A new era in beam generation

Secondary beam sources induced by laser will trigger a raft of new applications in industry and medicine.
The dawn of a new age

Each year, I eagerly await to see who has won the Nobel Prize in Physics. This fall, the award went to an international research trio of Alain Aspect, John F. Clauser and Anton Zeilinger for their groundbreaking work in quantum mechanics. Although the fundamental insights of these three brilliant physicists remain beyond the grasp of many people, the impact of their truly amazing research will be felt by all of us. In announcing its decision, the Nobel Committee for Physics had the following to say: “Being able to manipulate and manage quantum states and all their layers of properties gives us access to tools with unexpected potential.” By this, they mean ultrafast quantum computers, absolutely secure quantum communications and quantum sensor technology. I, for one, am convinced that quantum technology is about to unleash a new industrial age in which photonics will play a key role.

With laser technology, we are seeing, once again, that the best is yet to come—in the field of quantum technology certainly, but also, and especially, in relation to secondary beam sources. Firing laser pulses at certain materials makes them emit various forms of radiation, which can then be exploited in all kinds of ways. As our cover story explains (page 12 onward), scientists are now using lasers to generate a whole variety of beam sources. The principle here can be illustrated in terms of a game of pool. To pot each of the 15 balls, you need to ensure that the white cue ball hits the colored object ball at exactly the right angle and exactly the right speed. In a secondary beam source, the laser is the equivalent of the white ball, and the colored ball represents an induced beam of electrons, protons or neutrons. These new sources of radiation have the potential to revolutionize medicine and industry. For example, the use of laser-driven electron or proton beams as a form of noninvasive tumor therapy may well transform cancer treatment. Secondary beam sources can also shed light on other problems. EV battery manufacturers, for example, might use laser-induced electron beams to monitor distribution of the electrolyte as it flows into the cells—virtually in HD-video quality. Combined with the right software, this can also be used to predict battery life. Read about this development on page 16.

In this area, too, TRUMPF has played a leading role, with the world’s first commercial breakthrough for the principle of laser-driven secondary beam sources, back in 2017. Since then, the microchip industry has been using extreme ultraviolet (EUV) radiation to photolithographically print circuitry on semiconductor wafers. Today, the production of high-power lasers for EUV lithography machines is a key line of business for TRUMPF.

Each day, smart minds around the world are busy pushing back the frontiers of physics. In the coming years, it will therefore be fascinating to see who ends up winning the Nobel. Readers of the latest edition of Laser Community can also discover some of the magic of physics. I wish you all a lot of fun in doing so!
Wham!

It is not easy picturing something that the human eye will never see. We therefore asked the AI text-to-image generator DALL·E to create an image from the following description: “Laser beam exceeds threshold and becomes particle beam.” Turn to our cover page to see what it generated: page 1.

Woof!

As anyone in labor studies knows, a company dog does wonders for the workplace atmosphere. At Alpine Laser in Minnesota, this is Emma’s role. Right now, she’s guarding a TruMicro. To find out what her coworkers are up to, turn to page 6.

Wow!

How do you generate a proton beam? What can you do with neutrons? Stephanie Dierolf offers a colorful introduction to this fascinating subject. Althoughpressedfor time, Stephanie was determined not to miss out on this project. Her great illustrations can be seen from page 12.

12 THE AGE OF THE BEAMS

With the advent of laser-driven beam generation, it will be possible to scan whole bridges, noninvasively inspect huge components in situ and predict the expected life of newly produced batteries.

6 A reboot for stents

There’s a shortage of lifesaving stents for heart patients. A startup in Minnesota has plans to change that.

10 POWER


11 GLORY

World’s first laser surgeon and father of laser microbeams—Michael Berns had many talents.

18 AHEAD

Researcher Andrea Lanfermann has declared war on microplastics. Her secret weapon: femto laser tech.

20 Reigniting the race for space

Agile Space is proud to call itself “market leader for moon landings.” The shift to additive manufacturing has helped boost sales.

23 Magic metals!

3D printing has brought the breakthrough for amorphous metal—and a range of products in engineering and consumer electronics.

24 At last, a gastight weld with aluminum

Long a big headache, now child’s play—with four multifocus beams instead of one.

26 “Sometimes, it’s good to be small”

Gediminas Račiukaitis knows Lithuania’s laser industry better than anyone. He’s therefore ideally placed to explain its amazing strength.

