LASER COMMUNITY.

Of people and photons

SPUTNIK'S HEIRS

Revolution in orbit: the new LEO satellites are taking over — with laser technology onboard.

#33

LASER COMMUNITY. *#33*

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Illustration cover and page 2: Gernot Walter

Gernot Walter

Thanks, but no thanks

It was a mild spring evening two years ago and I was sitting with my wife and daughter on our patio, winding down with a glass of wine after a long day. All of a sudden, we saw several tiny flashes of light in the sky. Intrigued, we wondered what they could be. Surely they were moving too fast to be aircraft? And weren't they too numerous to be shooting stars? Pulling out my smartphone, I soon discovered that Elon Musk, CEO of US space exploration company SpaceX, was in the process of launching his Starlink satellites into orbit. His goal is to build a big enough network of satellites to provide worldwide internet access. We all agreed it was a spectacular sight.

Our thoughts having turned to space and satellites, the three of us fell into a philosophical conversation. What would life be like without satellites? Imagine having no GPS navigation, no live broadcasts, no weather forecasts—and no Google Maps!

Cutting-edge laser technology is helping to make space more accessible than ever. For example, data transmission in the ether requires special antennas; for the sake of efficiency, these not only require complex geometries with intricate designs and internal cavities, but also need to be extremely lightweight. That's a tough combination for conventional methods, so the only way to produce such antennas is with a laser-based 3D printing process. Laser technology is also a hot topic in satellite communications. Modern satellites can use the medium of light to share information and data and communicate with each other directly. This is much more efficient than the traditional use of radio waves.

Satellite technology is important to TRUMPF because it offers so much promise for the future. As is so often the case, our lasers are a key enabler: they can help industry to produce state-of-the-art satellites and to safeguard inter-satellite communication through the use of robust and reliable components. That's why we're constantly improving our technologies and tailoring them to the requirements of antenna and satellite manufacturers.

Returning to that mild spring evening, I remember how, shortly before we entered the house, my wife asked me if I might one day like to be a space tourist. Good question, I thought. Obviously the only sensible answer was no, since traveling into space for tourism would be incredibly expensive and of no use to anyone except me. Yet, at the same time, the temptation to see our blue planet from space was almost irresistible.

So, Christian, one seat for you on the next rocket out of here? Thanks, but no thanks! I prefer to stay right here on Earth and continue to develop cutting-edge laser technologies with my team, so that all of us can enjoy seeing more of Elon Musk's shooting stars in the future.

DR.-ING. CHRISTIAN SCHMITZ

Chief Executive Officer Laser Technology
Member of the Managing Board of TRUMPF GmbH + Co. KG
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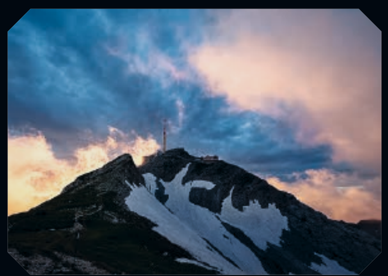
Blood

Art Director Gernot's heart pumps to the photon beat, so he was happy to donate some of his blood to Laser Community. All he had to do was prick his finger, squeeze out a drop of blood, and then quickly take a photo before it dried. See the results on **page 31**.



Sweat

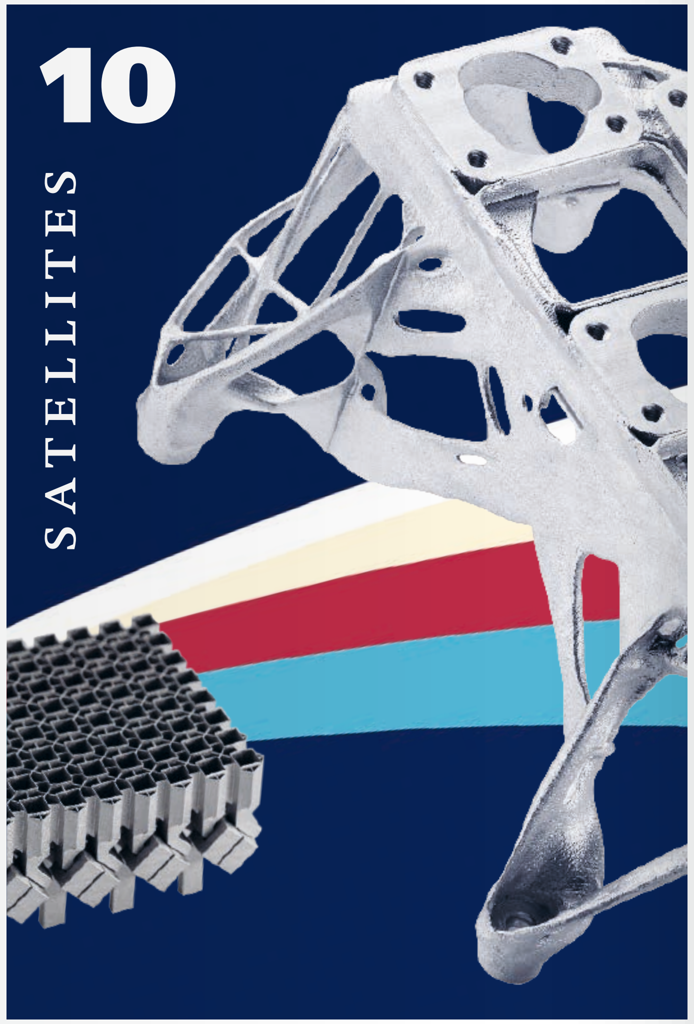
Time flew during our interview at the summit of Säntis mountain. Suddenly Professor Wolf looked at his watch and realized his laser was about to be fired for the first time! His closing words? "… we're going to need these tools, so we better get down to developing them!" Read more on **page 24**.

Tears

People always make sharks look terrifying. We did too—but only to grab your attention. Sharks are magnificent creatures, but they have a terrible reputation. So no one sheds a tear when millions are killed for their fins. It's enough to make you shudder with pity, not fear, when looking at this issue's **back cover**.

Lena Schindler, Martin Stollberg, Gernot Walter

LASER COMMUNITY.

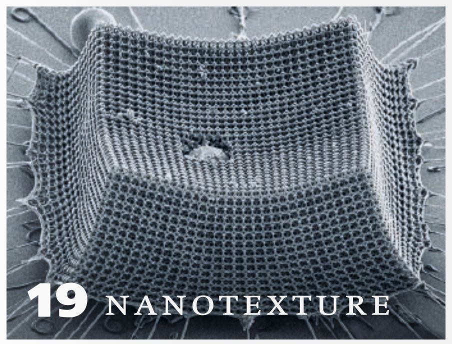


10 SATELLITES

8 PILLOW PLATES

Miquel Gonzalez, TRUMPF

MIT/Caltech/ETHZ, Stefan Hobmeier, Florian Burkhardt



19 NANOTEXTURE

20 MED-TECH

28 LIGHTNING HUNT

POWER

THE PULSE OF TIME

First use of the new engraving laser: the Meister S Chronoscope Platin Edition 160 by Junghans.

Adjustable USP lasers are critical to the design of today's luxury watches.

The edition logo engraved using a UKP laser onto a PT950 platinum case back.

Enthusiasts see prestigious timepiece brands as highly desirable and are willing to pay accordingly. Every little detail matters, and it's the back of a wristwatch that often reveals its true value. High-quality engravings on the case draw attention to key brand information or finely-wrought logos. Yet producing these engravings can be frustrating for watchmakers, who rely on costly assistance from external etching specialists. They would much rather have a clean, chemical-free method of embellishing their timepieces embedded in their own in-house fabrication process. And now they do! The new TruMicro Series 2000 lasers from TRUMPF mark a new era in watchmaking that will set pulses racing among design enthusiasts everywhere.

With extremely short pulse durations of just a few hundred femtoseconds, these ultrashort pulsed lasers have enough power to process any metal without creating burrs. This includes 316L/1.4404 stainless steel alloys, titanium and copper, all of which are commonly used in the watch industry. With typical engraving depths of up to 100 microns, the pulse energy is transferred to the metal so amazingly fast that it has no time to heat up or melt to any significant degree, so there is no risk of forming burrs. These new lasers also cater to a classy look: conventional laser engravings typically have a dark appearance, but timepiece enthusiasts tend to favor bright, almost white engravings that could previously only be produced by etching.

The new lasers can create this elegant hue, but only by applying enough heat to the metal to form a melt pool, which requires the laser's pulse duration to be lengthened. TruMicro Series 2000 lasers therefore allow users to switch between different pulse durations on-the-fly. It takes less than 800 milliseconds to switch the pulse duration from 400 femtoseconds for efficient, burr-free engraving to 20 picoseconds for creating a thin melt film. These speedy adjustments are made possible by a newly developed component that tailors the laser's pulse duration to the requirements of the material and application.

The ultrashort pulsed laser can conjure up even the most complex and delicate logos on any watch housing. It even includes the option of quickly switching to "burst mode," a multi-pulse operating mode that minimizes processing time while maintaining stable processing quality. This and other parameter settings open the door to white engravings on the back of a timepiece, with color engraving also possible for certain materials. Embedded in an industrial manufacturing process, the speed of this solution has to be seen to be believed! ■

Junghans, Tobias Gerber

GLORY

No Netflix? Today's global internet would have been impossible without David Payne's pioneering work on optical fiber technology.

University of Southampton

NO PAYNE, NO GAIN

Sir David Payne receives the Berthold Leibinger Future Prize.

If David Payne had been more interested in, say, horticulture instead of physics, we probably wouldn't be able to stream tonight's movie, hold tomorrow's video conference, or mine a single Bitcoin. (OK, that last point wouldn't be so bad. And video conferences aren't always a barrel of laughs. But hey: movies!) Payne has been conducting research in the fields of photonics, telecommunications and optical sensors since the 1970s. Over the years, his teams have made a series of major improvements to optical fiber technology.

