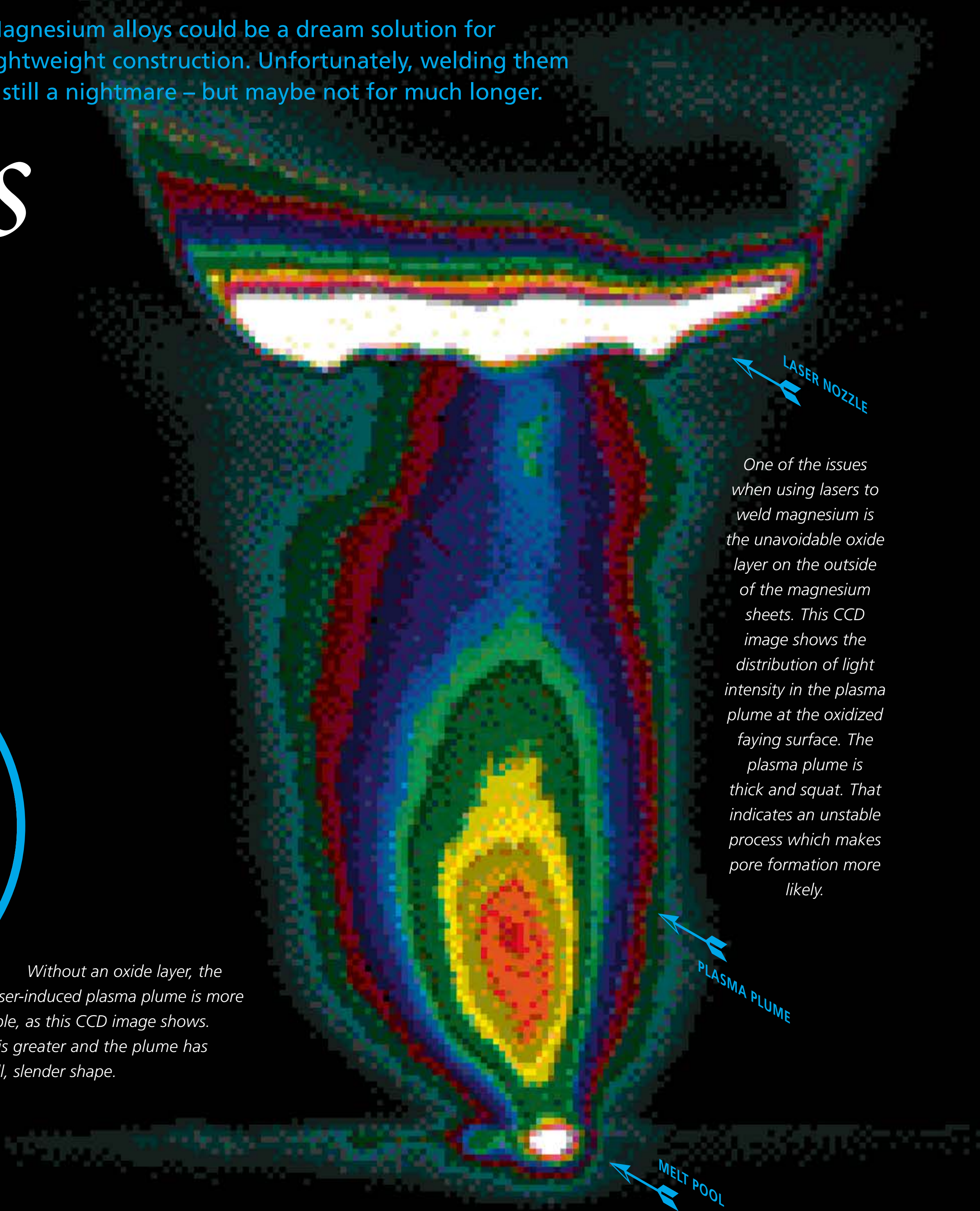
Alternative materials are the common theme running through Oliver Schauerte's life. He wrote his dissertation on high-temperature fatigue in a titanium alloy. In 1998 Schauerte joined the VW research department and was quickly appointed project manager for titanium and special materials. Schauerte headed up development work for lightweight engineering at Bugatti and was in charge of technology and the development of properties in fiber-reinforced plastics at Audi.

On May 1, 2015 he was appointed head of materials research and manufacturing processes at the Volkswagen Group.