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31 WHERE’S THE LASER?
Joe Kempf sits comfortably in a swivel chair in the functionally furnished conference room: “The team and I have spent years developing a specialized laser cutting platform specifically for medical tube cutting. Every aspect of the workstation has been optimized to make the machine as efficient and fast as possible, while addressing the technology and usability gaps present in the legacy product offerings.” Confident words from an engineer who quit his regular job in the med-tech industry, scraped together his savings and, together with a partner, founded the start-up Alpine Laser. That was back in 2019.

A CAPACITY BOTTLENECK

With an eye for an opening, Kempf saw a golden opportunity for a new manufacturer of the machines used to make stents and interventional tubular components. Stents are the semi-elastic wire-mesh tubes that surgeons insert into constricted blood vessels to hold them open. In industrialized countries with rapidly aging populations, minimally invasive surgical procedures like these are becoming more and more common and replacing riskier methods. In the U.S. alone, over two million stents are implanted yearly—a number that is growing all the time. What’s more, new therapies are coming to market each year that utilize laser cut tubular components.

Yet Kempf’s plan to produce a machine for manufacturing stents faced a major hurdle: entry into the medical manufacturing market is not an easy process. The medical device market is strictly controlled by regulating bodies around the world. Understandably, the laws and regulations governing quality and certification are extremely rigorous. As a result, the major manufacturers of stent cutting machines have carved up the sector among themselves. "Now the
MICROPROCESSING

established manufacturers can’t keep up with the rising level of demand, and it’s created a bottleneck,” Kempf explains.

SMALLER, FASTER

Kempf and his team know the medical manufacturing industry. For decades the team at Alpine Laser have been users and operators of this type of equipment. They understand what works, what doesn’t, and what the machines need to do. Over the course of the last 18 months, they have benchmarked their laser cutting system against nearly all other systems on the market. The design of any such machinery always involves a key trade-off: on the one hand, the machine should be easily scalable and thereby allow inexpensive manufacturing; on the other, it should be highly customizable and configurable to individual user requirements. “We realized that a modular design was the only way of combining these two goals,” says Kempf. Alpine Laser came up with a design for a system that would micromachine high-quality components between two and five times faster than conventional machinery.

One reason is that extensive effort has been placed in developing robust and flexible tooling—setting up the machine with new part holding and aligning the optics, for example—takes less than five minutes. That’s significantly faster than all previous systems. What’s more, with a footprint measuring a mere 1.2 × 0.7 meters, it is the smallest stent-making machine in the business.

A FIBER DELIVERED USP LASER

Kempf then discovered that TRUMPF was working on the world’s first fiber delivered USP laser. “We immediately realized that this was key to a modular design.” The new laser light cable is made of a hollow-core fiber. This delivers the USP laser pulses from A to B without any loss in stability. “That meant we could separate the laser source from the cutting optics without having to mount a bulky laser head unit near the processing area,” Kempf explains. “This makes the machine significantly more compact and allows us to standardize our machine design for both USP and Fiber lasers.”

Alpine Laser contacted TRUMPF. The two companies then got together on the development of Alpine Laser’s Medicut Pro. This is the first ever machine to use a USP laser with hollow-core fiber delivery for production on an industrial scale. What’s more, the beam quality delivered by the TruMicro yields a further benefit. “Ultrafast lasers can deliver such clean-cut edges that our customers can produce parts that require, in many applications, no postprocessing with aggressive chemicals,” Kempf explains. “And that removes one significant barrier for device manufacturers; people don’t want to work around hazardous chemicals.”

BOOSTING OUTPUT

Having initially hoped for a modest and steady ramp in sales with the launch of this new machine, Alpine Laser has been blown away by the demand. Bolstered by this experience, Kempf is now turning his attention to new USP flat sheet cutting systems for complex laser cut catheter delivery systems.

Kempf says, “We feel our job is far from done—we’re just getting started. We have a large list of products in our pipeline that stand to benefit from an Alpine revamp—upgrading old industry designs with new, more advanced technologies. The team at Alpine will continue to investigate and implement the latest technologies, ensuring that our machines continue to outperform market offerings for years to come.”

Contact: Alpine Laser, Joe Kempf, Phone: +1-651-353-4376, joe@alpinelaser.com

In reality, only two and a half millimeters in diameter and absolutely life-saving: In the U.S. alone, over two million of these semielastic tubes are fitted each year.

