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Laser Community

THE LASER MAGAZINE FROM TRUMPF

WWW.TRUMPF.COM

Simplify it

Hansgrohe marks chrome and plastic in one step

Snap it

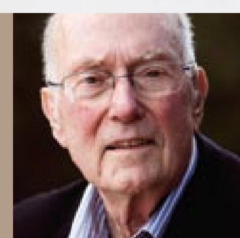
Grenzebach cracks glass using light and water

A Green Future

How automobile engineers respond to the challenge of CO_2

NOBEL PRIZE WINNER CHARLES TOWNES

AN INTERVIEW WITH THE MAN WHO INVENTED THE LASER → Page 26



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IMPRINT

KD Busch

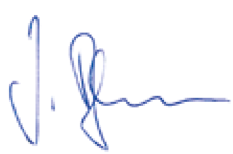
On the surface, the thought of using a single laser beam source for every application is compelling. It would eliminate the profusion of manufacturing techniques now prevailing. Regrettably, there is no one beam source that can do every job equally well. The reasons are to be found in the complex interactions among physical parameters, the multitude of materials, highly diverse applications and customers' very specific requirements. In the automotive industry, for example, lasers weld materials of differing qualities to make up transmission parts. They cut out tailored blanks, process aluminum and high-strength steels, and they engrave glass, plastics and rubber. If you take a close look at day-to-day production processes you will quickly realize that developing an all-purpose beam source is easier said than done. This is true even for the two innovations currently considered to be the new guiding lights on the market — those pointing the way to the laser processing of the future.

The first of these is the ultrashort pulse laser. It has what it takes to supplant many classic production processes and to open up entirely new applications, as well. It efficiently applies energy exactly where needed, making this laser ideal for "cold" processing of temperature-sensitive components and novel materials. The second of these innovations is the diode laser. It exhibits outstanding wall-plug efficiency at more than 40 percent and has the potential to replace current technologies — in welding, for instance — once the quality of the beam reaches the level achieved by today's solid-state disk lasers.

The universal laser remains elusive!

But before we get to that point it will be necessary to overcome numerous technological challenges inherent to the arduous industrial production setting. The fiber laser now prevails in the lower output ranges while the disk laser is defending its primacy in the multi-kilowatt spectrum. Over the next few years the CO_2 laser will continue to be the standard for cutting sheet metal.

All this means that using a variety of laser equipment will continue to be the name of the game. Disappointing? Not at all. Because one factor that applies equally to every player is the enormous development potential in laser technologies. The technology platform represented by the various beam sources offers a wealth of properties in regard to wavelength, pulse duration, focus position and performance. Extensive dialog with users will reveal countless new applications that, taken together, will bring lasers to a new level of technological maturity. Particularly in areas that are currently the industrial front-runners — such as photovoltaics, electromobility, semiconductor production, manufacturing using composites, and mass production of lightweight vehicular structures — are adopting laser processing and are benefiting from its productivity.



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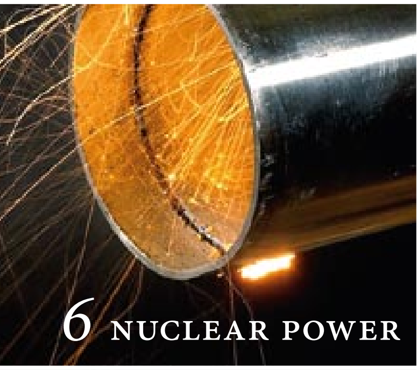

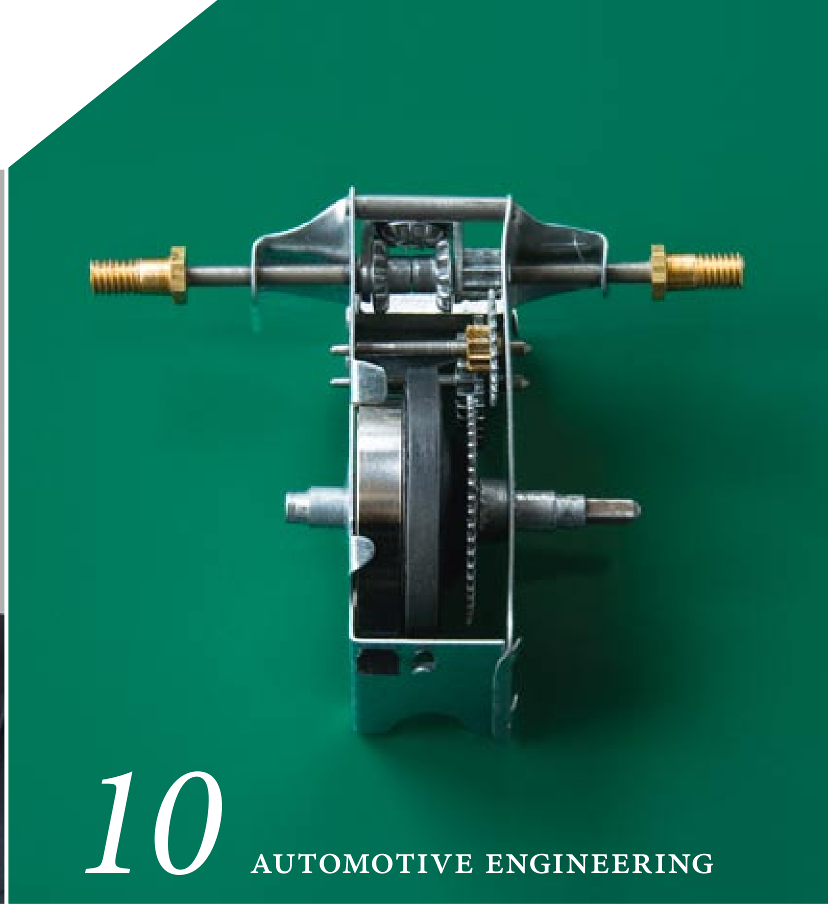

COMMUNITY

Lasers and people at a glance PAGE 06

ICALEO CELEBRATES 50 YEARS OF THE LASER // Lasers help decommission nuclear power plants PAGE 06 // Heads: Dave Hudson, Lutz Abram, Prof. Muneharu Kutsuna PAGE 07 // **RAPID FIRE AT THE KILOWATT RANGE** // Philips customized frame // Concepts: Tempered steels, K nodes, micro sintering PAGE 8 // **DR. JEFF ALLEN EXPLAINS WHY ROLLS ROYCE NEEDS IMAGINATION** PAGE 9

TOPIC

TITLE

Auto Vision

The automobile industry grapples with fuel consumption and CO_2 emissions without sacrificing driving comfort or security. And it succeeds. **PAGE 10**

Join the future

Engine and drive train, car body construction and materials. There are many ideas for more fuel-efficient cars. And increasingly, the laser plays a role. **PAGE 12**

STATEMENT

Planning is a waste

Controlling? A pure waste of time and resources, says consultant Niels Pfläging. He advises his customers to stop planning. PAGE 15

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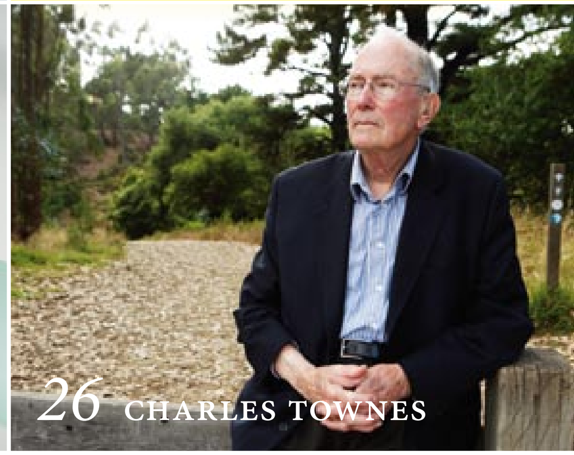


2010

REPORT

"I want 3D"

The third dimension was a dream of Erhard Hujer who now lives and breathes large-scale production orders. PAGE 16

355 nanometers into eternity

The dance around plastics and metals or why Hansgrohe AG needs only half as many marking lasers as they thought. PAGE 18

Clean break

Cutting without hurting the surface, no easy task when it comes to glass—but a solvable one. Grenzebach is leading the pack. PAGE 21

SCIENCE

DR. RALPH DELMDAHL AND DR. ALEXANDER USOSKIN

Superconductors for everyone

The wonder tapes could revolutionize energy technology. Now they can finally be mass-produced. PAGE 24

PEOPLE

"Do what no one else does!"