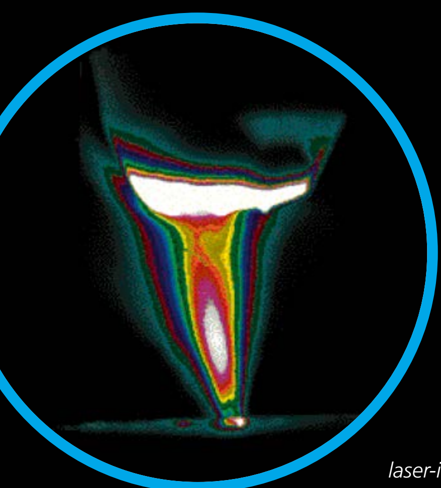
Battle against the pores

Magnesium alloys could be a dream solution for lightweight construction. Unfortunately, welding them is still a nightmare – but maybe not for much longer.

by Dr. Masoud Harooni



One of the issues when using lasers to weld magnesium is the unavoidable oxide layer on the outside of the magnesium sheets. This CCD image shows the distribution of light intensity in the plasma plume at the oxidized faying surface. The plasma plume is thick and squat. That indicates an unstable process which makes pore formation more likely.



Without an oxide layer, the laser-induced plasma plume is more stable, as this CCD image shows. The intensity is greater and the plume has a tall, slender shape.

Magnesium is the lightest structural material and has the best strength-to-weight ratio among metals that are commercially available. Its density is 36 percent lower than aluminum and 78 percent less than steel, making magnesium a seemingly ideal choice for lightweight construction. However, welding magnesium is — to put it mildly — challenging.

Pores and cracks are the two main problems. The issue of cracking has been largely resolved thanks to improvements in alloy production, but the pore formation problem remains. Pores in the weld bead affect the mechanical properties of the weld and in particular its tensile strength. To tackle this problem, it is important to understand how pores form and how they can be mitigated during the laser welding process.

The oxide layer is a key factor

A number of different mechanisms and factors can cause pore formation, including hydrogen pores, an unstable keyhole, pre-existing pores, surface coatings, gas entrapment, and alloys with a low vaporization point.

Magnesium reacts easily with oxygen, causing an oxide layer to form on its surface. Furthermore, newer generations of magnesium alloy coatings — such as Keronite, Magoxid-Coat and Tagnite — all use oxide-based coatings.

The porous oxide layer on magnesium easily absorbs moisture from the atmosphere. This moisture leads to the formation of magnesium hydroxide ($Mg(OH)_2$). Magnesium hydroxide has a low decomposition temperature of about 200 degrees Celsius, at which point it releases the molecular water to the atmosphere ($Mg(OH)_2 \rightleftharpoons MgO + H_2O$). The problem is that the water vapor thus released cannot escape through the two superimposed sheets. Instead, it seeks a way to escape through the molten pool, resulting in pore formation inside the weld bead.

Three ways of achieving the same goal

One technique used to stop the oxide layer from triggering pore formation is preheating with a plasma arc. Our research group did this by introducing a plasma arc torch in front of the laser welding head. We used this method to weld the overlapping magnesium alloys and then compared the results with those obtained from welding without preheating. The preheating parameters were optimized based on the temperature at the faying surface. Our results showed that using a plasma arc — in advance of the laser head and preheating the metal — can improve the quality of the weld by reducing the pore ratio. To verify the results, we carried out a separate experiment in which we heated the samples in a furnace prior to welding. We discovered that a preheating temperature higher than 200 degrees Celsius effectively mitigates pore formation.

The second technique is dual beam welding, which involves welding magnesium alloys using two laser beams, one behind the other, with different beam ratios. A comparison of the beam ratios (42.5 : 57.5 | 35 : 65 | 27.5 : 72.5 und 20 : 80) in our experiments revealed that a ratio of 20 percent for the leading beam and 80 percent for the lagging beam can effectively improve weld quality, yielding pore-free samples. When the lead beam taps 20 percent of the laser power for preheating, 80 percent of the laser power is left for welding, which is enough to form a stable keyhole. The keyhole acts as a chimney, exhausting the hydrogen gas from the decomposed magnesium hydroxide. When we tested the other beam ratios, we found that the leading beam provided more than enough energy to preheat the sample, but the weaker lagging beam was not able to form a stable keyhole. This increased the likelihood of hydrogen gas being trapped in the solidified weld pool.

So you need both mechanisms to happen simultaneously during laser welding: the leading beam preheating the faying surface to decompose the magnesium hydroxide and the lagging beam forming a stable keyhole to vent the hydrogen gas.

Another alternative is to use a two-pass laser welding procedure. In the first pass we directed a defocused laser beam across the top of the two overlapped sheets to preheat the faying surface prior to laser welding. The second pass was then used to melt and weld the samples. We optimized the laser power and focal distance for the preheating pass so as to obtain enough heat at the interface of the two overlapped sheets to produce higher quality welds.