Payne's big breakthrough came in 1985 when he presented his gift to mankind: the erbium-doped fiber amplifier, or EDFA. Payne discovered a way to specifically contaminate, or "dope", silica optical fibers with rare-earth elements. This "impurity" amplifies the light in an optical fiber. For the first time, it was possible to send light signals over long distances through a fiber-optic cable without loss. Previously, anything over around one hundred kilometers required the use of an expensive electrical amplifier. All of a sudden, fiber optic cables became highly attractive, heralding the start of a revolution in global telecommunications. Less than ten years later, the first submarine cable to incorporate Payne's EDFAs was laid between America and Europe. At the time, its primary use was for telephone calls, which is why cable performance was measured by the number of calls that could be transmitted simultaneously through a cable. The old copper cables could manage hundreds or a few thousand at a time, while the figure for Payne's doped optical fiber was in the hundreds of thousands. For today's data transmission over the global internet, cable throughput is measured in gigabits per second. Having started with single-digit figures in the 1990s, techniques such as wavelength multiplexing now let us transmit data at a rate of 100 terabits per second. If you imagine the Internet as an invisible information superhighway, David Payne replaced the old pavement with high-performance asphalt.

In September 2021, Sir David Payne received the Berthold Leibinger Future Prize for his pioneering research in the field of fiber optics. A professor at the University of Southampton, Payne is the eighth person to receive this prestigious award. ■

ENJOYING THE PILLOW BOOM

Roel Doornebosch knows how to build the best pillow plates at an affordable price.

Real pillow plates are obviously rather less comfortable!

AHEAD

Mr. Doornebosch, you manufacture laser welding systems that weld two flat sheets together. What's so difficult about that?
It's all about joining the sheets together very quickly with a continuous seam all the way around, as well as applying circular welds that may run into the thousands. The whole thing has to be totally watertight.

Because?
The finished plates are subsequently inflated by pumping them full of water at pressures of up to 500 bar!

A bit like an air mattress?
Absolutely, or an inflatable pillow. That's why we refer to these dimpled plates as "pillow plates". They act as a special kind of heat exchanger.

But who actually uses them?
Pillow plates can be used to make containers, boilers or tanks. By circulating hot or cold fluid through the pillow-plate walls of a vessel, you can heat up or cool down the contents. Pillow plates are used in the pharmaceutical and petrochemical industries as well as the food and beverage sectors, and they can even be used as cooling elements for car batteries. The technology is nothing new and is actually quite simple, but it's becoming more popular as people realize that this kind of heat exchanger requires relatively little material and does the job more efficiently than tubular heat exchangers, for example. So the market for these "steel air mattresses" is booming!

What are the trickiest parts of the fabrication process?
The sheer number of welds and the high quality standards, plus the fact that pillow plates are often much bigger than an air mattress. They can be as large as 2.2 meters wide and 20 meters long, and a part that size can easily run to 10,000 circular welds. It's essential that none of the welds crack, not a single one, because otherwise the manufacturer—our customer—will end up having to repair it manually, and that pushes up their costs. Crack-free welds are especially important if the plates will only be pumped up after assembly. The whole process has to be tremendously reliable.

Even so, we're still only talking about welding together two flat sheets of metal …
Sure, but it's not as simple as it sounds. The parts are sometimes very large, and the metal sheets can be very thick. This presents its own challenges. The longer the machine is running, the more the metal sheets heat up. Left unchecked, that would cause variations in the weld depth in the lower plate. But we need that to remain stable, so we cool down the plates during the process. Another challenge is that the sheets are never perfectly flat. To maintain a constant distance between the laser optics and the metal surface, the system continuously measures the focal distance and adjusts it automatically. It's also vital to ensure that there is no air between the two plates. We solved that by using a clamping device with servo technology that precisely controls the clamping force. Some companies use hydraulics, but that's less reliable. And then there's the laser itself, of course.

What kind do you use?
It's a disk laser, which, on the face of it, is nothing out of the ordinary. But we're the first to use the BrightLine Weld option for this kind of application. That helps us significantly increase the welding speed. For the first time, it also gives us an affordable way to weld thicker sheets while maintaining quality and minimizing spatter. That wasn't previously possible because it would have required a higher laser power than 3.2 kilowatts, and a higher power output would have led to an unstable process with more spatter. TRUMPF got around this problem by developing a special laser light cable which achieves optimum power distribution and ensures that the material heats up in a controlled manner, even at high speeds. So we get fast, deep welds without spatter—that's the beauty of BrightLine Weld.

It sounds like a revolution in the heat exchanger industry!
Well, it certainly slashes the cost of producing pillow plates. Work that used to require two machines can now be done on just one. And of course we can also work with thicker sheets. So it is quite revolutionary in its own way!

THE COMPANY
Based in the Dutch city of Deventer, Rodomach Speciaalmachines B.V. (Geurtsen Group) produces laser welding systems and robot cells for various industries.

THE SYSTEM
The machine uses two sets of laser optics to weld pillow plates up to 20 meters long and 2.2 meters wide. It can handle high-strength and coated steels, stainless steels, aluminum and titanium.

THE TECHNOLOGY
BrightLine Weld technology from TRUMPF boosts welding speed. A special laser light cable ensures optimum power distribution and keeps the workpiece temperature low.

OUR SWARM IN SPACE

Gernot Walter

The era of low Earth orbit satellites has begun. Their advance into space relies on cutting-edge laser technology—not only for construction and communication, but also for some high-tech orbital traffic enforcement.

Viewed from the moon, our home planet looks like a giant blue ball with patches of color and white stripes. But thanks to billionaires Elon Musk and Jeff Bezos, it could soon look more like a bees' nest! SpaceX and Amazon are aiming to put huge numbers of satellites into low Earth orbit (LEO), meaning that our planet will be surrounded not by insects, but by swarms of satellites the size of washing machines. The hope is that these satellites will provide answers to pressing questions on issues such as arable soil health and the extent of forest fires. They should also help us to improve traffic planning, optimize shipping routes and find ways of processing increasing quantities of data.

The prospects for LEO technology look good, and with experts expecting it to become a multi-billion-dollar market, the future looks bright for business. More and more data is being transmitted by governments, mining firms, agricultural enterprises and shipping companies, and reliable global network coverage has become a prerequisite for smart cities, the Internet of Things and autonomous vehicles. Greater satellite coverage could also see poorer and more remote regions of the world finally get access to the internet. That would allow more people to participate in global e-commerce—as well as finally being able to follow their favorite Instagram influencers! All in all, it is something of an economic stimulus program for the entire world.

One glance at the figures shows just how confident satellite builders are about the future of the market. Bezos's company Amazon has sought approval to launch 3,236 satellites as part of "Project Kuiper". Meanwhile, state-owned China Aerospace Science & Industry Corporation plans to create a network of 156 satellites by 2022, and California-based ViaSat aims to put 288 satellites into low earth orbit by 2026. But the most ambitious plans of all are currently those being pursued by SpaceX: Musk's company intends to launch an incredible 42,000 satellites into space to create a global communications network—at least if it can figure out how to significantly reduce the cost of producing and operating them at scale.

RACE THROUGH SPACE This is no easy task, because the closer an object orbits the Earth, the higher its speed must be to counteract Earth's gravity. Conventional communications satellites fly some 36,000 kilometers up at a speed of about 11,000 kilometers per hour, which allows them to match the Earth's rotation as they travel. That's why they always seem to be in the same position above us when viewed from Earth. In contrast, LEO satellites travel at an altitude of just 500 to 2,000 kilometers and fly at a speed of around 27,000 kilometers an hour, faster than the Earth's rotation. They therefore orbit the Earth every 90 to 120 minutes, which is why each satellite can only communicate with a ground station for a few minutes at a time. SpaceX therefore needs a lot of satellites to ensure that when one satellite goes out of range of the ground station, the next one can take over, much like an orbital relay race!

Every kilo launched into space costs 15,000 euros.

This is the only way to maintain a continuous connection. Achieving this goal is vital not just for Netflix viewers on Earth, but also for SpaceX: should a satellite collide with a piece of space junk and shatter into pieces, the resulting debris would immediately endanger all the other LEOs in the same orbit. That's why it's so important to have real-time information on what the satellite swarm is doing.

But why would companies go to all this trouble in the first place? Why not simply aim for the higher-altitude regions like before? The answer is simple: closer proximity to the Earth offers the huge advantage of fast data transmission speeds. The time required for data to travel from its source to its destination and back—known as latency—is far shorter for LEO satellites than for those in more distant orbits. Systems in conventional orbits have a median latency of up to 600 milliseconds. SpaceX is aiming for 20 milliseconds and is eventually hoping for half that. Because signals propagate faster in orbit than through fiber-optic cables, LEO satellites have the potential to compete with, and possibly even surpass, ground-based networks.

INFRASTRUCTURE WITH LASERS One thing is already clear: LEO satellites have a key part to play in future broadband communications. Their deployment will create new infrastructure in space—and laser technology will play a major role in their construction and operation. The choice of the laser is a logical result of satellite builders' preferences for high-tech materials, which engineers typically like to machine with lasers. Laser light can also be used by inspection teams to check welds and by technicians to mark parts, all of which helps to ensure full traceability in a quality control system. Now, laser specialists have introduced a further innovation of metal 3D printing for components such as antennas.