“USP lasers cut with such clean edges that our customers can now produce parts that no longer need any post-processing with aggressive chemicals.”
A new space mission seeks to determine whether life once existed on Mars.

Key to this quest is a small but extremely robust solid-state laser.

Sadly, it is highly unlikely that anything could today exist on the surface of Mars. The aridity and punishing radiation would kill off even the hardest of life forms. Yet conditions were different two to three billion years ago. Back then, water was plentiful on Mars, and the climate warm and humid. A good number of scientists postulate that life may very well have evolved around the same time as it did on Earth. Were this the case, the remains of such life forms should lie buried beneath the planet’s crusty surface—in the form of fossils.

This is what the European Space Agency (ESA) aims to find out. To this end, it will dispatch a small drilling rig and analytics lab to the red planet. All this gear will be packed into a Mars rover some two meters high, two-and-a-half meters wide and weighing a mere 310 kilograms. The rig will drill to a depth of two meters—despite delivering a power of 100 milliwatts. To ensure the requisite robustness, the Fraunhofer Optics and Precision Engineering (Fraunhofer IOF) worked for seven years to develop such a laser. The full laser resonator and other optical components. Such joints are strong enough to withstand severe mechanical and thermal stress.

Researchers at the Fraunhofer Institute for Applied Optics and Precision Engineering (Fraunhofer IOF) worked for seven years to develop such a laser. The full module is the size of a quarter and weighs a mere 50 grams—despite delivering a power of 100 milliwatts. To ensure the requisite robustness, the Fraunhofer team made use of a special laser-soldering technique to assemble all the various parts of the ultra-sensitive laser resonator and other optical components. Such joints are strong enough to withstand severe mechanical and thermal stress.

Originally planned together with Russian state space corporation Roskosmos, the second leg of the ExoMars program was scheduled to take off in 2022. However, in the light of the current political situation, this collaboration has been put on ice and the launch postponed, provisionally to 2024.
Breakthroughs in USP laser technology will provide industry and medicine with easy access to hard X-rays and high-energy particle beams. A host of new applications will follow.

SECONDARY SOURCES

Secondary beam sources are created when laser pulses are fired at certain types of material, thereby generating a further form of useful radiation—e.g., light in the X-ray spectrum or a particle beam. The origin of this principle lies in the use of extreme-ultraviolet (EUV) light for the production of microchips. Future beam generators could well look something like this seed module for an EUV lithography machine.
What’s behind this new trend?

For many years, ideas lay dormant on the drawing board — but new USP lasers are now turning them into concrete applications.

The minimum length of beam pipe is 100 meters. This will ensure that the electrons attain the requisite velocity somewhere in the region of the speed of light. For decades now, there have been ideas about how beams might be generated in a simpler and more compact manner. One of these was to use packets of photons, produced by a laser, to accelerate particles. The problem here was the lack of a laser beam source capable of meeting these requirements.

But no longer. It is about ten years since USP lasers made the leap from the lab to industry. This shift has given the technology a powerful boost. For in order to adapt it to this challenging new world, USP pioneers such as TRUMPF have pulled out all the stops to improve performance and reliability. Two priorities have been to increase pulse energy and average power — i.e., the number of pulses per second. In the last five years alone, the average power of USP lasers from TRUMPF has grown from 50 to 200 watts. On a number of occasions, company engineers have also succeeded in demonstrating the potential to revolutionize medicine and industry. So what’s behind this new trend?

THE USP BREAKTHROUGH

What’s behind this trend is the ultrashort pulse (USP) laser. Until now, it has only been possible to produce on a widespread scale X-rays and electron, proton and even neutron beams. Thanks to technology that will simplify the production and radically reduce the cost of such beam sources, scientists and engineers are now busy brainstorming new ideas about how best to use them (see pages 16 and 17). These ideas have the potential to revolutionize medicine and industry. So what’s behind this new trend?

The coming years are going to see a massive increase in the availability of hard X-rays and of electron, proton and even neutron beams. Thanks to technology that will simplify the production and radically reduce the cost of such beam sources, scientists and engineers are now busy brainstorming new ideas about how best to use them (see pages 16 and 17). These ideas have the potential to revolutionize medicine and industry. So what’s behind this new trend?