Real time inspection

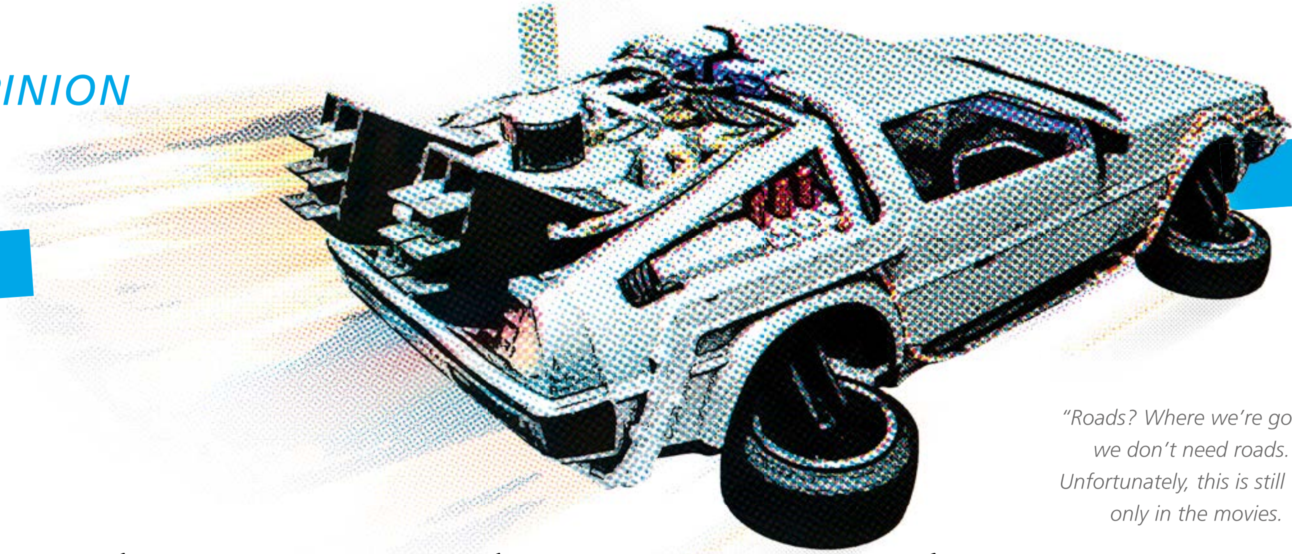
One way to detect pore formation non-destructively in real time is to use a spectrometer to measure the intensity of the laser-induced plasma plume. We know that the stability of the laser welding process affects the plasma plume, so we can use this knowledge to predict unstable conditions and pore formation in the weld. We tested with two different situations on the surface of the sheet, one with an oxide layer at the faying surface and the other without this layer. Then we calculated the electron temperature from the spectrum intensity using the Boltzmann plot method and correlated this with the formation of pores. We found a good correlation between the calculated electron temperature detected at the laser-induced plasma and the presence of defects in the lasered welding beads.

A promising future for magnesium

Between 1995 and 2007 magnesium production jumped by 390 percent. This increase indicates the growing demand for magnesium in various industries including, but not limited to, the auto industry. There are still plenty of challenges in using magnesium alloys — in terms of both costs and joining techniques, but it's clear that these alloys will be playing a more significant role in the future. ■

Masoud Harooni

Masoud Harooni** studied mechanical engineering at Isfahan University of Technology in Iran. He went on to earn his PhD from Southern Methodist University in Dallas, Texas, with a project on joining lightweight alloys that he carried out in collaboration with General Motors. He now works as a laser welding specialist at Keihin North America.* ***E-mail: mharooni@keihin-na.com



"Roads? Where we're going we don't need roads." Unfortunately, this is still true only in the movies.

Whatever happened to the flying DeLorean?

DOC BROWN'S BIGGEST LETDOWN

Approach for landing in Hill Valley, California. Faced with a traffic jam on the skyway, the flying DeLorean takes the exit and makes a smooth landing on Courthouse Square next to Cafe 80's. With its gull-wing doors and Maserati-style rear end, the DeLorean clearly comes from a different era. Inside the car are Doc Brown and Marty McFly—and the date is October 21, 2015.

The science fiction blockbuster "Back to the Future Part II" gave us a tantalizing glimpse into the future when it was made in 1989. The time travel movie presented the year 2015 as a bewildering mix of hoverboards, self-drying jackets, voice-controlled household appliances, and, even more remarkably, flying cars. Well, it's 2015—but where's the flying DeLorean?

I have to admit I'm very disappointed. Why is it that cars still can't fly? Why do they still stubbornly stick to the road? I mean, look at everything we've done to make them light as a feather! Carmakers use carbon fiber, fiberglass, innovative plastics and aluminum alloys. They strive to eliminate flanges and shave off every inch of unnecessary weight. Lightweight engineering is on everyone's lips, and it's a top priority in the auto industry.

Obviously I realize that weight isn't everything. An aircraft is not exactly the lightest thing going. So clearly what we're missing is a means of propulsion specially designed for flying cars! How is it more realistic to have something delivered by drone than to equip a car with rotors and propellers? After all, the DeLorean's fold-out wheels in the movie even look a bit like the propellers we need! So I'd like to issue a challenge to all you automotive engineers out there: How long do I have to wait before I can buy a car with a hover drive? Or even just the hover drive to fit to the car I have now?!