Young researchers should not listen to every Nobel Prize winner they meet advises Nobel Prize winner Prof. Charles Townes. PAGE 26

MARKET VIEWS

Laser diodes are more affordable than ever. And it gets better, says Dr. Guido Bonati from Jenoptik. PAGE 30

S P O T

--- TRACTOR BEAM

Researchers from the **Australian National University** are turning "Star Trek" fiction into reality. Inside a hollow light beam, they succeeded in moving tiny light-absorbing parts one and a half meters in distance.
www.anu.edu.au

--- LASER RECYCLING

The company **Unisensor** has developed a laser-based waste sorting process. Using laser spectroscopy, various components are identified and separated from one another.
www.unisensor.de

--- MALAYSIA

The industrial laser industry in Southeast Asia is slowly recovering from the impact of the financial crisis. The trade magazine **Industrial Laser Solutions** is reporting 9 percent growth in the second quarter of 2010. *www.optoiq.com*

--- QUANTUM NOISE

Erlangen-based physicists managed to adjust what is called quantum noise when increasing light signals by removing the photons from the laser pulse. *www.uni-erlangen.de*

--- SOLAR INDUSTRY

The **solar industry** is investing heavily in laser machines to handle solar technology's many different applications. The industry market research company **Solarbuzz** estimates sales will exceed Euros 200 million for 2010.
www.solarbuzz.com

--- MSG WELDING

Technicians from the **Laser Center in Hanover** have doubled the speed of gas metal arc welding by guiding the arc along a laser beam.
www.lzh.de

--- MINI DISK LASER

New infrared semiconductor disk lasers are the result of the European research project called **Vertigo**. The small, powerful lasers make applications possible in the fields of medicine, technology and sensors.
www.iaf.fraunhofer.de

"Science and technology have given us solutions in the past. With the right government policies, it will come to our aid in the future"

Dr. Steven Chu, Nobel prize winner and United States Secretary of Energy

Planning for the future

ICALEO 2010 celebrates 50 years of the laser and its promising future

Like last year, **ICALEO 2010** was all about being "green." The conference focused on environmental protection and the contribution that innovative laser applications could make in this area. "We need science and technology in order to solve many of today's most urgent problems, including transitioning to clean energies and finding solutions to our environmental problems," summed up **Dr. Steven Chu**, US Secretary of Energy. The physicist and Nobel Prize winner was honored with the **Arthur L. Schawlow Award** during the ICALEO Conference. The second main topic was, of course, the 50th anniversary of the laser. The Laser Institute of America, the conference host, had something very special in mind for this occasion. Four of the founding fathers of laser technology, **Dr. Kumar Patel**, inventor of the carbon-dioxide laser, **Dr. David Sliney**, pioneer in laser safety as well as entrepreneurs **Dr. Marshall Jones** and **Bill Lawson** narrated their stories of the laser's beginnings. *www.laserinstitute.org*

A particularly dense laser also cuts pipes that are accessible only from one side.

Decontaminated

Lasers help decommission nuclear power plants

Commissioned by the British government, **The Welding Institute in Cambridge** is testing the potential use of lasers in the decommissioning of nuclear power plants. Several remote-controlled solutions for removing contaminated pipelines and sections of concrete look very promising, but they involve very different challenges. For example, there are two ways to get rid of concrete: mechanically or using water jets. These methods are not only expensive and time-consuming, but they also result in much unwanted residue. Lasers with a low beam density quickly remove just the contaminated layers. However, when it comes to pipelines, a completely different approach is necessary. A dense laser beam cuts pipes up to 170 millimeters thick from one side. *www.twi.co.uk*

"We will introduce the American market to the most advanced systems and technologies"

Dave Hudson

Joining Technologies (JT) and **Fraunhofer ILT** co-operate in creating a strategic partnership in the form of the **Joining Technologies Research Center** (JTRC). It will be dedicated to bringing laser additive technology and equipment to the U.S. markets. The center will be located within a new facility in East Granby, Connecticut. JT-president **Dave Hudson** expresses his high hopes for the project, which will be the only entity in the U.S. that addresses the entire scope of laser additive manufacturing. *www.joiningtechnologies.com*

"The laser processing industry has finally reached the Internet era"

Lutz Abram

The Dutch company **247TailorSteel.com** combines Internet-based order processing with fully automated secondary laser cutouts. Customers simply place their orders with the click of a mouse. This business model has firmly positioned the Dutch company on the European market. In early 2010, it opened its first branch office in Bremen with **Lutz Abram** managing director of its German operations. *www.247tailorsteel.de*

"German applications are the best advertisement for introducing new laser methods in Japan"

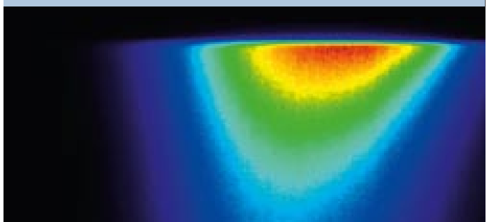
Prof. Muneharu Kutsuna

Rapidly developing technologies benefit from international exchange. This is the view of **Prof. Muneharu Kutsuna**, president of the **Advanced Laser Technology Research Center Co. Ltd.** from Japan, who, together with a delegation from the **Laser Materials Processing Research Committee** (LMP) of the **Japan Welding Engineering Society** (JWES), visited Germany as part of a tour through Europe. The findings from the trip will be presented at the beginning of next year to the entire LMP committee. *www.jwes.or.jp*

NETWORK NODE

The Industrial Research Institute Swinburne (IRIS) founded in 1992 ranks among the leading research and educational centers for innovative industrial applications in Australia. IRIS has a dual mission: the development and treatment of surfaces and interfaces. The Institute carries out long-term and short-term projects in cooperation with businesses and the government that range from fundamental research and feasibility studies to the design, construction and testing of new developments. The laser plays an important role in IRIS applications, especially those that involve welding. Current projects involve the joining of magnesium and aluminum alloys. For such research projects, the IRIS has set up a laser application lab whose modern technology and equipment will make it unique on the Australian continent. IRIS is also one of the important partners of the government-sponsored research program, Cooperative Research Centre, in which various academic and industrial partners combine forces to work on future projects. *www.swinburne.edu.au/engineering/iris*

Quantum Leap



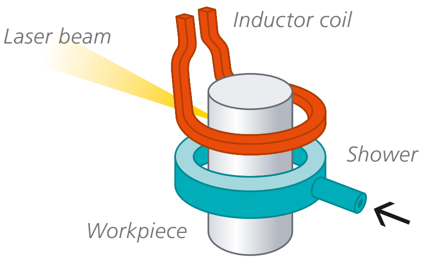
Color play

Almost at the same time,
but independent of one another,
Fritz P. Schäfer and Peter Sorokin
invent the dye laser. So far,
its most important area of
application is laser spectroscopy.

1966

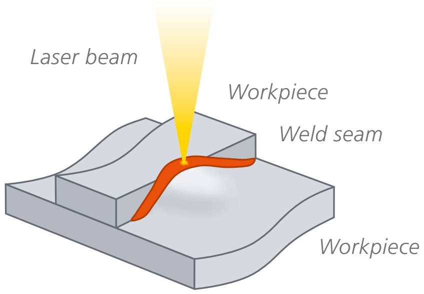
Laser Institute of America; The Welding Institute; Steve Adams; Lutz Abram; Steffen Hartmann; Kristian Hankte, Tobias Schickling, Niko Köster/wikimedia

CONCEPTS



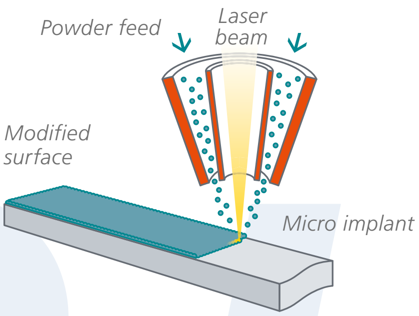
--- TEMPERED STEELS

Experts from the Laser Center in Hanover and **Leibnitz University** have developed a new process for welding tempered steels. The processing head combines inductive heating, laser welding and quenching into one process step. *www.lzh.de*



--- K NODES

TRUMPF-patented "K nodes" allow sheet metal to be welded edge to edge. Established limit stops along the joint contour also function as a positioning aid and as anchor points for a series of short weld seams. *www.trumpf.de*



--- MICRO SINTERING

The **Laser Center in Hanover** is introducing laser sintering for modifying the surface of tiny medical micro implants like stents by gradually applying a powder whose particles absorb the laser energy and melt together. *www.lzh.de*

The MBI-physicists want to create a new high-intensity laser with powerful light pulses and high repeat rate.

Power package

New high intensity lasers fire 100 times a second

The Max Born Institute (MBI) in Berlin has collaborated with the **Ferdinand Braun Institute** to develop a new kind of high intensity laser. This new laser technology involves sending extremely short light pulses with unimaginable power — far more than the combined power of all the world's nuclear power plants. Applications in medicine and technology are more diverse now than ever. But there is one flaw: The repeat rate is still only 10 light pulses per second, resulting in an average output of under 10 watts. The MBI is seeking to increase the number of pulses without having to reduce the power. In the coming years, this should open the door for a design that is built on a fully diode-pumped solid-state laser. In the long term, disk lasers are likely to be used as the beam source for these high intensity lasers. MBI has been working closely with its partner TRUMPF to construct an operational laser architecture. *www.mbi-berlin.de*

In a personal frame

Philips uses marking lasers for customized gift ideas

Those who want to give a digital photograph frame from **Philips** as a gift can have a personalized message marked on it. For manufacturers as well as customers, it is an uncomplicated process made possible by the flexibility of the marking laser. The Philips online store sends the desired text directly to the TruMark 5000 marking station in the company's main warehouse in the Netherlands. Operators only have to select the correct frame and place it in the machine. The TruMark 6230 performs all other steps such as setting the right variables and guiding the laser head completely automatically. At the end, only a brief quality check is necessary before the frame is sent to the shipping department. *www.philips.com*

Philips labels picture frames with personal dedications by using a laser.

Gernot Walter; Philips, Uwe Bellhäuser

"Valuable future benefits"

Dr. Jeff Allen explains the reasons for Rolls-Royce's interest in laser metal deposition (LMD) and selective laser melting (SLM), and why the company participates in Joint Ventures like Fantasia

Dr. Jeff Allen has been a Staff Technologist at Rolls-Royce, Derby, Great Britain since 2006. He is Global Process Owner for Powder Bed Manufacturing Processes at Rolls-Royce.

The Rolls-Royce Trent XWB will power the Airbus A350. Significant aspects of its state-of-the-art design are the result of new materials technology.