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THE LASER AS BEAM GENERATOR  
On the face of it, this new generation of particle accelerator has to fulfill extremely demanding requirements. The miniscule photon packets must hit a spot only a few micrometers in area with exactly the right energy and at exactly the right moment — to within the nanosecond. If not, the acceleration process will fail to start or falter and peter out. Yet users of the latest USP technology know better. After all, mode-locked oscillators have a temporal precision within the range of a few femtoseconds. On the other hand, laser enthusiasts may well experience a certain kink. For, in the end, the immensely powerful laser pulses serve merely as a means to an end. In lab jargon, this is what is known as a laser-driven secondary beam source. It’s like the power socket and the kitchen microwave. I want to heat up my lunch, but instead of directly using electrical energy for this, I use the power to generate microwaves, which then warm up my bowl of soup. In this analogy, the laser beam is the electricity—a precious form of energy—but the real aim is to generate other types of beam. In other words, the laser is the beam generator.

THE COMMERCIAL BREAKTHROUGH  
TRUMPF has been pursuing this idea for quite some time now. The first commercial breakthrough for the principle of laser-driven beam generation came in 2007. This was the use of very soft X-rays—extreme ultraviolet (EUV)—radiation—to photolithographically produce semiconductor circuitry on silicon wafers. TRUMPF supplies the high-performance laser system used in the lithography machines supplied by ASML to the chip-manufacturing industry. The TRUMPF system fires laser pulses at a waterfall of tin droplets. This causes the plasma to emit radiation of 13.5 nanometers—exactly the right wavelength with which to create even the smallest of transistor circuitry in the wafer. The ASML lithography machine produces 100 chips per hour. This new generation of microchip is found in cellphones and a host of other devices.

It is hoped that many more successful commercial applications of laser-driven beam generation will follow over the next few years. Many of them are still at the trial stage. Experts estimate it will take another five to ten years before most of them have found widespread use in industry and medicine. But the potential is huge—as is the resulting boost for laser technology. Each leap forward in the—a sort of—is a new development in Formula One racing: whatever proves its mettle there will one day find a way into normal production vehicles. In the case of USP lasers, that means advances in the field of material processing. We are seeing the dawn of a new age, one in which the ready availability of coherent subatomic particle beams will become the most normal thing in the world. As with all inventions, a technological and social transformation did immediately result from the very first successful application of this technology. That came a number of decades ago, with the development of the electromagnetic particle accelerator. Instead, the real revolution only begins when a technology becomes cheap, simple and widely applicable. In the case of laser-driven particle accelerators, this is about to happen. And, with this type of radiation readily available, everybody will soon be beaming.

Contact: Torsten Mans, Product Management Secondary Sources  
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Ms. Lanfermann, you’ve declared war on microplastics. Don’t the wastewater treatment plants already take care of them?

Sadly, no. In fact, a key problem here is the lack of a clear directive telling the treatment plants what they have to do.

What do you mean by that?

At present, microplastics are merely defined as particles smaller than five millimeters. That’s a very open-ended definition, given there are also plastic particles on the nanometer scale. It’s unclear down to which size particles have to be filtered and below which they are allowed to pass through. We’re now aiming to filter down to a particle size of ten micrometers.

How will you do this?

We’ve teamed up with partners to develop a cyclone filter with a ten-micrometer mesh. This removes particles from the water by means of centrifugal force and a filter unit. Initial tests at a wastewater treatment plant were very promising. We were able to filter out almost all particles of plastic down to a size of ten micrometers.

That’s a very fine mesh. Correct. To create such a fine mesh, we use an ultrashort pulse laser. Our project partner Laserjob used a TruMicro 5225 to cut the mesh for the filter unit in our prototype. It took two weeks. That’s because they had to drill 59 million holes with a single laser beam.

Why is that?

It isn’t, but now we’ve developed a process for multibeam drilling. This uses the TruMicro 5280 Femto Edition to drill tiny holes in a sheet of stainless-steel foil only 100 micrometers thick. A special optical system creates a matrix of identical laser beams. This splits the laser beam into 144 individual beams, meaning we can drill 144 holes at once. This slashes the processing time. But there are still difficulties. Splitting the laser beam means less energy for each individual beam. Nevertheless, the system still has to be capable of drilling precisely positioned holes. And because we are also heating a larger area, there is greater thermal distortion. With multibeam drilling, it’s therefore vital to monitor the process and the quality. That way, we can better understand and control these thermal effects. Here, at the institute, we’ve developed simulation software for laser drilling, which is also backed up by optimization software from our partner OptiF. This enables us to calculate the shape of the drill hole and thermal stresses and to choose the correct parameters to prevent distortion. We’re aiming to produce a filter unit with as many holes as possible.