Obviously we still need to clear up that whole issue of new traffic regulations and floating signs in the stratosphere. I'm assuming the highway authorities will start working on that soon. I think that speed restrictions and driving on the right side of the road will still work just fine on the skyway. But if I could ask Doc Brown just one little favor: a flux capacitor that actually … fluxes would be a wonderful thing. Then we could finally start traveling through time in the real world, too! ■

What other physical restraints are keeping us from constructing a flying car?
Or have you thought of a way to build one?
E-mail me at athanassios.athanassios.kaliudis@de.trumpf.com

Gernot Walter

LASER-COMMUNITY.COM

Hiya Images / Corbis

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LASER LIGHT FOR CFRP

Fiber-reinforced composites are increasingly popular, but tough to machine. Production engineers are increasingly turning to laser light as a wear-free, high-precision and highly productive choice of tool.

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THE UNWELDABLES

Joining aluminum to steel, to titanium, or to fiber-reinforced composites has not been possible before now in lightweight construction. Laser technology welds them all.

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“A REVOLUTION? WE’LL SEE.”

Helmut König worked at Audi AG in Ingolstadt for an incredible 50 years. Shortly before his retirement, this master of efficiency gave us an interview.

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HIGH-SPEED 3D CUTTING

The automotive industry has greatly accelerated development of the laser as a cutting tool. Lasers can now process 3D components so quickly that machine operators are practically left behind. Hujer Lasertechnik GmbH, however, is keeping pace.

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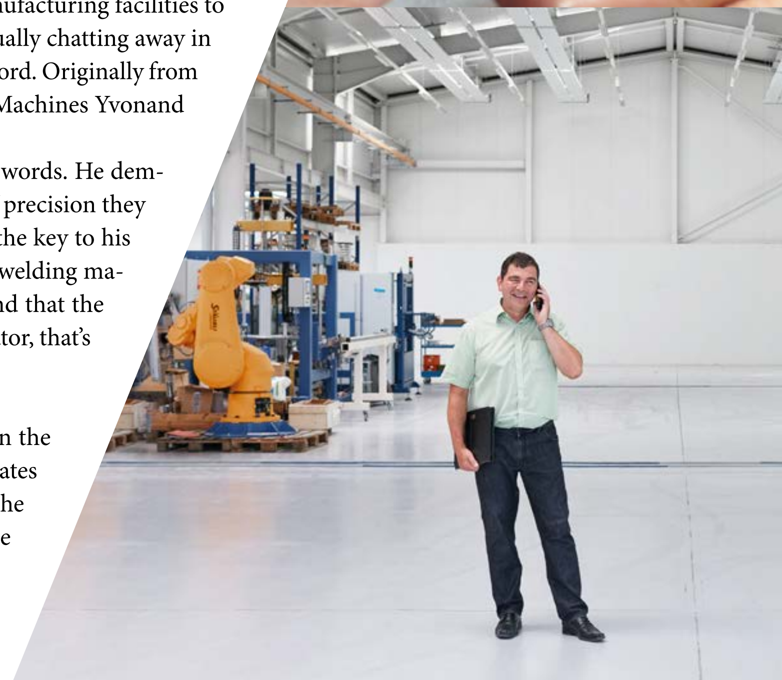
News and fascinating updates on laser research and material processing in 140 characters. Follow **twitter.com/Laser_Community**

Welcome to *infinity*

First cut, then weld. At THE Machines lasers are used to ensure that the coil never ends.

When people visit Wolfgang Reith in the Swiss town of Yvonand they are generally looking to do one thing — buy time. Reith promises them coils that never end, a fantasy of their punching machines and tube formers running on and on, without constantly having to be reloaded. In short, he promises the real deal of continuous production. Of course Reith would never say he gives people the chance to buy time. He prefers to be more specific. "My customers acquire the ability to exploit the productivity of their manufacturing facilities to the full." Reith stands out somewhat from his colleagues around him who are casually chatting away in Swiss French. He speaks crystal-clear standard German, enunciating every single word. Originally from Dortmund, he moved to the west of Switzerland to join a company named THE Machines Yvonand SA seven years ago, and he's been running things there for the last five years.

But Reith's passion for precision is obvious from more than just his choice of words. He demonstrates his machines with genuine enthusiasm, explaining the amazing levels of precision they achieve. Right now he's standing in front of the SLT cross welding system that is the key to his promise of continuous production. "That's where the coil runs through the cross welding machine," he says, pointing to the strip guide. "When the sensors in the decoiler find that the coil is reaching its end and that there are only 200 meters left in the strip accumulator, that's when things get serious."