What advantages does Rolls-Royce see from participating in research projects with other organizations?

The main advantages to the company are that projects like Fantasia provide an opportunity to get to know and to work with prospective suppliers on research topics which have potential benefit in the future. They allow us to see what capability is being developed in the field of interest within the EU by world class suppliers. Important for our company is the opportunity to look at the practical aspects of concepts which could be useful to us in the future.

What makes LMD and SLM so special?

The initial short-term potential from powder based processes is to reduce the cost and lead times of existing components. However, the revolutionary aspects of the processes stem from their ability to make shapes not possible with conventional processes. This will give our designers more flexibility and scope.

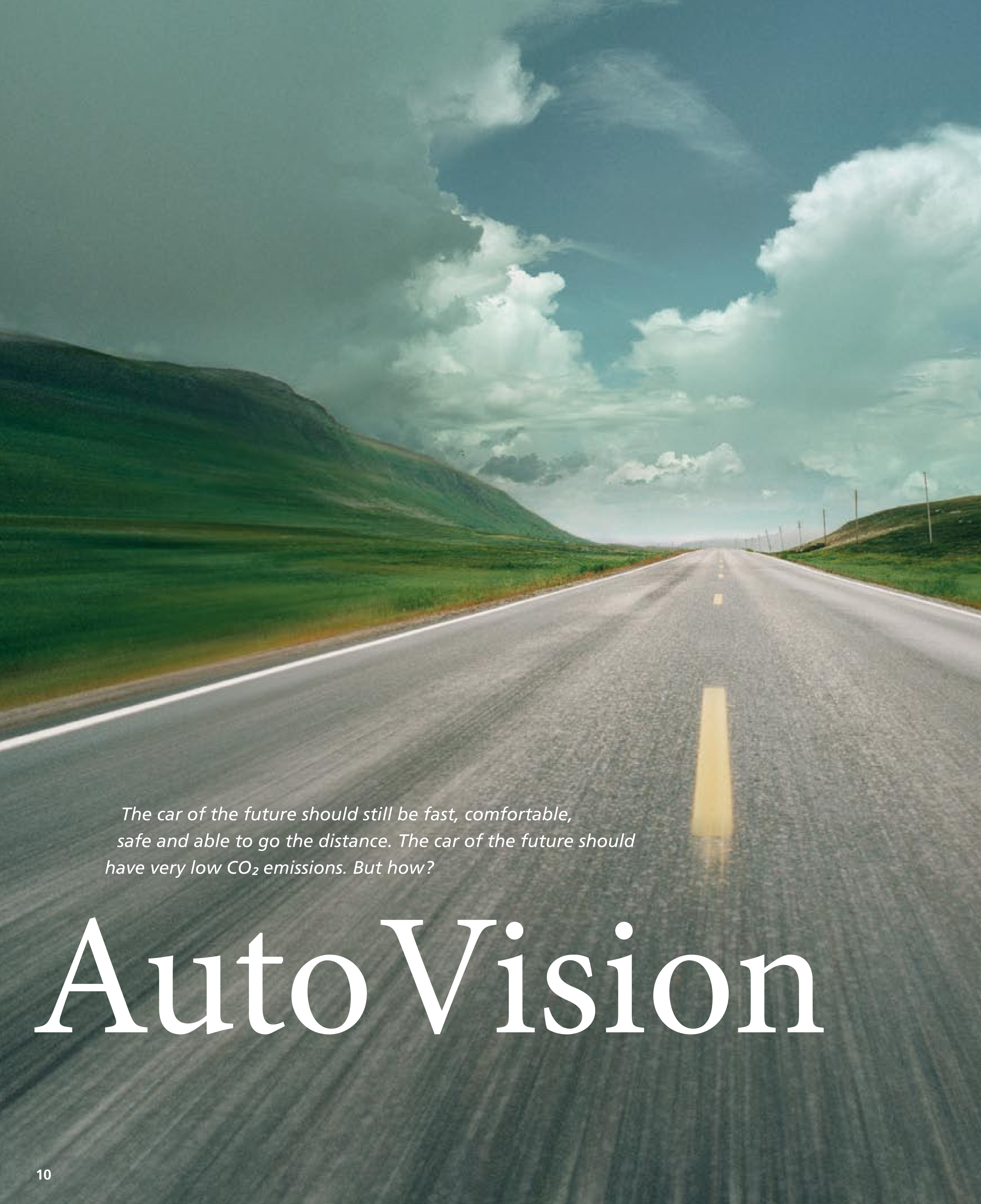
Can you give an example?

They could specify a part made from a standard low-cost material with areas of different material added by DLD (direct laser deposition). It is possible to meet specific aspects of the duty of the part such as a wear-resistant leading edge or a fatigue-resistant mounting. As parts become more complex and expensive, the capability provided by DLD to replace worn features and return the parts to revenue-generating service is vital to the economic viability of their use.

What are your plans regarding the practical implementation?

FANTASIA gave us valuable insights into the mechanical properties of materials produced by Powder Bed Direct Laser Deposition (PB DLD) processes and the techniques required to make aero engine parts by a "hybrid" route. This knowledge will be invaluable for future component design and setting up supply chains to deliver parts made by powder bed processes. In particular, we will be looking at ways of using the unique ability of the technique to produce "organic" shapes which could be used to optimize the performance and minimize the weight of aero engine parts.

Fantasia is one of 11 EU-funded laser projects with a total budget of 30 million Euros.



The car of the future should still be fast, comfortable, safe and able to go the distance. The car of the future should have very low CO_2 emissions. But how?

Auto Vision


Corbis; Gernot Walter


How to save both on fuel and weight: The famous silver race car "Silberpfeil" was silver because the paint was scratched off.

The K node is a tiny thing. Nothing more than a wee imprint in a car body component. Yet this imprint acts as a shock and anchoring mechanism for another component in the joining process. A welding robot draws a laser weld seam a few millimeters long from one edge to the other and then jumps to the next node point. That is all there is to it. This means the K node is a typical laser-driven innovation for the automobile on its road to the future, even though it's invisible and maybe even uninteresting to car buyers. Yet innovations such as the K node are leading to far-reaching rethinking of the way future cars are designed.

The regulations for the coming decade are clear: Anyone burning a liter of gasoline produces 2,320 grams of carbon dioxide and with combustion 8.9 kilowatts of power are released. Those are the rules of chemistry. Fleets of cars that are built on combustion as a power unit may not currently emit more than 133 grams of CO_2 per kilometer. Otherwise, manufacturers risk being subjected to severe fines. Those are the laws of important sales markets such as the European Union, Japan and China. Others will follow. That much is also clear. Ultimately, fuel prices will continue to rise over the long term. This is dictated by the laws of supply and demand in a market that obviously deals in non-renewable resources like oil.

The belief that the age of powerful combustion engines will come to an end at some point is firmly anchored in the minds of the consumers. Cars should be more fuel-efficient and release fewer emissions — legislators and customer purchasing decisions couldn't be making this clearer. However, the car should change as little as possible in the process. By their purchasing decisions, customers are also emphatically driving home the point that they want to continue to drive fast, go far and be safe on the road. They just want to get rid of the exhaust emissions.

How is this possible? This question brings us back to the K node — a small example of how laser-oriented designs are changing automobile design and manufacturing. What automotive engineers can best influence is how much energy they must use to move a car, how much of that remains leftover for the on-board systems and how much energy disappears into the air as heat. Many solutions in this process will have little or nothing to do with laser technology, others will have a lot to do with it. The laser plays a particularly important role in terms of moving mass. →

In this case, this inconspicuous little K node helps make a characteristic feature of the classic self-supporting car body disappear: flange connections.

If you can subtract flange connections from the equation, you reduce weight and materials considerably. In addition, components could be placed closer to one another in many areas because it is usually only the flange collar that marks the distance between parts. In the next step, the weight of an entire assembly could be reduced because the K nodes incorporate a form closure and are welded edge to edge. These characteristics combined with the high quality of laser seams stabilize the design, allowing for a reduction in material strength and weight in some areas.