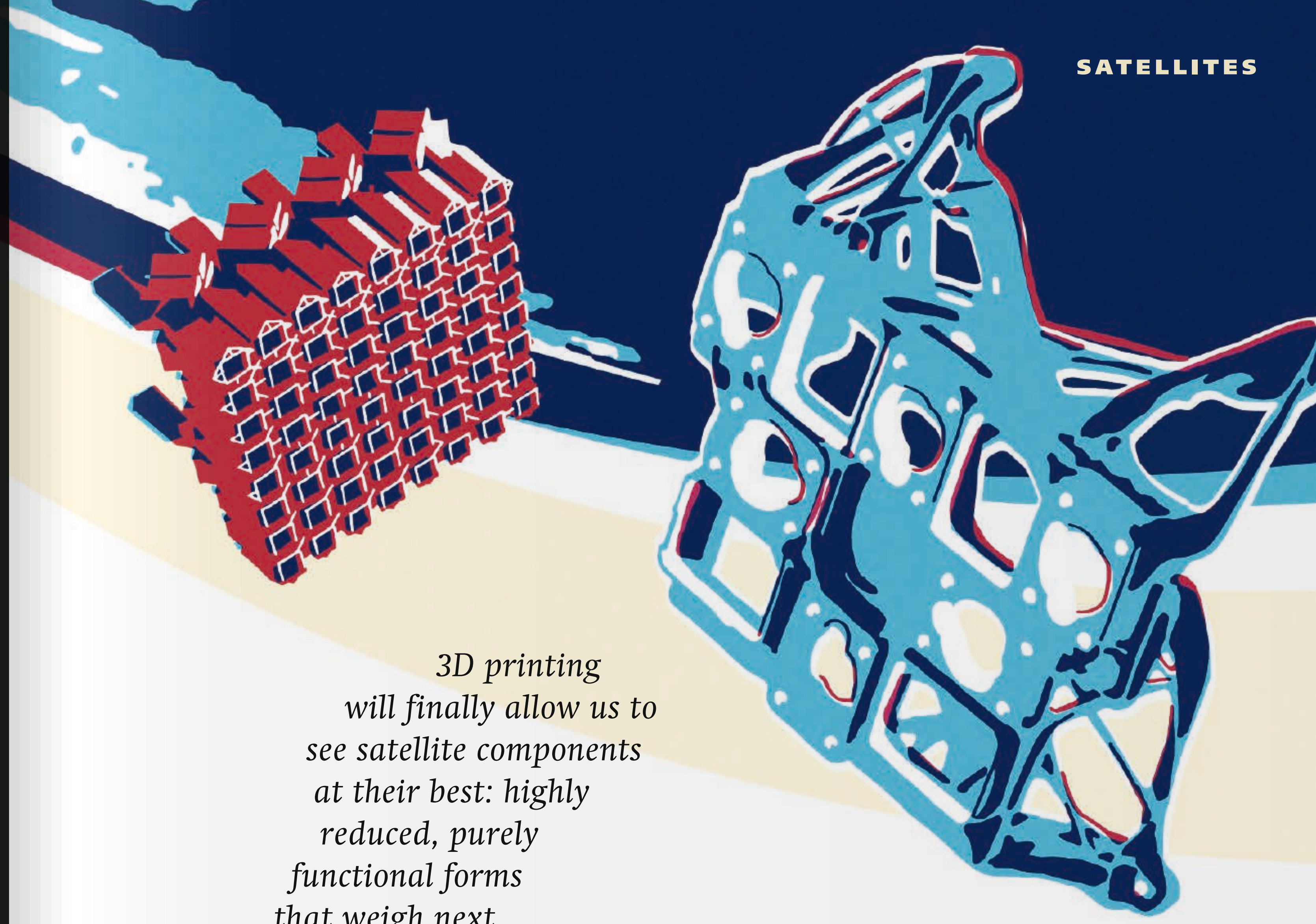
[BEEP]: 3D PRINTING

Sending chunks of data through the ether requires special antennas that look very different to those we may have seen in the past. One of the antenna systems that is currently available looks like a series of mini upright flashlights clamped together. The lower section contains a specially shaped waveguide as a filter. These structures are designed to amplify electromagnetic waves or attenuate them in certain frequency ranges. The upper, wider part is the output to which the data is transferred. Phase shifting allows the antenna to point its data in a specific direction without having to rotate.

The fabrication of these antennas is a masterclass in precision engineering. Many of their structural components cannot be produced by conventional means such as turning, milling, casting and bending, so additive manufacturing is often the best option. 3D printers can cater to even the most complex and contorted shapes, so they are the perfect choice for building the antennas' curved cavities with their extremely thin walls and stabilizing ribs. These geometries have a major impact on the frequency at which the antennas are used. The higher the frequency, the higher the data throughput and the smaller the components ultimately have to be.

The tiny laser spots used by modern additive manufacturing systems cater to the most delicate of wall thicknesses; depending on the geometry, these can be as thin as 100 microns. 3D printers can distribute material with pinpoint accuracy, allowing the geometry to fully reflect the distribution of forces in the structure. This means engineers can use 3D printing to faithfully recreate any idea in metal form—in high volumes, and with maximum precision.

Another area where 3D printers come into their own is in the fabrication of satellite brackets to support the antennas and other components. Brackets are used in multiple places on a satellite, but these vital parts take up space and add to the overall weight. Engineers long ago resigned themselves to accepting brackets as a necessary evil in satellite construction, but when you're building satellites



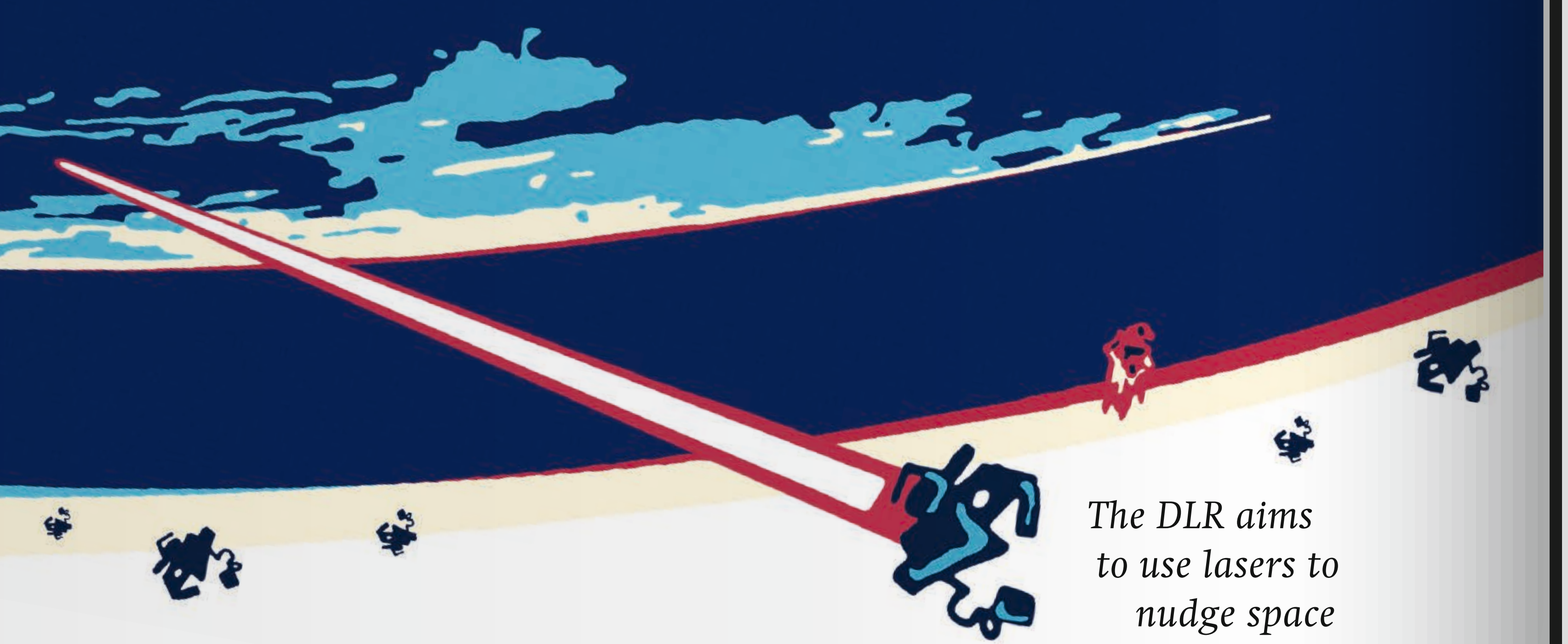
Gernot Walter

3D printing will finally allow us to see satellite components at their best: highly reduced, purely functional forms that weigh next to nothing.

in their tens of thousands, it's worth taking time to revisit the topic! This is another area where 3D printing can help. Engineers can now minimize the amount of material in each bracket by printing them in shapes that are based on precise calculations of force distribution, just like with the antennas. Bracket weight can be reduced by up to 55 percent—a big saving for a component that is used numerous times in each satellite!

A PLACE IN SPACE TRUMPF, the European Space Agency (ESA) and other project partners are also investigating the possibility of laser-printing coils that align themselves to the Earth's magnetic field and help position the satellite—key components that are barely larger than a two-euro coin. The ESA is already using 3D-printed thrusters to correctly align satellites in space, each one kitted out with special channels for cooling and for carrying fuel. These internal channels were almost impossible to build before the invention of additive manufacturing, but now the 3D printer simply forms the cooling channels during the build process, looping them through the walls to achieve optimum fuel distribution. Once again, this 3D printing solution also helps to reduce weight.

Weight savings are always a powerful argument in any new laser application—and for LEO satellite builders, every gram counts. From an economic perspective, it's fairly simple: every kilo launched into space costs money. The exact cost varies considerably depending on the rocket and the company, but 15,000 euros per kilo is a good rule of thumb. On that basis, laser technology can potentially save between 10,000 and 20,000 euros per satellite. Considering how many satellites are in play, this leaves companies with millions of extra euros to spend on other things. Laser systems also offer a welcome additional benefit: since all of them follow digitally configured parameters and use sensors to store a multitude of data, users also get the unexpected benefit of seamless documentation. This prevents manufacturing defects and faulty



The DLR aims to use lasers to nudge space debris into a crash and burn trajectory.

[BEEP-BEEP]: SPACE JUNK

craft from ending up in orbit. Space is already full of junk. One of the downsides of LEO satellites is their relatively short operating life of five to seven years. Their close proximity to Earth subjects them to tremendous atmospheric friction and rapid aging. Using remote control, they are eventually brought into a controlled descent and allowed to burn up in the atmosphere. Sometimes, however, satellites suffer a collision or failure and end up as space debris.

Near-Earth orbit already resembles a gigantic junkyard, including 3,000 non-functional satellites, 34,000 individual parts that are ten centimeters or larger, and 128 million parts smaller than a millimeter. Crashes are inevitable when so much stuff is whizzing around. The International Space Station (ISS) has already had to conduct 25 evasive maneuvers since it began operations. NASA scientist Donald Kessler even fears that we might eventually set off a chain reaction known as the "Kessler syndrome," a scenario in which the density of objects in orbit is so high that collisions between objects end up causing a self-sustaining cascade of further collisions and ever-increasing amounts of space debris.