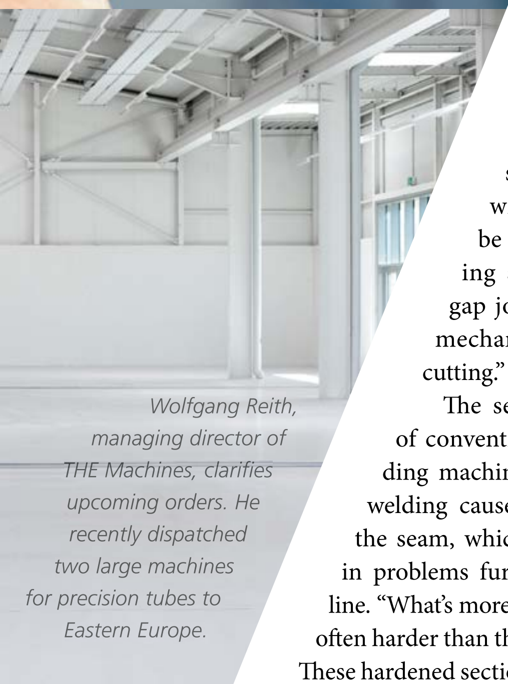


Everything ready for the coil countdown The machines further down the line stubbornly continue calling for up to 100 meters a minute. The operator activates the accumulator and the coil stops, so now only the strip accumulator is delivering the metal strip to the machines. There are now 150 meters left in the accumulator. The SLT clamps the end of the old coil and a laser beam cuts it. Only 120 meters remain in the accumulator! By now the operator has threaded in the new coil. It is also clamped in place and cut to the same angle. 80 meters to go. The clamping jaws move simultaneously, guiding the laser-cut ends of the two coils together and creating a "perfect zero-gap joint" as Reith puts it. In the meantime, the control system has switched the parameters for the laser and the same laser optics now weld the ends of the metal strips. There are still 40 meters remaining in the accumulator. The clamping jaws open and the "lengthened" coil now races into the accumulator and continues down the production line. The people and machines downstream from the accumulator are blissfully unaware of what's been going on. To them, it simply seems as though the coil will never end.

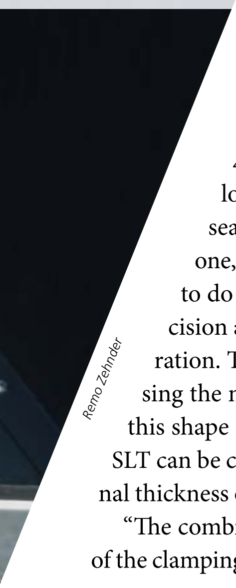
The laser cuts the strips from the old and new coil to an oblique angle. The clamps line the ends of the strips up perfectly. The same laser optics are then used to weld the ends of the coils so that production can continue.

Zero-gap joints thanks to laser Cross welding machines are essentially nothing new. They have been around a long time in the form of shears and TIG welders. But when strip thicknesses fall below 0.3 millimeters, the metal warps too much during shear cutting, and that has a negative impact on the quality of the seam. "That kind of seam could easily tear somewhere down the line, given all the tensile forces it's subjected to," says Reith. But the machine built by THE avoids

The seam is clearly visible but has the same characteristics as the strip. The cross welding machine can weld virtually any metals and alloys, with maximum repeatability.



Wolfgang Reith, managing director of THE Machines, clarifies upcoming orders. He recently dispatched two large machines for precision tubes to Eastern Europe.



Remo Zehnder

THE MACHINES Yvonand SA is headquartered in Yvonand, in the French-speaking region of Switzerland, and is part of India's Jain Group. The company specializes in two key areas: welding systems for very thin and small precision tubes and machines for producing plastic pipes for drip irrigation.

this problem thanks to the precise interplay of the clamping jaws and the contact-free cutting with a laser. "Once the clamping jaws are closed, we have a tolerance of just 0.01 millimeters over a length of up to 750 millimeters. The laser beam cuts the strip smoothly without any warping. There would be no way of creating a perfect zero-gap joint if we used mechanical shears for cutting."

The second problem of conventional cross welding machines is that TIG welding causes scorching at the seam, which often results in problems further down the line. "What's more, TIG seams are often harder than the base material. These hardened sections can damage tools, especially in punching applications." Reith has two other apparently simple tricks up his sleeve to increase the tensile strength of the seams. One is that the SLT always cuts and welds at an angle of between 15 and 45 degrees, depending on the model. That makes the seam longer and distributes the tensile forces over the length of the seam. "Plus, we always try to produce a weld factor greater than one, which means the seam is thicker than the strip. The only way to do that without filler material is by cutting at tremendous precision and positioning the ends of the strips in a zero-gap configuration. The strips undergo thermal expansion during welding, pressing the melt together, and that creates a stable convexity." However, this shape is sometimes problematic for subsequent processes, so the SLT can be combined with a press that compresses the seam to the original thickness of the strip immediately after welding.