What other goals do you have?

We want to laser-drill holes as small as 500 nanometers in even thinner sheets of steel foil and make the process suitable for industrial use. Our partner LUNOVU has created an interface where users can enter the size, area and configuration of the holes they want to drill. That saves us the time-consuming business of having to plan the process manually. And it also means filters can be made for other purposes.

And what might those be?

Local water treatment. This means the filter is installed right where microplastics are produced. That might be a PET recycling facility, which would filter its own wastewater before it went to the treatment plant. Apart from that, there are also applications beyond microplastics. One idea is to equip filters with a biological component. After mechanical filtration, nanoparticles would then be combined with enzymes or proteins in order to break them down. That would be a way of removing trace substances from water. There’s heaps of potential. We’re only just getting started.

Hazardous microplastics are everywhere, even in treated water. But Andrea Lanfermann has netted a solution.
Durango, Colorado  It’s early morning and Charlie Garcia’s inbox is full—queries of the kind: “We’re planning a moon shot ...”; “We’re looking to orbit Venus ...”; “We’re going for a Mars landing ...” Garcia is chief engineer for special projects at Agile Space Industries in Colorado. His previous employer was SpaceX, which is where he gained his expertise in a hot commodity required for every space mission: thrust.

**MARKET LEADER FOR MOON LANDINGS** “Spaceflight has become cool once again,” he says. “There’s now a boom in civil and commercial missions. Year on year, we have more and more customers; year on year, they’re ordering more and more of our hardware.” What they purchase from Agile Space are thrusters—spacecraft propulsion systems. Thrusters come in different types, depending on their function. There are thrusters to keep satellites in their proper orbit, for example, and there are classic thrusters that propel rockets into space. One of Agile Space’s specialties are the kind used for lunar landers. “We’re market leader for moon landings,” Garcia explains. The attitude control thrusters for a lunar lander are about the size of a 0.5-liter beverage can. The housing features a system of inner ducts to transport a bipropellant fuel and oxidizer. As the lunar lander descends toward the surface of the moon, the thrusters ignite to level the craft and ensure a soft touchdown. This special propellant combination combusts when it comeslings and burns at a temperature of up to 3,000 degrees Celsius.

**LIKE THROWING AWAY GOLD** Agile Space has pioneered the use of 3D printing to manufacture its thrusters. It is only recently that the space industry has overcome its reservations regarding this technology—also known as additive manufacturing. In the past, it has preferred processes that have stood the test of time. After all, there’s no one in space to send along a spare part when something goes wrong. “Around four years ago, the race for space reigned,” Garcia explains. “People realized that 3D printing was a perfect match for the space industry.” By that, he means the need for ultra-lightweight, ultra-complex parts with inner ducting and fabricated of exotic alloys, often in very small or even one-off batches. “But what really clinched it was what we in the industry call the buy-to-fly ratio.” This describes the weight of the material used to make a component compared to the weight of the material that actually ends up in flight. Additive manufacturing offers an unbeatable buy-to-fly ratio.

Agile Space explorer Nick Gabrielli always come up with new 3D printing strategies and gets more out of the machines than they then are officially capable of.

Sinfully expensive space alloy Niobium 103.

3D-printed thruster for the attitude control during the moon landing.
“People have finally realized that 3D printing is a perfect match for the space industry.”

Charlie Garcia, Chief Engineer at Agile Space Industries

The specialist alloys used in the space industry are seriously expensive. The thrusters from Agile Space, for example, are made of the extremely heat-resistant alloy niobium C-103, which can cost as much as 1,600 U.S. dollars per kilo.

“If you manufacture from a solid piece of material—i.e., turning, milling and drilling a metal blank—you may be buying as much as five kilos of niobium C-103 per thruster,” Garcia explains. “And then you end up with four-and-a-half kilos of waste, while the part itself only weighs half a kilo. It’s a lot like making a wedding ring out of a gold bar and then throwing the rest away.” With additive manufacturing, by contrast, Agile Space uses only as much of the expensive alloy as is actually contained in the finished product.

Mount Pleasant, Pennsylvania No wonder, then, that 3D printers are in big demand in the space industry right now. As are contract manufacturers who are able to mass these machines out. That’s why Agile Space teamed up with the Pennsylvania company TroniX3D and then, in 2021, made it part of the corporate family, under the new name of Agile Additive. Co-founder Kyle Metsger and the rest of the TroniX3D team were quick to pinpoint how additive manufacturing could give Agile Space that decisive edge.