The Institute of Technical Physics in Stuttgart, part of the German Aerospace Center (DLR), is turning to lasers to help tackle the problem of space pollution head-on. Their plan is to use "laser nudging" to prevent collisions, in other words using light pressure delivered by lasers on the ground to nudge debris in orbit. All that is required is a gentle push, because nudging benefits from the fact that even the smallest deviation can lead to large changes in orbit due to the high speeds and enormous distances covered by orbital debris. A gentle nudge with a very small amount of energy is all it would take to direct space junk back towards Earth, allowing it to burn up in the atmosphere.

MAKING DEBRIS VISIBLE BY DAY But the first step is to track down the debris and identify its current course. Fortunately, there is also a laser-based application designed to do just that. ESA researchers have succeeded in using a special combination of telescopes, detectors, lasers and light filters at specific wavelengths to increase the contrast of orbiting objects in the daytime sky, making them easier to see. "We've become so used to the idea that we can only see stars at night. The same applies to looking for space junk through telescopes, except that the window of opportunity for observing objects in low Earth orbit is even smaller," says Tim Flohrer, head of ESA's Space Debris Office. "This new technology will enable us to track objects that were previously invisible against the blue sky—and that means we'll be able to work with laser ranging all day long to help prevent collisions."

Laser beams are also set to become an essential tool for a completely different aspect of the new

Gernot Walter

[BEEP-BEEP-BEEP]: COMMUNICATION

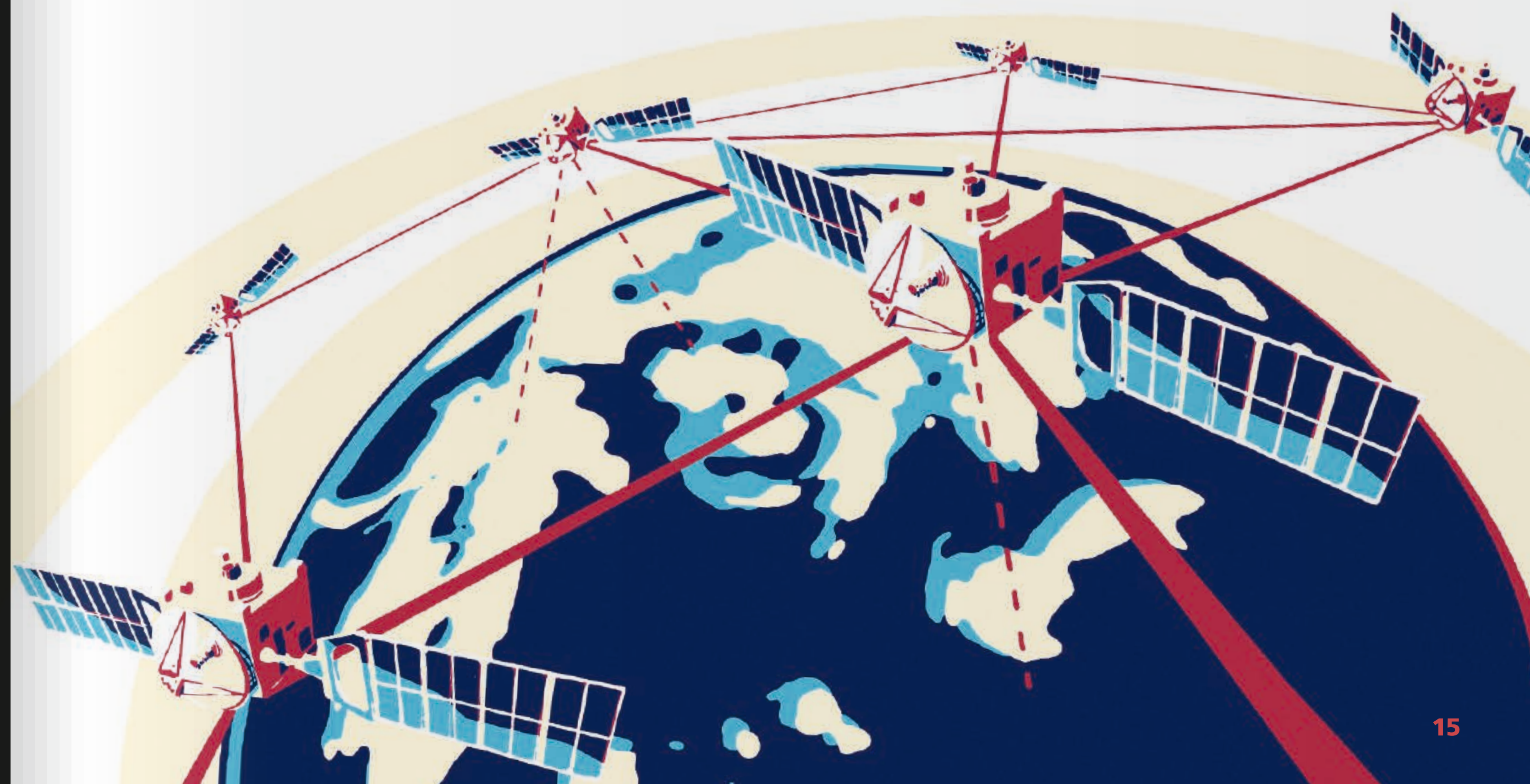
LEO satellites, namely that of data transmission. Traditional geostationary satellites stay in the same position relative to Earth and communicate with ground stations by radio.

In contrast, LEO satellites race around the Earth at incredible speed and must communicate by radio not only with the Earth, but also with their fellow satellites in space. This is the only way in which companies can guarantee permanent network coverage. Here, too, lasers could come to the fore in the future, because additional inter-satellite radio links will make communication even more dependent on large antennas and energy-hungry amplifiers. An optical solution therefore offers clear benefits. Whenever a fellow satellite races through the search algorithm's field of view, the LEO satellite will simply fire an information-packed laser beam at it—sharpshooting in space over distances of 5,000 kilometers!

Researchers at the German Aerospace Center near Munich have successfully used a laser beam to transmit data at 1.7 terabits a second, almost fifty times higher than the amount of data that can be sent by radio. Another advantage of laser beams is the way they bundle light. This channels the information directly to the recipient and makes it much more difficult to illegally intercept the data en route. Optical communication also has the advantage of being efficient and having minimal size, weight and energy requirements. What's more, it doesn't require a license! A satellite can only use a radio frequency once authorization has been obtained from the International Telecommunication Union (ITU). Having been assigned a frequency band, users must then pay a regular fee. Light, on the other hand, is free.

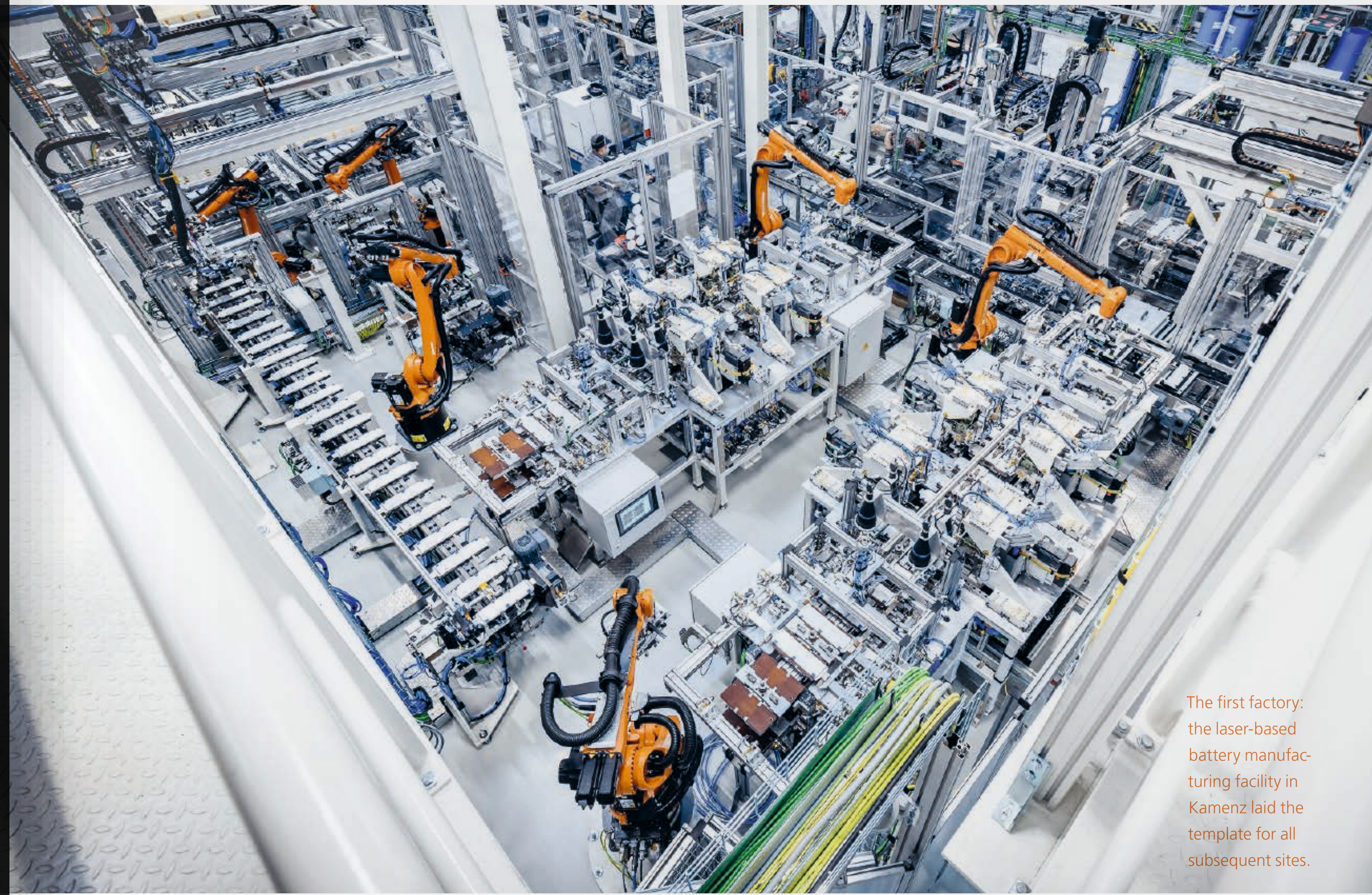
NEW LASER ERA SpaceX has already successfully sent 1,500 satellites into orbit. Apps such as Star Walk 2 offer a fun way to search for satellites in the sky and watch the swarm increase in size from one week to the next. With our smartphones in our hands and the LEO swarm overhead, there's no doubt that we have entered a new era. The age of mass satellite communication is upon us—and so, too, is the era of laser technology. ■

Laser communication between satellites—amazing sharpshooting skills in space!