"The combination of light from the fiber laser and careful positioning of the clamping jaws lets us create a homogeneous joint that can handle the tensile forces involved. The seam is still visible, but the strip has the same characteristics as an unsullied coil that has never been welded, just as if the cross welding process had never taken place." By default, the machines by THE can handle strip thicknesses from 1.2 millimeters down to 0.05 mm, which is only slightly thicker than the aluminum foil used to package foods. In certain cases, it can also be customized to handle other thicknesses.

"Our customers acquire the ability to exploit the productivity of their manufacturing facilities to the full."

Say goodbye to wasted time Reith's customers are all after the same thing: they don't want their production line to stop. "When you're producing tubing, you obviously need a feedstock you can draw on constantly. And in many cases continuous production also makes sense for downstream punching processes. Some of my customers punch thousands of electrical contacts a minute. Whenever the time comes to thread a new coil into their sophisticated punching tool, they have to work laboriously through as many as 90 steps. That takes a half hour and may have to be done six times a day, depending on the length of the coil! In this case, the SLT could give them three hours of additional production time, equivalent to 180,000 additional parts a day!"

Originally, the SLT was conceived as a permanent component in tube welding machines. Three to four hours generally pass between cross welds, and that gave Reith the idea of designing the SLT as a mobile system. "That means customers with multiple lines can organize their production process to ensure that the SLT is always in the right place at the right time, so they only have to purchase one machine. This became practical only after TRUMPF launched the new, compact generation of its fiber lasers."

The SLT family cuts and welds a huge range of metals and alloys, including copper, bronze, aluminum, stainless steels, bimetals, gold-plated strips and "all your everyday metals – and all with the same optics". Reith adds with conviction, "It's essential to use non-touch methods for both cutting and welding. My customers often tell me that this is the approach that works best." And when Reith's customers leave Yvonand and head back home, they know they will soon be making money from time that used to be wasted. ■

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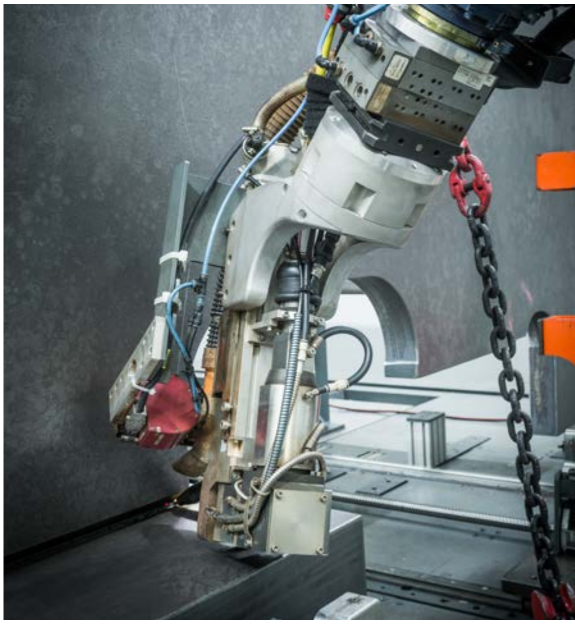
THE BIG WELD

Weighing 20 tons and up to 200 millimeters thick. The sheets TRUMPF welds in Austria are the biggest ever tackled by a hybrid laser welding head from Fronius International GmbH. The TRUMPF plant in Austria uses a fully automatic process to produce huge frames for press brakes.

Herbert Staufer and Thomas Reiter (left) witness the birth of a press brake. A machine table tilts the clamped machine frame into position, ready for welding.



Left: The welding head. Left center: *A freshly made fillet weld, approximately eight millimeters deep.* ***Right center:*** *You need sheets this thick to build machine frames that can handle hundreds of tons of press force without any loss of precision.* ***Far right:*** *A fully welded frame in front of the "hall in a hall" where the welding machine does its work.*

Ask people randomly what they associate with the word "sheet metal" and most people would probably respond with something like "baking sheet" or "fender". Chances are they wouldn't picture what Herbert Staufer, head of high-power welding at Fronius International, comes across every time he enters the production hall at TRUMPF Austria in Pasching. The steel sheets here are four meters long and so thick that the one on the bottom reaches to his ankle, measuring an impressive 200 millimeters. Staufer knows this material like the back of his hand — hardly surprising since Fronius is one of the leading suppliers of hybrid welding machines.

He generally visits Pasching as a customer, though he recently slipped into the supplier's role for a project carried out jointly. His project partner and customer Thomas Reiter, who heads up sheet metal processing in Pasching, explains why they brought Staufer on board for the project. "We're welding these sheets to make the frames for our press brakes, and that involves some very special welds indeed." To show how it works, the two men leave the metal sheets behind and wander over to a gray wall. It resembles the windowless exterior wall of a production building, yet is clearly inside the hall. The TruDisk 8002 disk laser standing against the wall seems tiny in comparison.