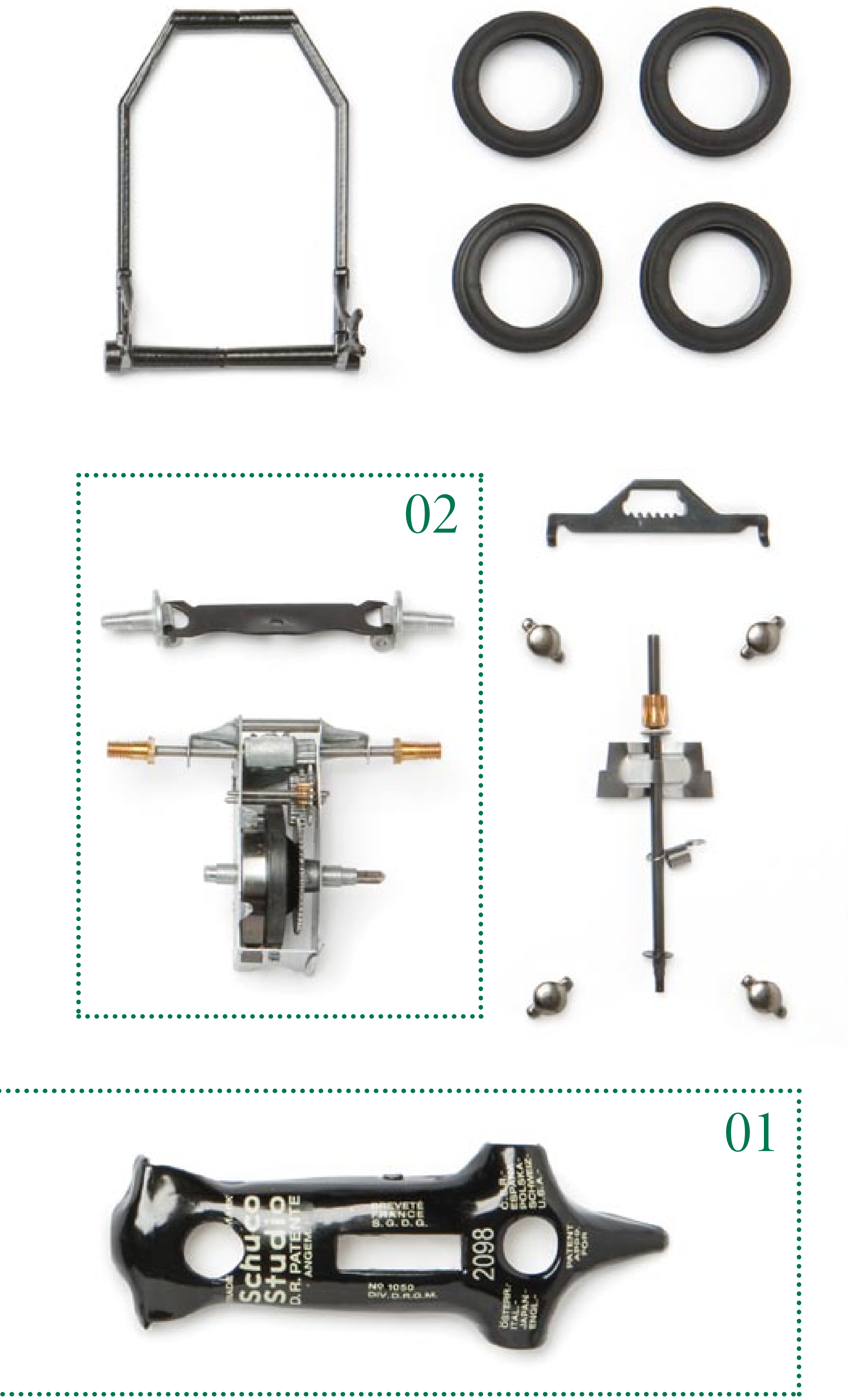
Another "laser-supported" trend in car body design and construction that's part of the drive to reduce vehicle weight is the quest for lighter weight workpieces. High quality and highly resistant steels are creating an opportunity that the industry is already pursuing. The laser is helping industry to make the thermoforming process chain more flexible and yet also more cost-efficient. When laser machines replace mechanical punching presses set up before the kiln and after the forming station, tooling times, tool costs and production damage like micro cracks will be eliminated from production.

Another very recent concept in car body design and construction is being adopted for certain bearing structure elements or assemblies that have been traditionally steel. Instead, light metal alloys are being used for these components. The components produced in the die casting process are as resilient as their steel counterparts, but they are some 20 to almost 50 percent lighter. Additionally, the cast parts can be designed such that, under certain circumstances, one component can replace an entire steel assembly comprising five, six or seven parts produced separately and subsequently welded on. In this case, too, highly flexible laser machines that operate contact- and tool-free eliminate limitations in the production flow caused by the need for additional mechanical cutting of cast parts. The same intention of replacing heavy components with lighter ones and designing leaner parts or eliminating them altogether, if possible, is also emerging in the design and building of the power train. Laser welding is increasingly replacing flange constructions on extremely stressed joints. Its ability to deep weld and join very different materials that are normally not weldable is very welcome here. →

Join the future

Laser light makes many of the innovations economically feasible for the first time—and for a number of them, laser light is the only way they are at all possible. Here are some examples

KD Busch



01 CAR BODY **Flangeless design:** Laser joining on the I-joint replaces overlap welding. Laser-cut profiles replace deep-drawn sheet metal parts. **Space frame:** A skeleton made up of laser-processed profiles bears an outer shell made of thin sheet metal. **Lightweight construction:** Laser processing leads to more efficient process chains for highly resistant steels or cast aluminum parts. Laser cutting replaces mechanical cutting processes in this area. Laser deposition welding "hardens" the surface of tools for forming highly resistant steels.

02 POWERTRAIN **Combustion engine:** Laser-drilled fuel injection nozzles deliver fuel more accurately. Laser-structured tire treads have less resistance from friction. **Coating:** Wear-and-tear protection of highly stressed surfaces using amorphous carbons. **Electric engine:** A laser-supported method allows for superconductors in extremely compact and powerful engines. **Transmission:** Laser welding replaces machine joining methods. The weight from screws and flanges is gone; more hydrodynamic forms reduce energy losses due to eddies in the transmission oil. Lighter weight and more compact components joined together by freely formable cast elements and resistant steel components are developed. **Wheels:** Lighter weight wheels thanks to rim tapes made of highly resistant steels welded onto the wheel rims.

03 ENERGY SUPPLY **Fuel cell:** Using laser seams, the metal films in the cell's interior can be joined efficiently and with low-warpage. **Batteries:** Lasers weld the battery housing made of lightweight, thin sheet metal with minimal warpage. **Photovoltaics:** New concepts for more powerful solar cells almost always involve laser processing. Lightweight, transparent and flexible photovoltaic modules could replace some of the energy on the way.

04 ADDITIONAL POTENTIAL **Emissions technology:** Laser-based analysis methods make it possible to track and optimize reactions on the surfaces of catalytic converters. **Vehicle lighting:** A new laser method makes it possible to produce large OLED elements. OLEDs consume considerably less energy than most other light bulbs.

But let's look much farther into the future toward the electric car. Imagine that the car now no longer emits CO_2 gases; however, it has to store the 540 kilowatt hours of power that was previously produced by a full 60-liter gasoline or diesel tank in the appropriate energy accumulator — without modifying the car's design. A lithium ion battery that stores this quantity of energy would weigh about four and a half tons. Though there is great potential in battery development, the car would nevertheless have to be modified to accommodate the new energy accumulator by slimming down on a massive scale. This would require far fewer pounds than the classic self-supporting steel body could afford to give up. In fact, it is now becoming apparent that hybrid cars will need different car bodies to accommodate electric drives that their "green-aware" owners want to be more than an auxiliary engine for city driving.

The body of future, more fuel efficient and mass-production-friendly electric and hybrid cars will probably return to the roots of car body construction: a supporting skeleton covered with an outer shell. Only the car body of the future will combine lightweight metal profiles with modern composites. The laser will also play a key part in that process. The know-how and process chains are already evolving in the most varying industries. Engineers are increasingly experimenting with designs assembled from profile constructions that are laser-cut, then 3D-formed and laser-welded. This knowledge can be combined with the experiences of automotive design engineers when it comes to concepts such as incorporating space frame construction into the mass market cost effectively. At the same time, current research is devising laser processes to produce future carbon fiber components rapidly, flexibly, and above all, efficiently.

The laser and the car have enjoyed an association that has been and continues to be mutually beneficial. The laser industry continues to exist in this form and scope because the laser has been such a key tool in so many different automobile applications in the last 20 years.

And the farther we look into the future, the closer the relationship between laser technology and the automobile appears to be. What would be good examples? The automated welding of lightweight materials like aluminum? The welding of thin films for fuel cells or batteries for future electric cars? High performance micro processors that are manufactured using laser-generated, extremely short-wave UV light? Optical networks that sooner or later will replace a majority of parts in the electrical on-board power supply? Then there are still the large-area OLEDs as lighting elements, glass panes and solar cells that both save and produce on-board power: A mass production-friendly process is currently emerging that coats glass with the aid of the laser. Or how about a powerful, compact electric engine with coils made of superconductors? There, too, laser light applies the functional layer. None of this is science fiction. These are developments of today that are paving the way toward an energy-saving, emission-free future for the automobile.

The next two or three decades will probably be the most exciting in the history of the automobile. The industry is already beginning to reinvent the car. Many changes will be visible on the exterior. However, most will never be seen. Laser light will make many of these changes cost efficient for the first time — and for a growing number of them, laser light will make it possible at all. ■

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Many of the innovations will not improve the product, but rather change it to make it viable for the future. No car buyer will want to pay for this. That is the economic challenge

KD Busch

Planning is a waste

Niels Pfläging is an author, lecturer and consultant for C-level executives. He lives in São Paulo, New York and Frankfurt.

Corporate planning is redundant—and damaging—asserts the long-term controller and now management consultant Niels Pfläging

When humans began to mass produce goods about 100 years ago, there was no need to worry about the market—shortages were big and the business world was transparent. This was the birth of planning. Companies began to plan budgets, production, sales, costs and personnel needs. The idea of being able to plan everything has been maintained by companies up to the present time. But the world that companies move within has changed. Satiated markets, enlightened consumers, globalization, terror attacks and clouds of ash have made control through planning an illusion. The planned economy of the Soviet Union is dead. Yet planning continues in many companies.

While we like to equate good planning with forward-looking action, the opposite is the case because when companies plan, they either waste their time or cause damage to themselves. Those who want to be successful today must be highly flexible so they can make quick adjustments to the changing conditions of the market. In contrast, those who plan and budget confine themselves by setting a certain course in a specific time frame. As a controller, I too have been responsible for such processes in many corporations; however, you cannot imagine a more dramatic waste of time and resources. All that has to happen is for a currency rate or raw material price or a law somewhere in the world to change—then the forecasts no longer match reality and the plans on every level have to be changed to deal with the new conditions. This shows that planning does not look ahead, but is rather reactive and static. The consequence is permanent frustration. Those who try to control the future with numbers create a perfect world driven by their own desires and hopes. It has nothing to do with reality. That is why companies do not need to plan or make forecasts. Not today. Not tomorrow.