Right from the start, Mercedes-Benz knew it wanted to power its electric cars with its own battery technology*.

THE BATTERY STRATEGY



The first factory: the laser-based battery manufacturing facility in Kamenz laid the template for all subsequent sites.

The electric vehicle market is evolving rapidly, and the demand for powerful batteries is higher than ever. Mercedes-Benz subsidiary Accumotive has been manufacturing vehicle batteries since 2012—and lasers played a vital role right from the start.

Since 2020, Mercedes-Benz has invested billions in an international manufacturing network of nine battery production facilities. To understand how the company has made such rapid progress, we need to cast our eyes back to 2010, the year when Mercedes-Benz decided that its future lay in building its own battery modules. To do this, it needed to come up with a method of interconnecting individual battery cells—in this case "pouch cells"—to create the necessary electrical connections. This is harder than it sounds, because the current has to be carried through two very thin conductor tabs made of copper and aluminum foil. The challenge was to find a way of connecting these with the lowest possible electrical resistance and the highest mechanical strength without bending or damaging them. This is far from easy, especially when you're working in an extremely cramped space and in close proximity to a heat-sensitive component! Once the modules were joined together, the 400-volt battery pack would be capable of delivering currents of several hundred amps, so there was no room for error.

BIG PLANS Mechanical solutions were clearly not an option, but high-precision laser processing looked like a promising way forward. At the time, Christian Elsner was head of laser material processing at the Mercedes-Benz Technology Factory in Stuttgart-Untertürkheim. It was up to him and his team to find a way of welding up to 350 pouch cells a minute to these two conductors in a tightly stacked set of battery modules. Any mistakes here could potentially affect the battery's charging speed, capacity and service life. And there was one risk that Elsner was particularly concerned about: "It was vitally important to ensure that the conductor tabs did not get too hot, because the other end of each tab is immersed in heat-sensitive electrolytes – and temperatures above 70 degrees could destroy the cell." So their task was to apply high-precision welds to extraordinarily thin metal without heating anything up—a classic dilemma.

This was just part of the company's ambitious plan to develop its own battery manufacturing process. The goal was to initially launch the process in the small town of Kamenz in the German state of Saxony and then gradually develop this into a template for the future factories of a worldwide manufacturing network.

THE ROAD TO KAMENZ But first Elsner had to get the heat problem under control. He and his team opted for remote laser welding, which uses mirrors to deflect the laser beam in order to achieve high-speed, high precision welding. The optics also allow the beam to jump almost instantly from weld to weld from a distance of about 30 to 40 centimeters. The laser system takes milliseconds to complete each weld, allowing it to complete hundreds of welds within a matter of minutes with virtually no heat input. To guarantee the electrical conductivity of each weld, it was important to prevent the beam from welding right through the thin conductive foils or spreading spatter around the weld. The team therefore needed to have complete control of process parameters such as focal position and power density—despite the distance and high process speed. They quickly found the right beam source in the form of the TruDisk 5001 from TRUMPF. As well as offering the beam quality required for fine focal adjustments in both standard and remote welding, this system also greatly reduces spatter formation even with difficult-to-weld materials such as copper.

This made it the perfect choice of welding tool for the first battery factory in Kamenz. Mercedes-Benz set up the subsidiary Accumotive to manage the plant, and production began in 2012. Today, this groundbreaking facility makes batteries on three 170-meter-long, fully automated production lines. Each line has 30 machining stations, many of which include welding. A total of 35 beam sources—mostly TruDisk 5001 systems—supply the PFO welding optics via a laser network. The decision to focus on one particular type of beam source and one type of welding optics is

*EQA 250: combined power consumption: 15.7 kWh/100 km; combined CO_2 emissions: 0 g/km   Photo: Mercedes-Benz AG

Mercedes-Benz AG

part of the design concept; as well as reducing complexity, it also necessitates less training and spare parts storage.

The production lines start with a fully automated station where robots glue two cells into a frame. These will subsequently be assembled to form modules, but first the conductor tabs have to be cut to size and bent over each other. When it's time for welding, special clamping devices press the metal tabs flat against each other, the optics move into position and laser light flashes across the metal. The clamping device opens, the frames continue on their journey and are combined into modules. Once again, a laser is used to make the connections. A gripper is then used to mount a sensor module with even thinner contacts; these are welded using the same technique but at reduced power. Once each module has been completed and tested, it is mounted in a battery tray along with several others and all the modules are electrically interconnected. Wherever lasers are needed to weld electrical contacts, the TruDisk 5001 and PFO optics are on hand to get the job done.

The finished battery assembly is connected to the chassis and the electric drivetrain during vehicle assembly. For fully electric vehicles such as the Mercedes EQC, it typically weighs around 750 kilograms and is almost as big as the car itself.

Laser beam accuracy is crucial, which is why the company chose to incorporate VisionLine image processing in its laser control system. Using an optical sensor, the software detects the edges of the clamping device and applies the weld at a precisely defined distance from those edges, says Elsner: "The machine literally sees what it's doing—and it documents everything, too."

DATA INTO GOLD This manufacturing data is incredibly valuable to Mercedes-Benz in three different ways. Firstly, it can be used to control and monitor processes in the manufacturing lines. Captured by sensors on the welding head, and properly analyzed and stored, this data documents the quality of each step in the process: "We can use it to monitor the weld online, almost in real time," says Elsner.

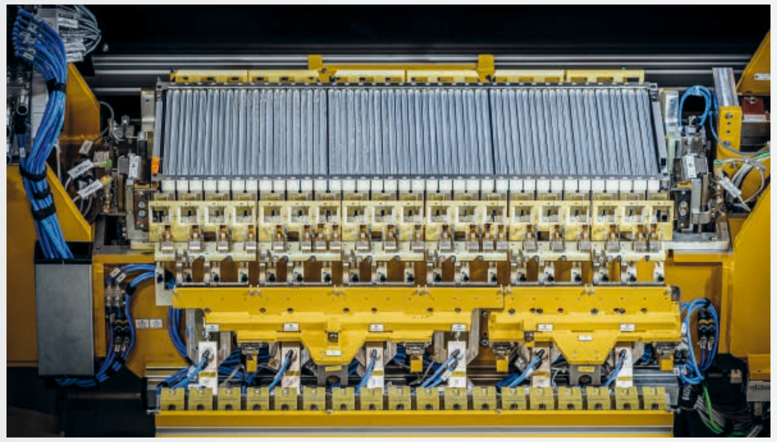
By carefully evaluating the data, the company can also obtain valuable information on how to further improve the systems and the process. Elsner says this is one advantage of lasers that is often overlooked: "Virtually no other tool delivers the same consistent results with the same parameters while simultaneously providing so much information on the process," he says.

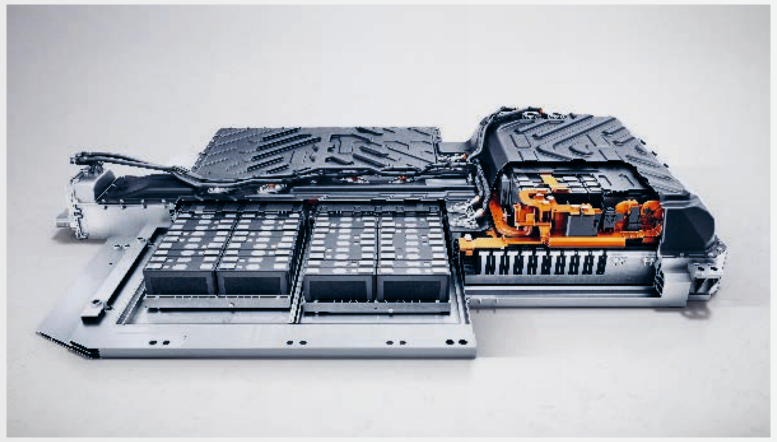
SCALING UP Both these aspects are tremendously important to the future of Kamenz, Accumotive and Mercedes-Benz. The automaker's battery requirements are growing steadily thanks to its fully electric EQ models and plug-in hybrids, and it is now reaping the rewards of the hard work done by Elsner and many others since the summer of 2010. Mercedes-Benz has invested billions in an international manufacturing network that currently consists of nine factories in Europe, Asia and America. And Kamenz serves as the template and center of expertise for all these new facilities.

The laser process itself is also evolving, says Elsner: "We're constantly improving the beam sources, laser optics and sensors to make our processes even faster, more robust and more cost-effective. Sometimes these improvements pave the way for entirely new applications that allow the laser to show off its capabilities. Obviously, everything we incorporate in our production vehicles has its roots in the passion and hard work of the development team in the lab." E-mobility offers a particularly rich environment for new developments, he adds. "The good thing about laser technology is that we never get bored and we can never complain about a lack of exciting challenges!" ■

"THE MACHINE SEES WHAT IT'S DOING, AND DOCUMENTS EVERYTHING."