VALUABLE FEEDBACK FROM TESTING As Metsger recalls: “Agile Space was always good at identifying and eliminating the bottle-necks that occur in the development and testing of thrusters, which is lengthy process at the best of times. That’s their thing. Then we came along and said, ‘we’ve got another idea, but we’re going to have to trust each other.’” What Metsger needed was the data generated during hot and cold testing of the thrusters. With direct access to this, Metsger and his supplier of choice was TRUMPF. Once again, trust was a key factor. “It quickly grew into a partnership of equals,” he explains. “There’s been a lot more trust involved than is usual in business dealings, but we’re both benefiting from that. We’re doing things here that go way beyond the machines’ official specifications, but in turn this means that TRUMPF gets valuable feedback from a sophisticated user.”

Agile Space currently has one TruPrint 1000 and two TruPrint 2000 machines in action and, as of this summer, the even larger TruPrint 5000—the first of its kind in the U.S. There’s a simple reason behind this: “To succeed in today’s space industry, you now have to be using additive manufacturing. Anyone not doing so is going to fall by the wayside.”

“To succeed in today’s space industry, you need to be using additive manufacturing.”

Kyle Metsger, Technology & Innovation at Agile Additive

MATERIALS

MORPHOUS BENEFITS: Design and manufacture on a single component; slender, elastic ribs in housing allow for equalizing play between bushing and housing.

Magic Metals!

Metallic glasses have fantastic properties—and, if in the past, few applications. This has changed with the advent of 3D printing. Four examples of products already in mass production.

SPECIFICATIONS: Lightweight, high resistance to corrosion

AMORPHOUS BENEFITS: Excellent flexibility, enabling higher levels of comfort and freedom of movement.

SPECIFICATIONS: High precision, including cavities, hardness plus elasticity, resistance to corrosion; low thermal conductivity for warm feeling in ear

MEDICAL PROSTHETICS

SPECIFICATIONS: High precision, including cavities, hardness plus elasticity, resistance to corrosion; low thermal conductivity for warm feeling in ear

EARRINGS

SPECIFICATIONS: Lightweight, high resistance to corrosion

AMORPHOUS BENEFITS: Excellent flexibility, enabling higher levels of comfort and freedom of movement.

SPECIFICATIONS: Accuracy within a small volume; complex shapes; mechanical strength without dropping or scratching; biocompatibility for bodily contact; comfort in motion; hard metal to wear

AMORPHOUS BENEFITS: Enhanced biocompatibility, including cavities; hardness plus elasticity; resistance to corrosion; low thermal conductivity for warm feeling in ear

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At last, a gastight weld with aluminum

A big problem with seal-welding aluminum is that you often end up with gas-permeable pores in the seam. Yet a quick glance into the fire and steam of the keyhole reveals that all it takes is a differently shaped laser beam—and the pores disappear.

It is now very easy to laser-weld highly reflective aluminum, creating wonderfully strong seams at high speed. That these seams contain a few pores—gas inclusions—does not impact the mechanical strength of the weld. Things are different, of course, when a gastight weld seam is required. If the seam contains a lot pores, this leads to the formation of tiny channels through which gas can penetrate or escape.

A Gastight Dilemma Conventionally, there are two ways of creating a gastight weld: those who require a fast, high-quality, energy-efficient process favor a laser along with a high-cost material such as stainless steel; those who prefer to use a lightweight material need solider in order to create a gastight joint—a process that not only is much slower but which also consumes a hundred times more energy and requires an area the size of a basketball court.

Tomorrow’s mobility will rely upon the ability to create millions and millions of reliable gastight welds. Ideally, these will be the work of a highly automated process that functions well with aluminum, as a cheap and lightweight material. This process will serve to produce casings for power electronics and the cooling plates found in electric vehicles. These carry water-filled cooling channels and shield the sensitive electronic components of the packed batteries from moisture and weather influences. The seals for these casings must be completely impermeable. This is what our development partner, automotive supplier Benteler, is looking to achieve. Together, we forged a plan to overcome the aforementioned dilemma and find a way to produce gastight laser-welded seams with aluminum. It was time to eliminate the pores!