Niels Pfläging
Die 12 neuen Gesetze der Führung

(The 12 New Laws of Management)

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So what replaces planning? Something that we already have: Intelligent, thinking people who are capable of responding flexibly to external demands and requirements, especially customers—if they are given the freedom to do so. For guidance, you could add what we call "relative goals," such as resolving to be better than the competition or other divisions within our company. Just don't define any specific numbers! A Formula 1 driver only resolves to be faster than the competition. If he isn't, then he has to figure out why, practice more or simply get better.

Some companies like Southwest Airlines, Google, dm, Aldi and Sweden's commercial banks have used this approach successfully for years. The most progressive companies transfer responsibility to employees where the actual customer contact occurs and, at the same time, they allow them to look at all relevant business figures. If a subsidiary is not running well, the relevant team members have to handle it themselves by asking colleagues for advice to identify the reasons behind poor performance. This means employees don't have to meet pre-defined numbers, for better or for worse, to get into management's good graces. They are given free rein to think for themselves and figure out how they can contribute to the success of the company. This is how you can avoid the time-wasting internal rituals of accusations and assigning blame. When you stop planning, a company-wide sense of entrepreneurship is allowed to grow. ■

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Niels Pfläging

"I want 3D"

What is so special about the third dimension? And how do you work through a 350,000-part series? Erhard Hujer is the man who knows

"I never got around to 2D processing" is one of your well-known quotes. You make it sound like it is a necessary evil to enter the third dimension.

It is. I never wanted anything to do with 2D processing. But customers who order 3D parts want to obtain all of their components from a single source if possible. So 2D cutting is a step in the process chain that we have to offer. That's why we started up our business with machines for both processing methods. While we were pushing hard for 3D processing, surprisingly, we received an increasing number of requests for 2D components, which shows that the two complement one another nicely. At all three of our facilities, next to 3D processing cells we have flatbed machines that are used for large-batch processing, particularly for parts for convertible car tops. But we do not want to expand 2D technology. There are specialized companies for those jobs — I don't necessarily want to compete with them. Our strength is and remains large-batch 3D laser material processing.

How do you define "large batch"?

These days, we define it as up to 350,000 units per part. We have built up a production capacity that enables us to produce 50,000 parts monthly. When it all began in 1994, we didn't foresee this volume. At that time 3D laser processing was only used for prototype construction. In large-batch processing, parts were mechanically separated. Then came thermoformed car body parts. Serial production first emerged when automobile manufacturers made the transition to it. Now we mainly cut B-pillars, sills and side paneling for the automotive industry, but also parts for home appliances, commercial trucks, farm machinery and equipment and profiles for doors and windows.

Although you have specialized in large-batch production, you still continue to produce prototypes. Does that pay off?

Yes, it pays off for us. We have a sophisticated system to complete these types of orders fast. The standard equipment for a prototype part costs only about 250 Euros. One day is enough to construct a prototype device and to ramp up production. In Harsewinkel, prototype production makes up about 40 percent of the total production capacity; in Drolshagen, it's 25 percent. At our facility in Lohfelden, it is only 1 percent. Currently serial production is the strongest part of our business.

But to keep up we always have to work with the most modern machines, otherwise we don't need to bother at all. To keep up with the pace of technological change, we replace our machines every 48 months. If we didn't, our machine fleet would be obsolete, the machines too slow, and we would no longer be competitive.

Recently you began using your first high-end 3D machine with a disk laser, the TruLaser Cell 7040. What tipped the scales in favor of the solid-state laser?

The low power consumption was a major deciding factor for me. The machine may be more expensive than the CO_2 model, but in the long run it will pay off. TRUMPF quotes a power savings of 40,000 Euros per year. But even if I only save 30,000 Euros annually per machine and add the total savings together for 10 machines, that comes to 300,000 Euros in savings. In addition, unlike the CO_2 model, which had to be serviced at regular intervals, the laser requires no maintenance. We just have to replace the air filter units once in a while. This means no downtimes. Another benefit is improvement in the quality of the parts produced. With the solid-state laser, there is less burr formation, so that we hardly have to do any touch-up work. Lastly, the machine is extremely fast.

In your opinion, will the solid-state laser continue to become more prevalent in 3D processing?

Definitely. I predict that in the 3D area solid-state lasers will soon be used to process thermoformed parts in the thin sheet range. We use one to cut parts 2.5 millimeters thick, and for this thickness it's ideal. For thicker sheets, the CO_2 laser will continue to be the ideal solution. Also straight job shops that have to be able to work with all sheet thicknesses will continue to use the CO_2 laser as a universal tool. But we will continue to invest in CO_2 machines in the future. After all, we also cut commercial truck components made of 10-millimeter thick steel.

Automation is quickly reaching its limits in the 3D range. How do you deal with this fact?

Automation is a hot topic for us. The new machines are becoming faster and faster, but at some point the machine operator can't keep up. We were already thinking about automating a machine ourselves. Technically it's possible, but you need a great deal of space for it. This is because first you have to connect a conveyor belt to the machine, then remove the parts again, synchronize pick-up, have them load in and unload again on the back side. That's why I think the best solution is a suspended robot operated via a carrier system on the ceiling. Set up in front of

Claus Langer

the machine would take up too much space. We are already thinking about constructing a machine in Harsewinkel to test this concept.

So far you have been using rotation changers and a partition for split-station operation. How has this set-up worked for you?
We have equipped half of our 3D machines with rotation changers. We will soon be equipping the majority of our 3D machines with them to give us greater flexibility. By using the rotation changer, we now have the entire work space available. With the split station, on the other hand, we are limited to a certain part size. Also, with the rotation changer, the operator no longer has to run to the other cabin to load and unload parts.

How does your business model look for the long term?
We are thinking about different options, for example, remote welding. For the long term, we would like to produce complete assemblies that would involve both welding and assembly, especially of challenging car body parts like the front or the rear. Currently, we are actively pursuing ongoing production orders that will enable us to get a foothold in that area.

You founded the Lohfelden facility right on the doorstep of a major automobile manufacturer. What came first, you or the orders?
We were there first — I opened the facility with three machines without having a solid order from our customer. A good businessman must be courageous. If you make only safe decisions, you can't grow your company. Risk is always a part of the game. The Lohfelden facility has been in operation now for three years and we have ordered our eleventh 3D machine this fall. We are completely satisfied. ■

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Erhard Hujer is a specialist in 3D processing and his company currently produces large-batch production orders.

HUJER LASERTECHNIK specializes in 3D laser cutting and welding. The company produces large-batch production orders and prototypes.
The company's three facilities — Lohfelden, Harsewinkel and Drolshagen — has a workforce of **180 EMPLOYEES.**
Hujer Lasertechnik mainly processes **THERMOFORMED CAR BODY PARTS** for the automotive industry as well as parts for home appliances, commercial trucks, farm machines and equipment, and profiles for doors and windows.
The company's machine fleet consists of **25 MACHINES.** Hujer Lasertechnik currently processes 2D and 3D components on 13 TruLaser Cell laser cutting machines, four TLC 1005 3D machines, one TLC 6005 machine and seven flatbed laser machines and a press brake.

Fancy design, fancy lettering: Round shapes and plastic surfaces represent no problem for UV lasers.

355 nanometers for all eternity

Two materials, one marking step — Hansgrohe AG manages the balancing act with the UV laser

Dirty water, greasy hands, aggressive cleaning agents. Throughout its service life, a shower head must withstand many stresses. Unfortunately, its lettering often fades far too quickly over time — to the dismay of the manufacturer. A logo should ultimately shine like new on the product for the long term. In turn, the user also wants to know where the red dot for hot water is even after ten years. "Aesthetics and quality are two pillars of our product philosophy," explains Verena Heizmann, department head for water mixer production at the Hansgrohe plant in Offenburg. "We were using the pad printing method, which simply wasn't up to date anymore and in many fields of application it didn't meet our high quality demands."

"Our requirement specifications were very comprehensive," recalls Bernd Schneider, who is responsible for operating equipment design and is also laser protection officer at Hansgrohe. "Especially because our materials came with special demands that not every method could meet." Shower heads, for example, consist of different plastics some of them with chrome alloy. Some of them behave completely differently when being processed. After extensive testing, those in charge opted for laser marking because the method met all the desired qualities even though several changes had to be overcome. Marking chrome surfaces was relatively uncomplicated in this case. The laser is perfect for removing just one chrome layer several micrometers thick without damaging the underlying layers. In this way, the metal's corrosion protection remains intact. The developers really had to rack their brains to find a solution for the plastic on the fittings. "Plastic does not equal plastic," says Schneider in describing the dilemma. Depending on use, different additives are mixed together in the base plastic material. Fillers like quartz

“The laser marking is more durable and of higher value than other lettering procedures”

Verena Heizmann, department head for water mixer production

or glass particles can drastically change the absorption behavior of the material, among other things. “With the method we use — laser engraving — we always want to remove some material, even if only a tiny bit,” explains Schneider. “But if we allow the laser to overheat the material, exactly the opposite happens.” The material melts and outgassing occurs. During cooling, small gas bubbles are enclosed so that they reflect incident light and a relatively wide embossed marking emerges. “This foaming can also be used anywhere as a marking method,” explains Schneider. “But it never looked as good as we wanted it to.”