Christian Elsner, Head of Laser Material Processing and Process at Mercedes-Benz



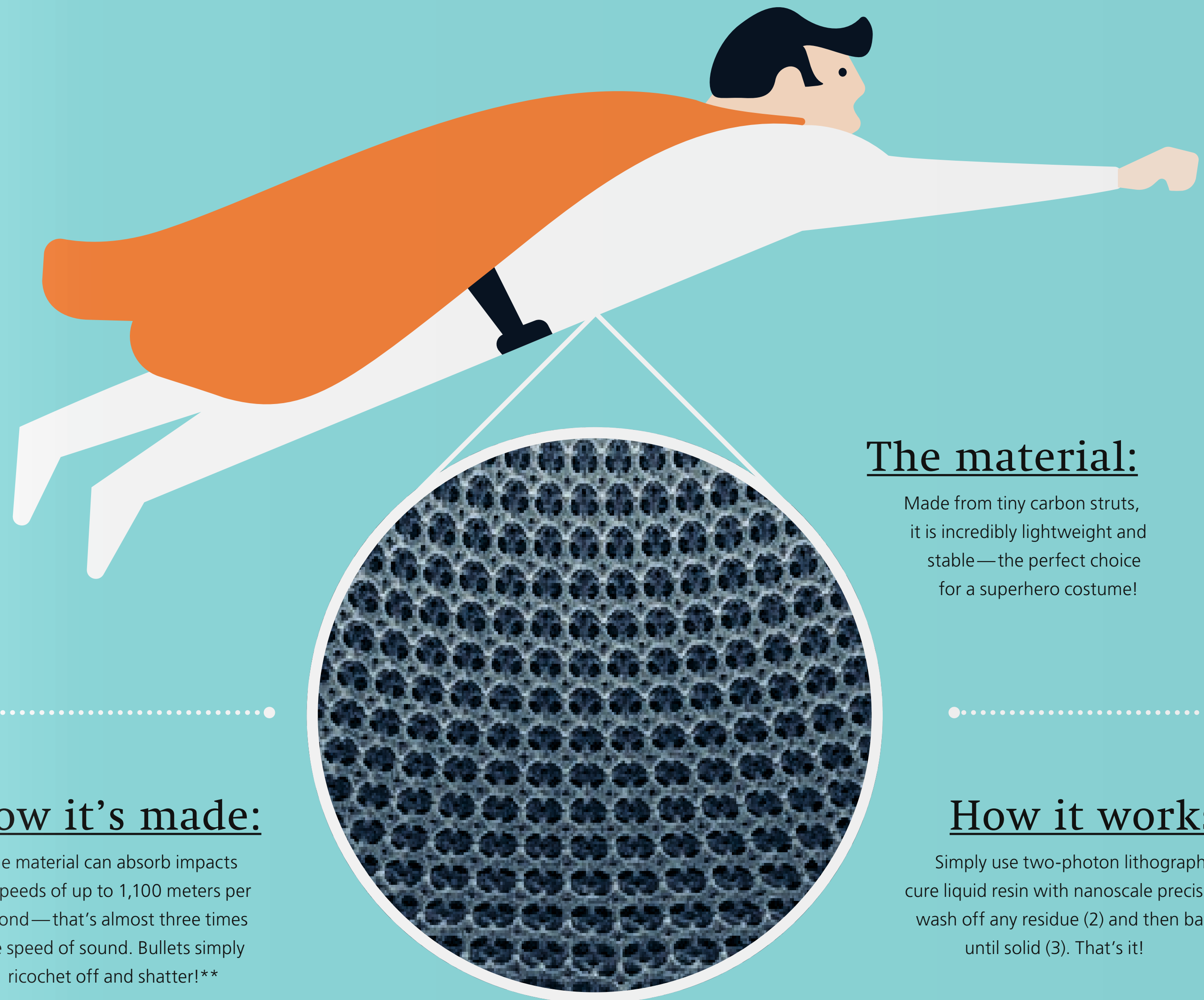


Top: A stack of battery cells clamped and ready for welding
Bottom: A finished battery for the EQA

Mercedes-Benz AG

Contact details: Mercedes-Benz AG, Christian Elsner, Head of Laser Material Processing and Process
christian.elsner@daimler.com

How to print your own superman suit*



The material:

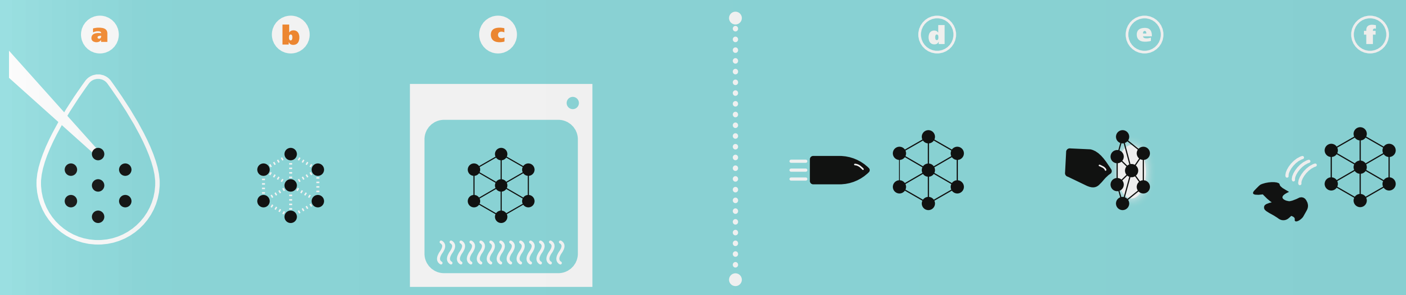
Made from tiny carbon struts, it is incredibly lightweight and stable—the perfect choice for a superhero costume!

How it's made:

The material can absorb impacts at speeds of up to 1,100 meters per second—that's almost three times the speed of sound. Bullets simply ricochet off and shatter!**

How it works:

Simply use two-photon lithography to cure liquid resin with nanoscale precision (1), wash off any residue (2) and then bake until solid (3). That's it!



Gernot Walter, MIT/Caltech/ETHZ

* Can also be used for bulletproof vests, or as a protective skin for satellites, for example.
** The new fabric was developed by researchers at ETH Zurich, MIT and Caltech. So far they have only created pieces of material in the micron range, but they are already working on larger ones.

DELICATE TOUCH

Using a mobile robot cell to automate eyepiece welding is a groundbreaking development in medical technology—and the pathway to a successful future for Karl Storz.

In one swift move, the robot takes two stainless steel cylinders, each topped with a stainless steel-framed lens, and places them on a welding fixture with perfect precision. A small clamp pivots down and fastens the future endoscope eyepieces in place. The machine hatch closes, and the laser starts welding. Quick as a flash, it applies three spot welds to attach the stainless steel ring of the lens to the cylinder. Then it welds the full circumference of the ring to lock it in place. All done—time for the next one!

"Impressive, isn't it?" says Sarah Mühleck, who manages the Swiss site of Tuttlingen-based medical device manufacturer Karl Storz in Widnau. The laser is indeed remarkable, but that's not what her gaze is focused on right now. There's no doubt that the laser is performing the kind of fast, reliable and high-precision welding that has made it such a popular tool. But the real hero in this story is the robot, which helps Mühleck get even more out of her laser.

HUMANS DO IT BETTER Robots are rarely encountered on the shop floors of medical device manufacturers, says Mühleck—and for good reason: "In industries such as automotive, which feature high-volume production with many identical parts, you'll find robots just about everywhere. But our business is more of a lower-volume, high-mix environment. Complexity tends to be higher, which makes automation harder to implement. And humans have far more of a delicate, intuitive touch, so they often get the job done faster and more skilfully than a machine."

Mühleck's highly qualified colleagues are also good at tackling more challenging tasks, and that's where she wants to see them focusing their energy: "We prefer to use our expert team to solve trickier assignments rather than simply loading parts into a machine. And of course the whole process of loading and unloading involves very repetitive movements that can put a real strain on staff," she adds. Together with her team, she decided to investigate whether they could somehow automate the eyepiece welding process—and the answer was yes!

Widnau soon welcomed a heroic and hard-working robot which now forms part of the Flextray automation cell from wbt automation. Right behind the robot is a TruLaser Station 7000 from TRUMPF. The robot's job is to load blanks into the laser welding system and unload the finished eyepieces after welding. It removes the welded eyepieces from the "trays" that give the cell its name, says Mühleck: "The cell has four of these trays. Together, they can store 960 parts. While the robot and laser are working their way through the contents of the first tray and depositing finished parts in the second, the operator outside the cell can be unloading the third tray and loading the fourth tray with blanks. Once that's done, the operator can spend time on other things until the manufacturing cell finishes its task and the second tray is ready to be unloaded." In this way, the same number of eyepieces can be produced with far less manual labor. The automation cell also offers all the benefits of a mobile system. If the operator wishes to produce a small batch without automation, they can simply undock the robot cell and move it to one side. So it caters to high-mix production, too!

AUTOMATED FUTURE But what about that all-important delicate touch? The secret lies in technical precision and a special eyepiece gripper system. Every aspect of the Kuka robot system has been measured out with pinpoint accuracy. This allows the robot to navigate to specific points with far greater precision than a standard industrial robot. "This is a crucial issue for us because some of the eyepieces differ by just a few tenths," says Mühleck. The final delicate touch is provided by the dedicated double gripper that inserts the blank into the welding apparatus. Each time it fetches a cylinder/lens combination from the tray, it uses a small vacuum bellows to hold the lens gently but firmly in place to ensure it reaches its destination without slipping. Once in the welding device, a laser scanner confirms that the lens is still in the right place. Only then is it clamped, spot-welded and completed with a circumferential seam.

So it seems automation does have a part to play in medical device manufacturing after all? "Absolutely!" says Mühleck, with a smile: "I've hardly noticed the new system so far, and that's a pretty good sign." She is keen for Karl Storz to continue along the path of automation in the future. "There will still be a lot of things we do by hand, but we want to remove the manual element wherever automation makes sense. And a flexible robot cell leaves both options open!" ■

Contact details: Storz Endoskop Produktions GmbH, Sarah Mühleck, Production Manager KSO Widnau, phone: +41 71 726-1272, sarah.muehleck@karlstorz.com

Operators can get on with other tasks while the robot processes the eyepieces. Only the loading process is manual.

Stefan Hobmeier

Sarah Mühleck heads up the Swiss site of Karl Storz.

The dual gripper system works with a delicate touch.

LIGHTNING HUNT

01 — PROFESSOR JEAN-PIERRE WOLF HAS AN IDEA

02 — CLEMENS HERKOMMER BUILDS A LASER

Martin Stollberg

“People think geoengineering is somehow disreputable.”