"It's a clamping fixture on a tilting machine table — it's just a bit bigger than usual."

Otwin Kleinschmidt, head of project management

320 tons of press force On the other side of that wall, inside the enormous laser safety cabin, the hydraulic system lifts the 20 ton weight and tilts the clamped steel sheets to the correct angle. A portal moves into place above the apparatus and a robot arm descends, carrying the hybrid welding head. It slowly passes over the first seam welding points, using laser light to heat the material. Now it's time for the fireworks to begin: the laser beam and the arc of the metal active gas (MAG) welding torch work together to weld the joint. These welds, which are up to eight millimeters deep, will eventually support loads stemming from up to 320 tons of press force. Over and over again, for the entire service life of the brake press.

The best of both worlds Outside the cabin, Staufer and Reiter watch the process unfold on the monitor. "We used to send the frames out for welding — by hand!" That took an entire week, and we were determined to make things more efficient," says Reiter. He immediately hit upon hybrid laser welding as a suitable solution. "The welding process is much quicker because you only need a single pass — instead of having to build it up bead by bead as you would in arc welding. We're also able to use the laser to preheat the material, and quality assurance is much easier in this automated process."

That's why he chose this solution as Plan A. He also had a Plan B just in case, an automated solution that would have worked with a conventional MAG welding robot. "But there we would have also needed a preheating station and subsequent stress relief heat treatment," says Reiter. Nobody wanted that, but there was a big question mark hanging over Plan A, as Staufer explains. "We've delivered over a hundred laser hybrid welding heads in our time, but the thickest sheets we had ever encountered topped out at 10 millimeters."

The courage to change depth Rewind two years to see Reiter and Staufer sitting in the Fronius development laboratory, a place where they spent a lot of time during that period. They are baffled by a series of micrographs showing a weld root showing numerous fine fissures and defects, making the seam unusable. And they had been so confident: "With eight kilowatts of laser power, we were easily penetrating 12 millimeters into the material. But down in the keyhole we had absolutely

Sigrid Rauchdobler

no control over the process," Staufer recalls. The type of fissure suggested that the issue was preheating. "But no matter how much we varied the temperatures — and we had plenty of control for that parameter using the laser as a preheating tool — the fissuring didn't change one bit."

Plan B was looking like the only alternative. But then in one of their meetings they hit on the idea of turning their welding strategy on its head, "maybe because we were so close to forsaking Plan A anyway," says Reiter with a chuckle. "We asked ourselves: Do we really need such a deep weld seam to create a perfectly stable joint?" he recalls. So Staufer and his team of laser experts at Fronius gradually began to reduce the weld depth. And when they got to 10 millimeters they were finally able to relax — the quality of the seam was improving continuously. "We finally got ideal welding results at eight millimeters," says Staufer.

In the balance

With this partial victory in the bag, the project team could finally turn to the next problem. "To achieve the optimum welding process, you need the laser light to hit the material at the right angle," says Staufer. "But the robot wasn't maneuverable enough to reach every single weld point." Luckily, Staufer knew exactly who to turn to.

Raimund Geh relishes this type of challenge. His company, Femitec GmbH in Gersthofen near Augsburg, specializes in designing welding systems. He explains how he approached the problem: "If the robot arm with the laser hybrid welding head couldn't reach the welding point, then we would simply have to take the part to the welding head." The result was a tilting table with clamps to secure the part. "We were sure that this would let us weld in the downhand position." Geh and his team developed a complex simulation to test their theory — but the next step was to put it into practice.

Yaskawa Europe — a leading manufacturer in the fields of drive technology, industrial automation and robotics — was the company chosen to transform their vision into reality. Otwin Kleinschmidt, head of project management, tilts the palm of his hand to the crucial 45 degree angle and says: "In principle it's pretty straightforward. It's a clamping fixture on a tilting machine table — it's just a bit bigger than usual," he says with a grin. The first challenge the team ran up against was how to design a hydraulic system able to hold a part weighing several tons solidly in position, at precision down to the millimeter. "That's what makes it possible for the welding robot to stay exactly on the welding path," Kleinschmidt explains. The other challenge was how to harmonize the movements of the robot and the portal. But after four months of work everything was finally in place.

Frame by frame

Back in the shop in Pasching, Staufer and Reiter are once again strolling from one machine to another. In front of them the parts are waiting on pallets, and a crane is helping a production worker to position the sheets on the setup table. It takes two hours to get everything exactly in place. That sounds like a lot. But bearing in mind the parts he's dealing with, it's an extremely quick solution. Next, the table moves along rails into the laser safety cabin. Once the welding robot is also on track, the worker moves to the other side of the safety cabin and starts clamping the next machine frame onto the second setup table. "Using this system, we can weld more than 20 machine frames a week," says Reiter. And Staufer is equally pleased: "We've already been able to use the welding process for a different order." ■

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FRONIUS
Headquartered in Austria, the company employs more than 3,300 people. It specializes in technologies and concepts to monitor and control energy, focusing in particular on welding technology, battery charging systems, and solar electronics.