Into the Fire and Steam Analyses with external R&D partners showed us the way forward. We examined the deep, narrow hollow that is created during welding as the metal melts and vaporizes under the heat of the laser. The resulting vapor forces the molten metal sideways and downwards. This creates a deep, narrow, vapor-filled cavity known as the keyhole. As the beam travels through the metal, molten metal flows around the keyhole and solidifies in its trail to form a seam.

As long as the keyhole remains stable, everything is fine. However, any fluctuation in the degree of laser power on the inner wall of the keyhole leads to variation in the diameter of the aperture. Should this aperture become too small, the following occurs: some of the vapor cannot escape and forms a protuberance on the back wall. In turn, this interruption in the gas flow creates negative pressure, causing molten metal to collapse into the keyhole and trap vapor. This leads to the formation of gas pores. This can happen with any material. But, with aluminum alloys, this occurs more quickly, easily and frequently than with steel, for example.

Keeping the Keyhole Open So what can be done when the keyhole becomes too small? Easy! Make it wider. And when fluctuations in laser power threaten collapse? The answer then is to ensure greater stability. In both cases, the solution starts with BrightLine Weld, our proven beam-shaping system. This delivers a much more stable process by splitting the laser light in the light cable between an inner and an outer fiber core, thereby optimizing power distribution for high-speed welding. Yet this is only the preparation for the real trick, which is performed by the optical system.

This splits the laser into four individual spots, which form a square and are arranged in such a way that their effective radii overlap. The aim, after all, is to create four small keyholes, but a very large one. Because the laser has already been divided between the ring and the core, each of the four individual spots is able to make extremely efficient use of the available power. With laser power now distributed evenly across the entire area, the keyhole remains open and allows vapor to escape. As a result, no molten metal collapses into the keyhole, no vapor is trapped, and there is no formation of gas pores.

In a clear sign of the success of the multifocus system, the keyhole area is now ten times as big. What’s more, the dimensions of the weld pool fluctuate by only seven percent as opposed to 30 percent. As a result, the process is much smoother.

Tests and measurements show that the new multifocus system is almost 100 percent reliable when it comes to producing gastight seams. And it is also very fast. At present, we are operating at speeds of up to 15 meters a minute. In the lab, however, we are already running tests at 30 meters a minute. Our development partner Benteler is now looking forward to launching production on the basis of this patented technology. After all, demand for laser-welded aluminum casings for power electronics and battery cooling plates is set to be huge.
“Sometimes it’s good to be small”

Gediminas Račiukaitis is president of the Lithuanian Laser Association. He explains how such a small country was able to build up such a strong reputation in this field.

We’re a small country of not even three million inhabitants, a former Soviet republic that joined the European Union less than 20 years ago. We’re used to people underestimating us. But we’ve had laser technology since 1966—longer than most other countries in the world.

Why so long? Basically, Lithuania’s laser industry can be traced back to three students who were all sent...
“If you have a cellphone, there’s every chance that some of the components were manufactured with a USP laser made in Lithuania.”

And who do you sell all these products to? They all go abroad. Sadly, there aren’t many Lithuanian companies that use laser technology in their manufacturing. That’s a drawback compared to Germany, for example, where there are lots of opportunities to meet up with companies and even take a look at their production facilities. That makes it much easier to sound them out and find out what they really need. Here, in Lithuania, we’re also looking at ways of getting more feedback from end users. But since they don’t come to us, we have to go to them. Right now, the Lithuanian Laser Association is organizing a visit to companies in Korea and Taiwan.

What's the secret behind Lithuania's success in laser technology?

That sometimes it’s good to be small. It means that we all know each other personally. Most companies are spin-offs from the leading institutes, and most of the company founders and workforce are of the same age as the people from the other companies and the institutes and know each other because they all studied together. It’s very common to move from academia to industry and back again. As a result, research and development at the institutes are strongly geared toward what companies actually require. In the laser community, we all trust each other—even across company boundaries. Sure, we’re still market rivals, but companies here tend to work together rather than against one another. In the photonics world, I’d say that’s pretty unique.

How does the country itself benefit from Lithuania's remarkable success in the photonics industry?

Well, first of all, in ways you might expect: it gives us a stronger economy, global prestige… But there’s also something else, even more important: a home for my fellow Lithuanians.

What do you mean by that?