Professor Wolf at the summit of Säntis in Switzerland—the test site for his laser lightning rod.

Martin Stollberg

01

PROFESSOR JEAN-PIERRE WOLF CAME UP WITH THE IDEA OF USING A LASER AS A LIGHTNING ROD. HERE, HE EXPLAINS THE POTENTIAL BENEFITS OF HIS INVENTION AND HOW IT COULD HELP US COMBAT GLOBAL WARMING.

Professor Wolf, you’ve completed your first field experiment with the laser lightning rod. How did it go?
It was the perfect summer for us, with plenty of thunderstorms, high winds and lots of lightning! We captured a huge amount of data that we will now be analyzing. It was often quite foggy when the lightning struck the tower, so the analysis will be slightly more complex because we don’t have very many images. I should also add that this wasn’t actually the first field experiment!

How do you mean?
Sixteen years ago, we spent three months at the summit of South Baldy, a mountain in New Mexico with an elevation of over 10,000 feet. We tried in vain to trigger lightning from the clouds using a laser, but that summer turned out to have the fewest thunderstorm events on record for that area! We had three thunderstorms in 90 days when the normal figure would be one a day, so we were remarkably unlucky. The laser had virtually no effect on the clouds whatsoever, and we soon realized that our whole concept was flawed. So we decided to take a completely new approach.

What did you change this time around?
We basically re-designed the experiment. Instead of triggering lightning strikes with the laser, we simply waited for a thunderstorm and then used the laser to guide the lightning to a conventional lightning rod. We think this is a more practical approach. The ionized air pierces the sky like a hundred-meter-long lance and protects an area from lightning strikes that also has a radius of hundred or so meters. We reckon that we will be able to increase this tenfold in the future, pushing the length of the lance and the radius up to one thousand meters. And now I imagine you're going to ask me the same question that everyone asks?

Um, what question is that?
About the birds (smiles).

What happens if the laser beam hits a bird?
To be honest, we don’t know. It’s never actually happened, even though we’ve been doing these experiments for years. But it’s reasonable to assume it would be bad for the bird. Our laser certainly isn’t eye-safe, and it’s possible that some unlucky bird could be hit when we turn the laser on. But since the beam is stationary and generally visible during operation, we’re fairly confident that birds are intelligent enough to avoid it, especially since their eyesight allows them to see the color green very clearly. During thunderstorms birds tend to hide rather than flying around anyway, so I don’t we need to worry too much about birds. But one thing we are careful about is aircraft. The Swiss Federal Office of Civil Aviation established a five-kilometer exclusion zone around the laser. We’ve also hooked up the laser to air surveillance systems so it automatically shuts down if an aircraft does enter the exclusion zone. Of course the ionized lance is only a hundred meters long, and the laser beam itself is divergent, though theoretically infinite, but there’s no way the beam is ever going to hit an aircraft. It wouldn’t be a problem for the aircraft itself, but it would be very hazardous for the pilots’ and passengers’ eyes.

How did you come up with the idea of using a laser to control lightning?
It’s a classic story of scientific discovery! French laser researcher Gérard Mourou was working in his lab one day in the mid-1990s when an optical mirror broke. He couldn’t understand why, so he decided to investigate. Soon, he had discovered the self-focusing of a laser beam in atmospheric air and the formation of “filaments.” In certain circumstances, a laser beam passing through a suitable medium, such as air, will go through a continuous process of self-focusing, collapse, a return to self-focusing, and so on. Anyone who works with lasers will be familiar with this phenomenon, which is a leading cause of the destruction of laser rods. But what was new was the whole idea of filament propagation, where the filaments ionize the air and make it conductive. Mourou ended up receiving a Nobel Prize in 2018, though for something different, namely a technique used to create high-intensity laser pulses.

So where does your work fit in?
Mourou’s discovery of filaments in the air showed us that we could use a laser beam to conduct high voltage through the air in a targeted manner. We immediately saw its potential, so we set to work and came up with all sorts of different ideas. My Paris-based colleague André Mysyrowicz is now experimenting with using small lasers on the roofs of high-speed TGV trains to make contact between the electrode and the filament, a process that makes high-voltage transmission work better and more reliably when the train is moving fast. I took a different path by using filaments for atmospheric research. I suppose high voltage in the air inevitably led you towards lightning?

Absolutely. But how did you know it would succeed?
I didn't! But as soon I published my ideas on the laser lightning rod several scientists got in touch from big companies, saying: "That sounds like something which could protect our airports and launch sites, so please keep going!" That's when I discovered that delays to flights or rocket launches caused by lightning are very expensive, and there's a real willingness to invest in innovative lightning protection methods. So I kept going!

Lightning has something of a mythical feel to it ...
I'm not sure about that. I've seen headlines that call me "Geneva's answer to Zeus," but it's all a bit of a misrepresentation! Lightning is a natural phenomenon and there are aspects of it that scientists still struggle to explain. I find it beautiful, but mythical? Not so much!

What other ideas do you have for your laser lightning rod?
Airports and wind farms would certainly be among the first to adopt this technology. I could also envisage lightning protection for major events such as the Olympic Games. And we could definitely try using this powerful ultrashort pulsed laser for other things, too. The filaments we create in the air also serve to concentrate water vapor. That means we could create clouds and possibly even make them rain.

Would that count as geoengineering?
People have been generating artificial precipitation since the 1950s, spraying chemicals into the atmosphere to specifically make it rain or snow. Ski resorts pay for it as a service, the Chinese do it almost every day, and US farmers can order rain for their fields from private companies, which charge them on the basis of liters per square meter. But the old rainmaking techniques can be really dirty, showering down huge quantities of heavy metals and hydrocarbons. That's why the laser would be such a blessing, because it would be a lot cleaner.

But it would still be geoengineering!
Sure. Most people think geoengineering is somehow disreputable, a kind of sin against nature. But it's not that simple. Imagine, for example, that someone invents a new rainmaking method that can put out forest fires quickly and efficiently. Which option is better for the planet? Using that geoengineering method or letting fires destroy the forests? We've actually launched a new project to examine these kinds of questions at the University of Geneva. The project team includes geoscientists, ethicists, experts in international law and organizations such as the Intergovernmental Panel on Climate Change (IPCC). Incidentally, do you know about the huge geoengineering experiment that is already underway?

Seriously?!
Absolutely. It started in 1850 or so, and it affects the atmosphere, the weather and lots of other things all over the world: it's called the burning of fossil fuels and the mass release of carbon dioxide! OK, I admit it wasn't really engineering; it was more of a quest for profit and comfort with no regard paid to nature. Basically, we have completely messed up nature and are now seeing the consequences. Scientists have spent the past 20 years telling us that the first effects of climate change would be extreme weather events such as more frequent and severe flooding, drought and forest fires. Everyone who knows anything about this subject says we will soon reach a tipping point where it will spiral out of control and human efforts will no longer make any difference. Everything will behave differently—the oceans, ice, weather, temperatures and wind. I think that refusing to explore geoengineering methods in this context would be negligent. Unfortunately, we're definitely going to need these tools, so we better get down to developing them! ■

"When we saw that we could use a laser beam to conduct high voltage, we realized that it had real potential!"

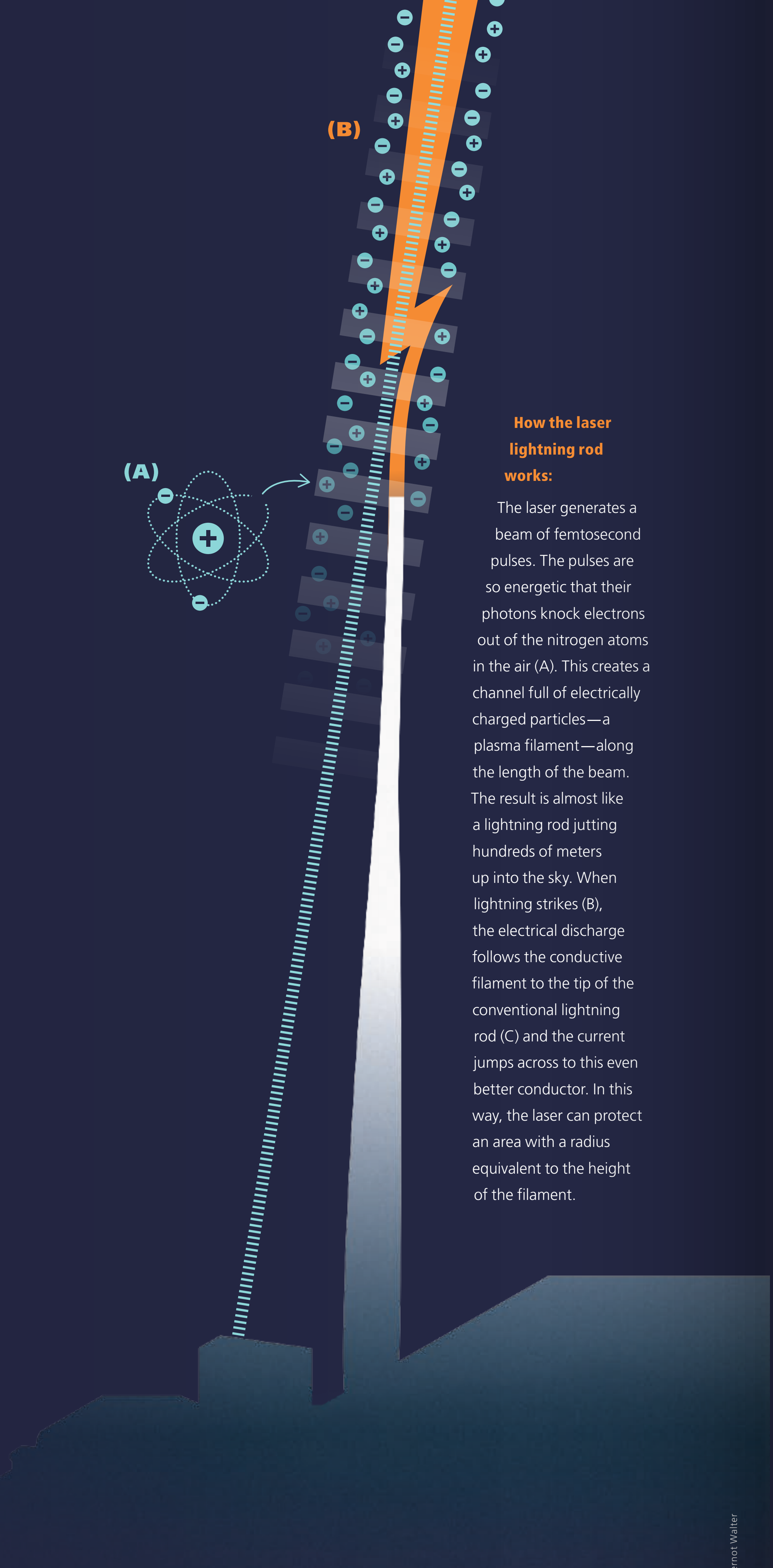
Jean-Pierre Wolf – Professor of Physics and Biophotonics at the University of Geneva – has spent years harnessing the power of laser technology to research and influence weather phenomena. This photo shows him at the summit of Säntis in front of the research station that houses the beam source for the laser lightning rod. Behind him are the containers in which the beam is expanded and fired into the sky through an opening in the roof.