MICROMACHINING OF STEEL WITH ULTRA-SHORT LASER PULSES

In his doctoral dissertation, submitted to the Institute of Beam Tools (IFSW) at the University of Stuttgart, Dr. Andreas Michalowski (39) developed a model for moving the melt in laser-drilled holes. His goal was to enhance the quality and productivity of material machining with ultra-short laser pulses. He followed this up by developing an optical system for laser drilling with excellent hole quality, which is already in industrial use. You can read the full dissertation (in German) here: *http://www.ifsw.uni-stuttgart.de/publikationen/forschungsberichte/dissertationen/Michalowski_978-3-8316-4424-7.pdf*

THIRD-GENERATION FEMTOSECOND TECHNOLOGY

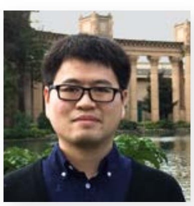
With its enhanced pulse compression, OPCPA (optical parametric chirped pulse amplification) heralds the third generation of femtosecond lasers. The technology promises beam sources with terawatt-scale peak powers and kilowatt-scale average powers. It can be used for applications such as filming the motion of electrons in solids. Dr. Hanieh Fattahi (34) presents the theoretical and experimental prerequisites for an OPCPA laser system in her dissertation, submitted to the Ludwig Maximilian University of Munich and the Max Planck Institute of Quantum Optics in Garching. Her findings (in English) are available here: *http://www.springer.com/us/book/9783319200248*

FURTHER READING

So what are the next steps for using light as a tool? The work of five young researchers gives some idea of the possibilities.

SYNTHESIS AND APPLICATION OF GRAPHENE-BASED NANOMATERIALS

Graphene — a highly conductive yet extremely strong form of carbon consisting of sheets that are one atom thick — is widely regarded as one of the most promising materials of the future. There is considerable interest in using lasers to produce graphene, since they function locally without requiring a vacuum or the use of chemicals. In his dissertation submitted to Rice University in Houston, Texas, Dr. Zhiwei Peng (27) investigated how this material can be produced using a laser and used as a microsupercapacitor. The full text of his work is available at: *https://www.dropbox.com/s/woxzbbffqolp8bn/Thesis_Zhiwei%20Peng.pdf*



FABRICATION AND CHARACTERIZATION OF METALLIC CAVITY NANOLASERS

A nanolaser is created by confining light on a metallic, highly reflective cavity, the dimensions of which are smaller than the light's wavelength. As part of his doctoral work at Arizona State University in Tempe, Dr. Kang Ding (30) successfully developed a metallic cavity nanolaser made of a semiconductor/silver core-shell structure that performs continuous wave (CW) lasing at room temperature. This could potentially be used for optical data transfer on or between chips. You can request a copy of the full dissertation from: *digitalrepository@asu.edu*

SURFACE FUNCTIONALIZATION WITH FEMTOSECOND LASER RADIATION

Surfaces with extreme water repellency are much sought after in the aircraft, wind turbine, mechanical engineering and shipbuilding industries. Dr. Elena Fadeeva (40) produced superhydrophobic surfaces using ultra-short laser ablation when working on her doctorate at Leibniz University in Hannover. Not only did she create structures specific to the application; she also succeeded in making targeted changes to surface properties such as wetting and interaction with tissue cells and bacteria. You can request a copy of the full dissertation from: *e.fadeeva@lzh.de*

Andreas Michalowski, Hanieh Fattahi, Zhiwei Peng, Kang Ding, Elena Fadeeva

Where's the laser?

Helping chefs make tasty fries Who can honestly say they don't crave a portion of french fries every now and then? But instead of the same old mass-produced frozen fries, comfort food connoisseurs prefer to fry their guilty pleasure afresh. To make the potato cutting process easier on the arm, American chefs use a professional multi-purpose wedger, dicer and cutter made by Edlund. Simply pop in the potato, pull the lever, and you're done! The laser-cut components in the stainless steel french fry cutter are pleasant to the touch even after they've been used dozens of times. What's more, there's nowhere for germs to lurk on these smooth surfaces.

The whole story at:
www.mastersofsheetmetal.com/edlund

Gernot Walter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WATTS…
… are pumped out with one pulse of the world's most powerful petawatt laser, the LFEX at Osaka University. You would need ten billion joggers running in sync to replicate that kind of power! LFEX stands for Laser for Fast Ignition Experiments. The high-energy pulses can be used for a wide range of research applications, allowing scientists to ionize atoms or molecules, generate various forms of radiation such as X-rays and gamma rays, and accelerate particles.