A deciding factor as to whether the plastic foams up or is removed is the selection of wavelength. Theoretically, the plastic component parameters can be used to calculate this, but in practice there are always unforeseeable effects. Each new combination also has to be subjected to comprehensive tests prior to production readiness. “We have always had outstanding support from TRUMPF’s laser application labs for this,” reports Schneider. “Nevertheless, it always took a lot of time to come up with the right combination of plastic and wavelength, which was also often very different from that of chrome. In the worst case scenario, we would need two lasers for one product.” That’s why the introduction of the UV wavelength (355 nanometers) opened up new dimensions for the developers. These shortwave light beams respond in a photo-chemical reaction directly with the plastic connections without heating the material and causing it to foam. Chrome can also be easily marked using the UV laser; in fact, there is just one more process step required.

Meanwhile, the first marking laser has been doing its job at Hansgrohe for more than ten years. In that time, the company has invested in more than 40 machines that are mostly integrated into the automated production lines. The parts then run on conveyor belts through the marking stations. The laser marks the parts using a pre-programmed pattern without the operator having to interfere. Stand-alone stations are located in the plant halls wherever necessary, such as when special solutions in small quantities are needed. Meanwhile, the Hansgrohe plant produces and delivers millions of laser-marked shower heads and bathroom fixtures. The company, based in Schiltach, Germany, now also uses the marking laser for quality assurance. The high flexibility enables each delivered part to be marked with the respective product date, making it possible to track potential quality problems later on.

There is one last piece of bad news: color. Pad printing has not completely disappeared from the production chain. It is still being used for bathroom products where there is a need to identify “hot” and “cold,” which means the colors blue and red are needed. At the moment, Hansgrohe has come up with a compromise as a temporary solution. The laser first scores the surface before the print machine applies the ink. This step ensures that the lettering lasts much longer. However, department head Verena Heizmann is not fully satisfied with this process. “First of all, it does not completely eliminate all of our problems. Secondly, a pure laser process would obviously be quite a bit more efficient.” So far, there has not yet been a satisfactory solution. “We could add special pigments to the plastic that respond to the laser colorwise,” explains Bernd Schneider. “But these materials are somewhat toxic, so the health risk is too high for us.” This means it will take some more time before labels on shower heads and other bathroom fixtures last for all eternity. After all, even if the ink wears off, the engraved logo is resistant to even the most obsessive clean freaks. ■

“We use the UV laser to mark plastic and chrome alloy in one single step”

Bernd Schneider, project manager for operating equipment design and laser security officer

KD Busch

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Clean break

Each time the glass surface is damaged, there is hell to pay in the production process. So wouldn't it be nice if there were a cutting process that did not damage the glass?

One thing is certain: It's not possible for lasers to cut large sheets of glass. Franz Krommer, who is developing a new laser cutting table for use with flat glass for Grenzebach, a company located in Hamlar near Augsburg, summarizes it this way: "Those who want to use the laser to cut through glass sheets the same way that they cut through metal sheets will destroy their workpiece." With laser cutting, the material is usually melted down, evaporated or burned, and then removed while the beam continues to move forward. In contrast, glass is brittle and slow to conduct heat, so lasers aren't used. "The thermal energy cannot be put to work in the focus point in the usual way. The resulting tensions break the glass," explains Krommer. Nevertheless, the company is testing a prototype it built of a laser cutting table for flat glass that is almost ready

Grenzebach's laser cutting table for flat glass. The unusual shape of the processing head emerged from the specially designed beam guidance system.

Peter Oppenländer

for production. It is a gantry machine with the workpiece — a nine square-meter glass sheet — placed on a firm cutting table. The workpiece does not move; instead, the gantry and the processing head are suspended above the table and move over the glass. Bernhard Röll, Krommer's colleague and the technical head in this project explains: "We have gone through all possible configurations with our project colleagues at TRUMPF, but to move the glass panel under a fixed processing head would have resulted in enormous traverse paths."

Cutting means breaking Since humans have been producing glass, they have cut it by etching it and then breaking it. No saws and no grinding wheel can cut glass faster. The only flaw in the process is the breaking edge. It endangers the whole workpiece. On the scale of a glass surface, the score, which is a fine guiding groove, causes massive damage to the glass. It leaves behind micro cracks along the breaking edge that can cause the glass sheets to easily break, such as during coating or hardening in the annealing furnace or due to its own weight during transport if the sheet bends or is shaken when the truck carrying it hits a pothole.

"There are only a few benefits that support developing a laser cutting method for glass," adds Röll. "But the 'edge' argument is a serious one. Yet laser light can be applied without causing such microdamages if it works with the glass and not against it." The goal — to cut sheets with an accuracy of four-tenths of a millimeter without the edges requiring touch-up work — led to laser-induced tension cutting or LiST (after the German name for this method: Laser Induzierten Spannungstrennen). This method works in the following way: The laser focus spot draws the score by applying heat and thereby tension to the glass. A coolant nozzle follows the laser and the tension discharges to form a fine sliver-free fissure. Röll now calls LiST " a good idea, but it also showed us its limits." The main limit was and is the heat transport in the glass that hinders the working speed. "We have to apply a sufficient volume of energy to the glass," says Röll. "And we have to give the glass time to absorb the energy. LiST was not ideal for processing thin glass."

> "Those who try to cut through glass with a laser beam will ruin their workpiece"
>
> *Bernhard Röll, Engineering Lasertechnology*

So two strategic decisions were made. Grenzebach entered into a partnership with the company MDI Schott and the development team redefined the task for the laser method. The LiST method was aimed at thick glass sheets that are produced in small batches and with high margins. Under the conventiontional method thick glass is particularly hard to break. Therefore laser technology seemed promising, with speed playing a minor role. The new MDI-Grenzebach method, on the other hand, will work considerably faster than LiST. It was designed for the purpose of the glass sheet volume market with formats from 3.6 by 2.5 meters in edge length and thicknesses between one and six millimeters, cut-

Bernhard Röll (left), Grenzebach's technical project manager, helped to develop the MDI-Grenzebach method. Glass Technology Sales Director Franz Krommer supervised the project.

ting sheets for further processing in an inline process. When finally on the market, the cutting table will cut and load dimensionally accurate sheets that don't need touch-up work into the annealing furnaces and coating machines of fully automated production lines for car, window, construction, furniture or solar glass. "With feed speeds of 40 meters per minute and thicknesses of up to 4 millimeters that we are currently reaching, we can serve our customers well," says Röll. "And chances are good that we will soon reach the next stage with 6-millimeter thicknesses and 80 meter feed speeds per minute."

"Glass is an unwilling heat conductor. We have to give it the time it needs. Otherwise it resists"

Franz Krommer, Sales Director Glass Technology

A decisive factor for this success was the decision to collaborate with MDI Schott. The company had already spent several years developing a very successful laser cutting method for thin glass sheets under one millimeter. However, the engineers at MDI Schott confronted the challenge of "energy absorption" by developing a special beam guide. While LiST generates a laser focus spot and directs it over the glass using a set of mirrors, a facet wheel made of polished aluminum rotates in the processing head in the MDI-Grenzebach laser cutting table, refracting the beam and aiming the laser focus spot into a fine long line. The energy of the beam is distributed across a large area, but depending on each individual dot along the line, it can have a longer effect and uniformly lower the heat profile emerging in the glass. Franz Krommer: "Laser cutting usually involves concentrating the energy on one dot so that it rapidly penetrates the material. This means giving the material as much time as possible to absorb the energy so that the light cannot cause any damage." As with LiST, the coolant nozzle then produces a fissure so fine and straight that it is completely invisible until the glass is cut on the cutting table — with breaking edges so smooth they might have been cut by a knife. A CO_2 laser from the TRUMPF TruCoax line with one kilowatt output supplies the laser light required for "cutting." The project team opted for the coaxial laser because it is compact enough to be operated on the gantry. In the future, it could even become part of the processing head to further shorten the beam path. The fact that the resonator design limits this laser type to a maximum two kilowatt output is not a problem, explains Krommer. "In the case of glass, more output would not help us achieve a higher processing speed. We would only begin damaging the surface again." ■

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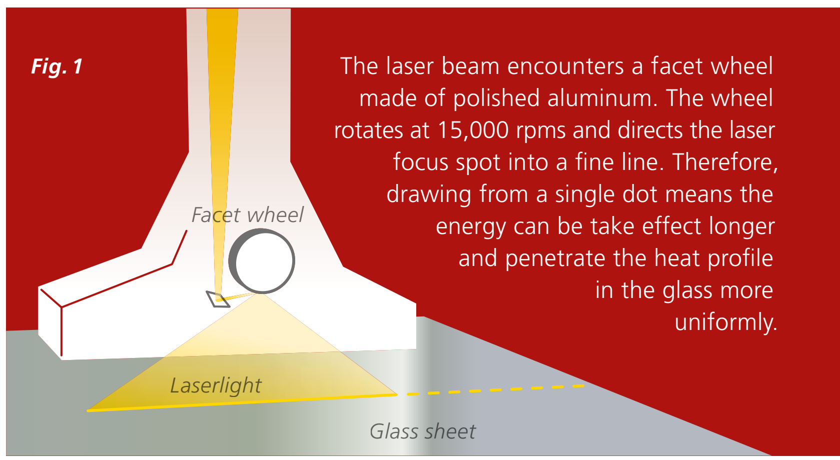

Fig. 1 The laser beam encounters a facet wheel made of polished aluminum. The wheel rotates at 15,000 rpms and directs the laser focus spot into a fine line. Therefore, drawing from a single dot means the energy can be take effect longer and penetrate the heat profile in the glass more uniformly.