Martin Stollberg

"We're going to need geoengineering methods, so we better get down to developing them!"

02

A LASER THE LIKES OF WHICH THE WORLD HAS NEVER SEEN: THE BEAM SOURCE FOR THE LASER LIGHTNING ROD RELIES ON AN INNOVATIVE AMPLIFIER BUILT BY CLEMENS HERKOMMER.



How the laser lightning rod works:

The laser generates a beam of femtosecond pulses. The pulses are so energetic that their photons knock electrons out of the nitrogen atoms in the air (A). This creates a channel full of electrically charged particles—a plasma filament—along the length of the beam. The result is almost like a lightning rod jutting hundreds of meters up into the sky. When lightning strikes (B), the electrical discharge follows the conductive filament to the tip of the conventional lightning rod (C) and the current jumps across to this even better conductor. In this way, the laser can protect an area with a radius equivalent to the height of the filament.

Gernot Walter

privat

GREASED LIGHTNIN'

AUTHOR: CLEMENS HERKOMMER

A plasma is a unique kind of soup. Plasma is generated when high-energy particles knock electrons out of their atomic orbits and temporarily prevent them from recombining. Because positive and negative charges are separated in plasma, it is a good conductor of electrical current—and that makes it a good option for conducting lightning through the air to a lightning rod, for example.

Generating plasma in atmospheric air is easy. You simply take a laser beam, place a focusing lens in the beam, and wait! If the intensity is high enough, a small ball of plasma will be generated at the focal point. And that's it! To control lightning, however, you need to stretch that ball of plasma out over a hundred, and eventually a thousand, meters. And that takes a special kind of laser.

CALCULATED CATASTROPHE When a high-intensity laser beam propagates through the air, the air itself begins to behave like a lens. It focuses the beam even more tightly and pushes the intensity of the beam even higher. That, in turn, triggers a reaction in the air, causing the beam to become even more tightly focused. This is known as the "Kerr effect" after the scientist who discovered it. Just like all self-reinforcing effects, this one eventually peaks and collapses in what is known as the catastrophic phase, where the photons of the laser light become so energetic that they start to knock electrons out of the nitrogen atoms in the air. The air ionizes, forming a conductive plasma.

This marks the liberation of the laser beam, which defocuses in the plasma before expanding and passing through more neutral air once again, whereupon the whole process starts over. By maintaining equilibrium between the Kerr effect and the catastrophic phase over an extended period of time, it is possible to create a filament, essentially turning the plasma ball into an elongated path of conductive plasma.

LONG AND DENSE A range of parameters can be adjusted to tailor this filament to specific applications. In the lightning rod project, for example, the aim was for the filament to start well above ground level. To achieve this, our colleagues at the University of Geneva built a special telescope which widens the beam from 30 millimeters to 30 centimeters right at the very end. As a result, the filament is only generated from a height of 120 meters and continues up until a height of around 200 meters.

Returning to the laser, our job is to deliver a beam that will generate a filament of about 100 meters in length in order to keep this conductive channel open. This requires a pulse rate of about a thousand laser flashes a second; at that repetition rate we're constantly knocking out enough new electrons to replace the ones that recombine, so we can keep the filament stable. At the same time, our aim is to kick out a lot of electrons simultaneously in order to create a very dense filament, so we need very high laser power and a very high pulse energy.

COMPRESSING AND PUMPING The time-stretched pulses first pass through a regenerative amplifier. This amplifies them by a factor of around 1,000. We also use this system in other specialist lasers, but the apertures of some special optics are too small for the pulse energies required in the laser lightning rod. We therefore send the pulses through a second stage, a special multipass disk-laser amplifier.

Multipass amplifiers take their name from the fact that the stretched pulses passes through the system several times. Powerful pump lasers give the pulses additional energy on each pass. The problem was that nobody had yet invented a multipass amplifier that could withstand a repetition rate of 1,000 pulses per second in our energy region. So we took up the challenge! One part of the solution was a sophisticated cooling system; the other was a new beam delivery system that prevents the high pulse energy from simply shooting through the beam-guidance optics.

The completed multipass disk-laser contains four diode-pumped disks that transmit their energy to the pulses in two stages as they pass through the system. At the end of this process, the high-energy laser pulses are sent through a grating compressor, which shortens the pulses in the time domain. What we end up with are picosecond laser pulses with an energy of 720 millijoules and a peak pulse power of nearly 700 gigawatts, which is exactly what we need. That's approximately equivalent to combining the power of about 500 nuclear power plants for one picosecond!

By the summer, our laser was at the summit of Säntis, a mountain in the Swiss Alps. When we ran the laser in infrared mode, the nitrogen in the air glowed with a bluish tinge. Those were the electrons we had knocked out of orbit recombining in the nitrogen atoms and releasing a photon to celebrate! On the green setting, the laser and filament shone brightly into the night sky. They were visible from the bottom of the valley. ■

Clemens Herkommer completed his industrial doctorate at TRUMPF. In his dissertation for the Technical University of Munich, he developed the multipass disk-laser amplifier for the EU's Laser Lightning Rod project.

The Laser Lightning Rod (LLR) project aims to develop a new type of lightning protection using a laser-based technique. The international project involves research institutes and companies from France, Germany and Switzerland and is funded by the European Union.

A LASER LIGHTNING ROD FOR DOC BROWN!

BOTH ON EARTH AND IN SPACE, LASER TECHNOLOGY IS MAKING THE WORLD A SAFER PLACE. PLUS: A NEW WRITER IS READY TO TAKE THE WORLD OF SCIENCE FICTION BY STORM!

Lasers in space are the stuff that science fiction is made of. But it never understood that the laser is on the side of the good. I would bet that when you hear the words "lasers in space" you immediately think of super weapons, annihilation and war, most likely with images of Star Wars and lightsabers flashing through your head. It's a real shame, because—as you've seen in this issue—laser technology is on the brink of staging a revolution in orbit that promises benefits all round.

"Geoengineering" tends to have the same negative connotations as "lasers in space". Interfering in the Earth's geochemical cycle is seen as downright disreputable. Yet Professor Jean-Pierre Wolf, weather research luminary at the University of Geneva, argues exactly the opposite, namely that by fully engaging with geoengineering, we can gain valuable insights to help us combat challenges such as climate change. His weapon of choice—now I have the war metaphors firmly stuck in my head!—is a one-of-a-kind super laser known as the laser lightning rod, or LLR. For the past few months, the LLR has been undergoing field trials at the summit of Säntis, a mountain in the Swiss Alps, where it has been teasing lightning out of the clouds. You might call it geoengineering, but with the noble aim of making the world a little bit safer by controlling lightning.

If only someone had told Doc Brown! The scientific genius from the science-fiction trilogy Back to the Future, which achieved cult status in the late 1980s, retrofitted a DMC DeLorean into a time machine. The car uses plutonium to generate the 1.21 gigawatts of power it needs to travel through time. However, a lightning strike hitting the DeLorean can also generate enough power to warp spacetime. This is a key plot point in the first part of the trilogy when Doc Brown's friend, Marty McFly, gets stuck in the past without any plutonium and has to find an alternative way of getting back to the future. Fortunately, his knowledge of the future means he knows exactly where and when the next lightning bolt will strike, namely the iconic town hall clock that has remained stuck at that time since the strike occurred. In the second part of the trilogy, lightning plays a much more accidental role, striking the time machine as it's flying—yes, flying!—through a thunderstorm and inadvertently transporting it to the Wild West. Life would have been a lot easier for Doc Brown and Marty McFly if they had known about the laser lightning rod.

A laser that controls lightning! It's amazing what laser technology can do. Once again, it's extraordinary enough to rekindle my dreams of becoming a science-fiction writer. After all, someone has to make it clear to this genre once and for all that lasers are a force for good! ■

Laser Community's editor-in-chief Athanassios Kaliudis writes a regular column on the laser as an object of popular culture.

Where do you think lightning should strike one day?
Send your answer to: athanassios.kaliudis@trumpf.com

Gernot Walter

Gernot Walter

WHERE'S THE LASER?

In mass medical testing:

To prevent pandemics, or at least bring them under control, we need tests that are fast, accurate, simple and cheap. Professor Bahram Javidi of the University of Connecticut thought that sounded like the perfect task for laser technology. His diagnostic systems consist of a simple laser diode, a microscope camera, a piece of glass and self-learning software that will even run on old laptops and smartphones—all technologies that can easily be deployed in developing countries. The device creates three-dimensional holograms of red blood cells from tiny blood samples and confirms in seconds whether a person is healthy or sick. This high-tech solution is already in use for malaria, sickle-cell disease and breast cancer. In 2021, Javidi added the capability to detect a SARS-CoV-2 infection. ■

The dental industry is finally enjoying the benefits of automation. A special apparatus automatically changes the substrate plates in the powder container during the 3D printing of dental prostheses. So it's goodbye to night shifts, and hello to simply pressing a button and heading to bed. The next morning you'll have a dental prosthesis that even a shark would be proud of!

400

TEETH PER SHIFT

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TRUMPF

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