In Lithuania, when it comes to choosing a career, people often look abroad. Ideally, you study at Oxford—no matter the subject, no matter how successful—and then go on to work in Sweden or in Germany. For some people, that’s great. But, in the process, you end up losing your roots, and many people are unhappy about this. The fact that Lithuania has a flourishing laser industry means that young people are now able to imagine having a bright future for themselves back home, complete with an exciting and well-paid job. That’s the best way of stopping the brain drain. It’s something I see year after year: the desire to stay at home, here in Lithuania.

Where do you see it?

Each year, 40 out of 50 of the new intake of physics students opt to major in laser physics or laser technology. Things are quieter in the corridors of the other physics departments because there is no collaboration with industry there. Of course, even without that, laser technology is still a great field. But primarily, it offers great prospects. And young people recognize that.

What does the future hold for laser technology in Lithuania?

Over the period from 2009 to 2021, our photonics industry grew year on year by 16 percent. That’s huge growth, and I see it continuing at a similar level. In turn, this will mean tapping into more markets, so that there is an outlet for this growth. Our job, at the Laser Association, is to help make this happen. As for new applications of this technology, I see good opportunities in the fields of optical and quantum optical communication. In fact, I’m already seeing the first evidence of commercial activities in this direction. And, soon, there will be more on the way.

Do you have any advice for other countries?

If you don’t use lasers in science and industry, then everything eventually grinds to a halt. Everything goes dark.
Netflix and all the other streaming services are the couch potato’s best friend—and natural enemy of a healthy back. And there’s also nature to contend with: from the age of 30 onward, disc degradation sets in—and, with it, all kinds of back ailments. Regular workouts are a big help here. But be wary of doing too much, too soon! Rushing into training unprepared can cause major injury. Fitness equipment such as Smart Strength from EGYM is great for workout newbies. These machines adapt to the training requirements of each user and feature onscreen animations to show whether the exercises are being correctly performed. The frame is made by specialist metal fabricator Steinhart from southern Germany, using laser tube-cutting and combination punch-laser machines. So, get off the couch and get down to work with your very own smart personal trainer!

Thailand’s industry is the most powerful in Southeast Asia. Companies in this sector are clustered in and around the capital, Bangkok. Other parts of the country are not heavily industrialized. The major sector is the automotive industry. Specifically, Japanese OEMs (Toyota, Honda, Mitsubishi, Nissan) manufacture here, as do Ford and Chinese automakers, with a combined output of around 2.5 million vehicles a year. Thailand boasts a correspondingly healthy automotive supply industry, with the Thai Summit Group as the largest player.

In Thailand, EV production is now being ramped up. Mercedes-Benz manufactures batteries here, and BMW assembles five different plug-in hybrid models, both of which will boost demand for certain kinds of laser machine. Companies in Thailand are primarily investing in high-power laser machines.

**VIEW ON THE ECONOMY**

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**Nominal GDP per capita**

7,168 U.S. dollars

**Industry as a proportion of GDP**

45%

**Inhabitants**

70m

**Laser Tech in Thailand**

Among automakers and suppliers alike, demand is high for 3D laser-cutting machines—to produce bodywork parts, for example. In Thailand, EV production is now being ramped up. Mercedes-Benz manufactures batteries here, and BMW assembles five different plug-in hybrid models, both of which will boost demand for certain kinds of laser machine.

WELCOME TO LASERLAND THAILAND!

**IN A STRONG BACK.** Netflix and all the other streaming services are the couch potato’s best friend—and natural enemy of a healthy back. And there’s also nature to contend with: from the age of 30 onward, disc degradation sets in—and, with it, all kinds of back ailments. Regular workouts are a big help here. But be wary of doing too much, too soon! Rushing into training unprepared can cause major injury. Fitness equipment such as Smart Strength from EGYM is great for workout newbies. These machines adapt to the training requirements of each user and feature onscreen animations to show whether the exercises are being correctly performed. The frame is made by specialist metal fabricator Steinhart from southern Germany, using laser tube-cutting and combination punch-laser machines. So, get off the couch and get down to work with your very own smart personal trainer!
OPTICAL MICROPHONES have a greater dynamic range than conventional mics. How? A combination of laser diode and interferometer accurately measures even the smallest vibrations of a silicone membrane—all without any self-noise from the microphone itself. Produced by Norwegian company sensiBel, this technology takes up a mere cubic millimeter in volume and is perfect for cell phones, headsets and similar devices. Now you can record street concerts, conversations and video soundtracks in studio quality for all eternity.