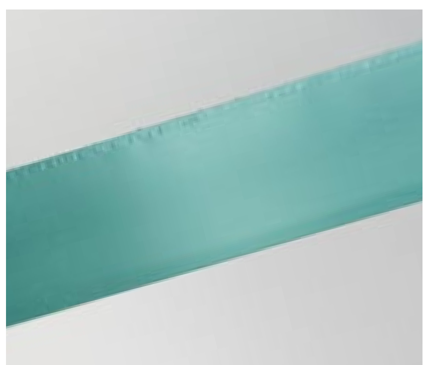

Fig. 2 *Conventionally cut and unfinished edge with clearly visible damage.*

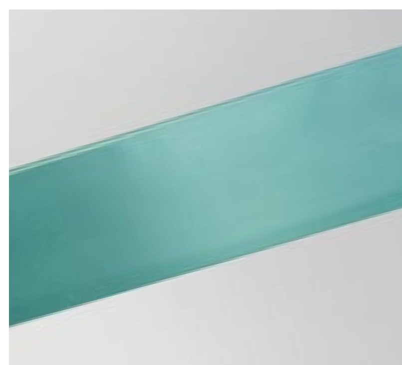

Fig. 3 *Unfinished laser-cut edge. The score is flawless and free of micro cracks.*

Dr. Ralph Delmdahl and Dr. Alexander Usoskin

Superconductors for everyone

Extremely thin superconducting tapes can transfer more than 100-times the electrical current compared to conventional copper wiring in the same conductor cross-section—and without any losses. Cooling with liquid nitrogen is sufficient for this purpose. Now these wonder tapes can be produced for the first time on an industrial scale —with the laser

The ceramic high-temperature superconductor (HTS), for which Georg Bednorz and Alexander Müller were awarded the Nobel Prize in 1987, immediately awakened the hope for a revolution in energy technology. Unlike the superconductors known up to that time, the HTS loses its resistance above the boiling temperature for nitrogen (–196 C°), which means it becomes superconductive and permits loss-free conduction of electricity. Cooling using environmentally-friendly liquid nitrogen is feasible both from a technical as well as from a economic perspective. However, commercial use has not occurred because it proved to be extremely difficult to produce new ceramic-coated conductors in suitable quantities with sufficient quality. The conductor's superconducting thin layer of only one-thousandth of a millimeter is made up of tiny crystals consisting of yttrium-barium-copper oxide ($YBa_2Cu_3O_x$ or YBCO, for short). To maintain the superconducting properties across the entire length of the conductor, the electrical current must overcome the boundaries from crystal to crystal as easily as possible. The conductivity along these so-called grain boundaries is highly dependent on the orientation of the crystals. To achieve the highest possible current-carrying capacity along the entire tape, the superconducting YBCO layer must have an almost perfect biaxial texture—just as if the superconductive YBCO in the conductor were made out of layers of identical Lego blocks.

Micrometer sandwich The completed conductor is built like a sandwich. It consists of several functional layers that are applied in consecutive process stages. First, on a polished and cleaned 100-micrometer thick stainless steel tape, which is typically 5 millimeters wide and lends tensile strength and flexibility to the finished conductor, a 1.5 micrometer-thin texture made of yttrium-stabilized zircon (YSZ) is separated by means of patented ion beam deposition from the company HTS Bruker. An additional metal oxide layer (CeO_2) only 0.05 micrometers thin functions as the diffusion block between the YSZ texture and the quasi-monocrystalline superconducting YBCO substrate. Finally, the conductor with a thin stainless metal layer is protected against external influences and is coated with copper or silver for contacting purposes.

Lab procedure for the plant The critical processing point for the performance of the tape is the application of YBCO. This is done by pulsed laser deposition or PLD. This process involves evaporating the YBCO powder in a high-

energy, ultra-violet (UV) laser pulse and transferring it to the supporting substrate. There, it grows atom layer by atom layer and forms a crystal grid structure. The PLD process is a method that has been proven in scientific material research for the production of high-quality thin layers over the last 25 years; however, the deposition speed is slow and the substrate size is limited. That's why no one took it seriously for production on an industrial scale. But there has now been a breakthrough. Today, by upscaling the PLD process, conductors up to two kilometers long can be produced with feed speeds of more than 75 meters per hour — without sacrificing layer quality. This advance has been made possible by innovations in the field of excimer lasers, extremely short-wave gas lasers with power outputs of up to one kilowatt and more than one joule per laser pulse of energy. Modern high-performance machines can be operated in continuous three-shift operation over a period of one year with more than six billion pulses at full capacity and a high level of stability for industrial mass production. However, upscaling the PLD process for industrial production required additional innovations in the beam guidance and deposition architecture because the material transfer per laser pulse cannot be increased as desired. In order for the current laser output to provide a correspondingly high volume deposition, the original laser beam is divided up into beamlets. Beam homogenization and scan algorithms that calculate the relative movement of the beamlets on the material to be ablated make it possible to increase the deposition speed almost in line with the laser pulse frequency and the number of beamlets. In addition, a suitable machine configuration had to be found. For the PLD coating of substrate tapes over two kilometers long with a quasi-monocrystalline quality, a roll-to-roll method was developed in which the substrate tape is wound in the deposition chamber using a rotating cylinder that moves on a longitudinal axis to achieve a uniform coating.

Like copper, the new HTS-coated conductors can be wound onto spools or power cables

What next As a result, using the machines currently available on the market and depending on the substrate width, up to 500 kilometers of conductors can be produced annually. Like copper, the new HTS-coated conductors can be wound onto spools or power cables. However, products based on the new conductors are considerably smaller and lighter as well as far more powerful and energy-saving than those that use copper as a conductive material. For example, in the area of energy transfer, inherently safe, conductor-based HTS fault current limiters restrict short-circuit currents a thousand times faster, i.e. in a few milliseconds, and thus recover on their own within just a few seconds.

This means that expensive power failures can be avoided and safety reserves can be set aside for power grids that are under increasing loads. Power cables from HTS-coated conductors can replace conventional copper cables in existing cable ducts. Although they can be laid using dielectric material, cryostats and diverse reinforcements, much more power can be transported through the same cable duct on the end. In energy-producing systems such as engines and generators, HTS-coated conductors can cut net losses in half — including cooling losses — compared to copper. The higher magnetic fields of the superconducting rotor spools make it possible to produce engines or generators that can be configured using the same output with up to one-third of the conventional volume or weight. Superconducting cables and current limiters, engines and generators have been successfully tested in numerous projects worldwide over the last few years, but their long-desired market launch was considerably delayed due to the lack of availability of the HTS-coated conductor materials. This problem has been solved with the successful mass production of the HTS-coated conductor using the laser. ■

Gernot Walter

The power outlet remains, a revolution happens behind it: Superconducting electric cables promise a stable power supply with safer power grids that are able to cope with much more power.

Dr. Ralph Delmdahl

Dr. Alexander Usoskin

***Dr. Ralph Delmdahl** (left) and **Dr. Alexander Usoskin** (right) together with Dr. Kai Schmidt and Rainer Pätzel received the Berthold Leibinger Innovation Award in 2010. Dr. Delmdahl works for Coherent in Göttingen on high-performance excimer lasers for industrial thin layer applications. At Bruker HTS in Alzenau, Dr. Usoskin is promoting the pulsed laser deposition of superconducting copper oxide layers for commercial use.*

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“Do

Prof. Charles Townes’ most famous idea came to him in 1952 while he was resting on a park bench after breakfast. It led to the discovery of Maser in 1955 and subsequently to the laser.

new things!"

Two Nobel Prize winners say: "Your idea is rubbish and it's a waste of the faculty's money." Prof. Charles Townes explains why one should take this as a good sign

You are the man who paved the way to the laser. If you had built the first laser, too, would your career have taken a different turn?
No, I don't think so. I'd gone to Washington, D.C. by that point to advise the government. The government had asked me to help and I felt I ought to do that instead. So I wasn't really competing to build the first laser. My brother-in-law Arthur Schawlow and I had mainly pointed out how it could be done. I knew lasers would be built and that was the primary thing. I had students working on it…

… with whom you shared your Nobel Prize money.
Yes, that's right. They helped me do my research and I wanted to recognize their importance. I was happy to do it.

That was in 1964. However, in 1955 nobody would have imagined that your work on the maser would lead to such honors. You have repeatedly risked your career to work on controversial projects. Why?
Taking chances is necessary to discover new things. It's a mistake to do what everybody else is doing. My advice to young scientists: Do new things and think about things other people are neglecting. Sometimes you won't find anything. But you could find something nobody ever expected. And that's exciting. One of my former students, Arno Penzias, was looking for hydrogen in space when he detected continuum radiation all over the sky. So he discovered the evidence of the Big Bang by surprise. He was looking for something completely different, but he was looking carefully.

When I was working on the maser, the chairman and the previous chairman of the physics department at Columbia, both of whom won Nobel prizes, were very good physicists, and knew something about my field, came into my office and said, "Look, we know it's not going to work. You know it's not going to work. You're wasting the department's money. You've got to stop." Fortunately, I was an associate professor then and they couldn't fire me. So I said, "I think it has a chance. I'm going to continue." They angrily marched out of my laboratory

Frederic Neema

and about three or four months later I had it working. You've got to be willing to differ with people, but think carefully because you don't want to waste your time.

Was that the reason you got involved with the Apollo space project? Back then quite a number of people disagreed about space research.

That was an interesting thing. I had run into a friend of mine, George Mueller, who was head of the program to land on the moon. He was being criticized by scientists at the time. And I said, "You ought to talk with these scientists and see if they've any objections you ought to know about. Then talk with them about your ideas and see who's right." He called me the following week and said, "I'd like to do that, and I'd like you to form and chair a committee of scientists I can talk to. Will you do that?" So I did.

I think scientific advice to the government is very important. Science has an enormous effect on industry, economics and how we live and interact with other people. It is a very important part of our civilization. I've been asked to advise the government on what science should be developed, how science might affect us, how it ought to be used, and how to protect ourselves militarily. It's part of a scientist's duty to help out civilization.

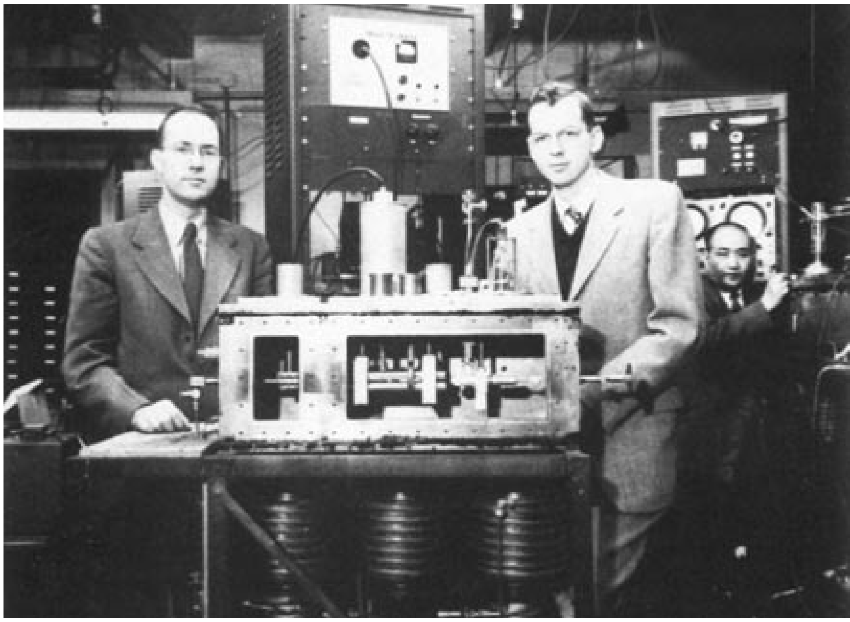
Still, differing with people can put one's career at risk.

That's true. At the time I became involved with the Apollo program, I was provost of MIT and told I'd be promoted to president of the university. And Vannevar Bush, a very important administrator at MIT, said "Look, Charlie, that's crazy. You shouldn't be involved with that. You're wasting your time. It's going to take a lot longer and a lot more money than they say. And it isn't going to work." I replied, "The government is committed to it and we ought to advise them on how to make it work as well as possible." Well, Bush was chairman of the committee to pick a new president, and Apollo hadn't landed yet. So he picked someone else because he thought I was stupid to be supporting the program.

Then the Apollo moon landing came in on-time and under budget. Bush was astonished and wouldn't talk with me for a while. About a year later, he began to congratulate me. By then I'd left MIT and gone to the University of California to do research. I was quite happy to get back to research. It's more fun than administration.

Rather than picking up laser research, you focused more and more on infrared astronomy. Why was that?

Well, I do keep up with laser research. There are a lot of excellent things being done. About 15 Nobel prizes have been given for research using lasers as tools. As a matter of fact I'm using them as tools in my research. But I've always been interested in astronomy, ever since I was a youngster and would look up



Left: The freshly selected Nobel Prize winner Prof. Charles Townes in 1964. His „park bench idea," as he called it, opened up an entirely new research field in physics, that of quantum electronics. Right: The first child born of the idea—Prof. Townes and Dr. James Gordon introduce the Maser in 1955.

> "Think about things other people are neglecting. It's a mistake to do what everybody else is doing"

LIFE Born in 1915, Prof. Charles Townes has made groundbreaking discoveries regarding lasers, masers, microwave spectroscopy and astrophysics. He still conducts research in Southern California where he lives with his wife of 69 years.

LASER After inventing the maser, Townes and his brother-in-law Arthur Schawlow co-published a paper proposing how optical masers, or lasers, could work and shared the first laser patent.

ACHIEVEMENT In 1964, Townes won a Nobel Prize in Physics for his work in quantum electronics leading to the maser and laser. He also discovered the first interstellar molecules and a black hole at the center of our galaxy.

LIA AWARD In September, Townes received the LIA's first Lifetime Achievement Award in recognition of his body of work and contribution to the development of the first laser.

Corbis, Emilio Segrè Visual Archives (AIP), Frederic Neema

Prof. Townes found his way to physics by way of his passion for astronomy. His current research work is once again dedicated to the stars.

at the stars and identify them. Infrared astronomy was something very important and I thought people were neglecting it. With infrared, you can see things people can't see otherwise. For example, some stars can't be detected in the visible region at all. Now, I'm doing infrared astronomy using heterodyne detection, which nobody else is doing. I'm using lasers as local oscillators for detection of infrared radiation. I mix the wave of a laser with the waves coming from the stars, get the beat frequency between them, and amplify them as much as I wish. From that, I figure out the sizes and shapes and changes in gas around the stars and uncover how the stars are behaving. I first detected the big black hole in the center of our galaxy — about four million times the mass of the sun — using infrared.

Taking a page out of your book, where would a scientist start to look in order to make the next big discovery?
There are many interesting things to discover in physics, biology, astronomy and chemistry. There are still some very basic puzzles in physics we don't understand, for example, dark matter. We see only about five percent of the total matter in the universe. Dark matter is all around us. If we discover what it is, boy, that will be exciting!

Speaking of puzzles: You are known as both a scientist and a religiously-oriented man. How do you reconcile these two different approaches to the world?
I think science and religion are quite consistent. In science, we make assumptions and then look at the conclusions from those assumptions. Religion does the same thing. We make assumptions and try to deduce conclusions from them. We can't really prove anything completely in science and yet it is very satisfactory. I could say the same thing about religion. Good religion can have a profound impact on us and many good effects. So experimentally, religion is provable and more similar to science in this respect than most people recognize.

Last, but not least, we congratulate you. You turned 95 in July and you're still working. What's your secret?
I never work. I do research, and that's fun, not work. I like to explore and see new things other people haven't seen before, and figure out things people haven't figured out before. I just have a good time. ■

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Prices will fall

Laser diodes are tiny, robust and powerful—and can be had for increasingly affordable prices. The trend will continue, says Dr. Guido Bonati

Dr. Guido Bonati is Vice President of Jenoptik Lasers & Material Processing.

Laser diodes are more affordable than ever. At Jenoptik, for example, the price per watt has dropped by about 15 percent since 2000. On average, our customers currently pay 10 Euros per watt. The price margin ranges from three Euros to 100 Euros per watt. The reasons for the price decline include rising output, better production methods with a higher revenue and a considerably growing market. Further price declines are currently being dampened by enormous overcapacities among manufacturers.

Underutilization causes high fixed costs per element. The worldwide production capacity is currently estimated at one gigawatt. At 10 Euros per watt, this would result in a theoretical market volume of 10 billion Euros. In fact, it "only" amounts to about US$ 200 million. About US$ 140 million are available for diode-based beam sources for material processing. In addition, there is the specialized market for lasers in military or medical applications and research amounting to about US$ 55 million. If you compare the theoretical with the actual market volumes, mathematical overcapacities at a factor of 50 result.

Yet the affordable price and the rising efficiency make the diode lasers also interesting for applications beyond industrial material processing. This could trigger a rapidly rising demand that reduces overcapacities and thus massively accelerates the price decline. But where will the new diode-based applications be used? One example is 3D films. Currently, high-tech movie theaters use lights that cause the films to rapidly deteriorate and they also have short service lives and are expensive. Very soon we could be able to equip about 150,000 movie theaters worldwide with modern 3D laser projectors. Each light contains 50 laser diode bars whose service life is about two years. Laser projection additionally provides quadruple the lighting density on the screen. This makes it possible to have larger screens and a brighter image. If half of these theaters opted for 3D technology and with it two projectors, the laser diode demand would rise by 5.6 million bars per year.

The demand in the cosmetics industry for laser diodes for hair removal could also rise. Currently, the industry uses about 200,000 laser diode bars annually. If laser epilation in Asia achieves similar market penetration as it has today in the USA, this demand would rise by 100 megawatts. And if only one-third of the epilators sold to households were replaced by laser devices, the entire worldwide diode laser production would already be sold.

In the search for alternative energy sources, laser fusion is gaining in appeal. This process involves one laser with 1.5 megajoules output igniting a controlled fusion of hydrogen atoms into helium to generate energy. Current research reactors can only produce one laser pulse per hour. But a future reactor would have to fire off up to ten pulses per hour. Diode lasers can bring researchers one step closer to this goal; initial projects are already underway. Should the reactors prove to be capable, overcapacities and high prices will finally become a thing of the past. To replace the current 192 rows of lamps with a pulse energy of one mega joule per jolt, 200 megawatts are necessary. This corresponds to one-fifth of the world's production capacity. For one single reactor.

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Where's the laser?

ON THE BABY'S SOFT SKIN: Babies are no longer bothered by itchy diapers because modern diapers are cut by lasers. While mechanical processes produce burrs that scratch the skin, the light beam produces a cut edge as smooth as a baby's bottom. Mom and dad can look forward to happy children, and manufacturers to happy parents. In addition, manufacturers can also enjoy flexibility when they switch between different types of diapers, which also means greater productivity. This is because the laser-cut material is not under load, so strips may become narrower and more diapers can be cut out of the web.

Gernot Walter


109,000,000
Hits for the word “laser” on Google in 0.17 seconds.
In the 50 years since its invention, the word has spread
into almost every language in the world.
strandperle, Gernot Walter