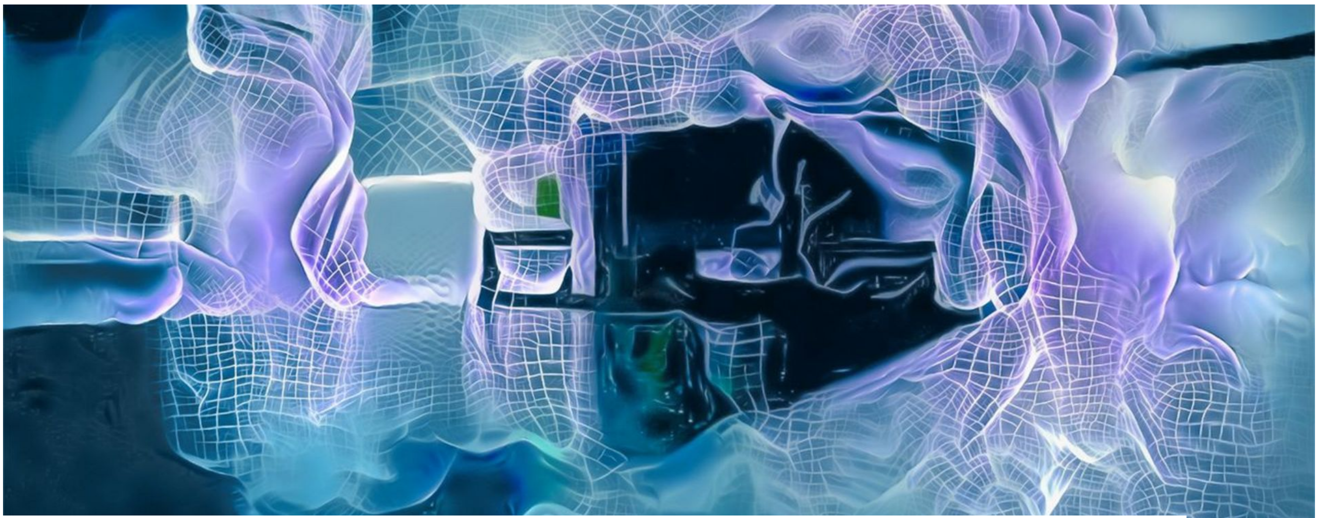


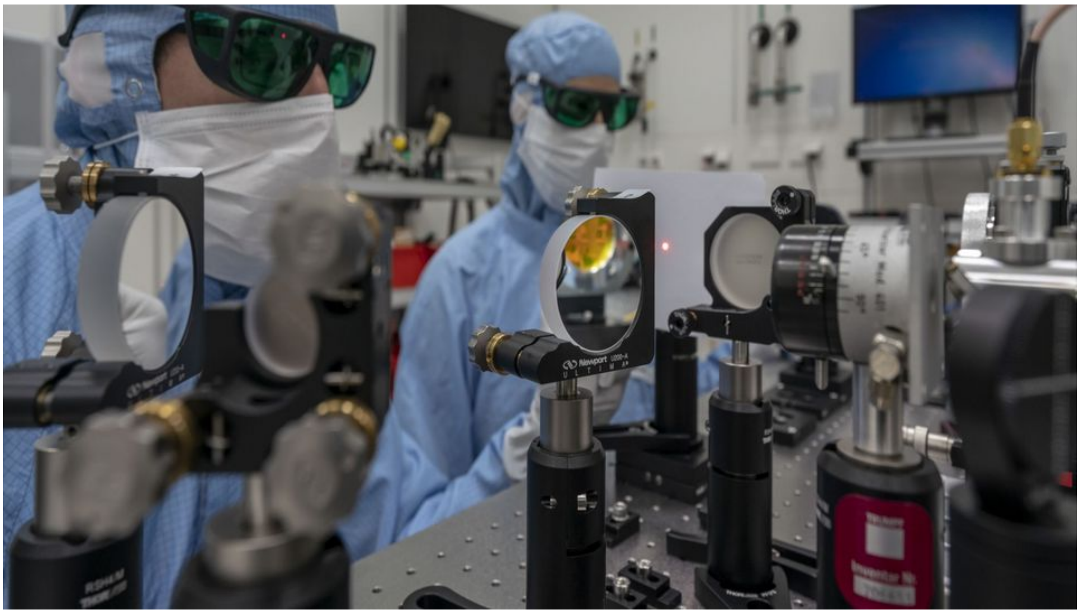
ATHANASSIOS KALIUDIS

The future of lasers will be magical

After years of attempting to reach the top, the laser is now the smartphone of industrial tools. Like lasers, smartphones are truly small marvels of engineering, but hardly anyone is amazed by them anymore. They've simply become to ubiquitous - too normal. But there is a lot going on in the field of laser technology at the moment - laser users are learning to think differently. This is because in the future, new productivity gains will only be possible if we start viewing laser machining as part of a larger process. Let's now take a look at the most exciting and promising trends and industries when it comes to the future of laser technology.

Promising new field: Optics und beam guidance

When laser experts finally succeeded in using ultrashort laser pulses to drill tiny, closely spaced holes in rapid succession a few years ago, it was an incredible feeling. So what’s next? We’ll soon be able to drill a thousand holes at once, of course! But this huge leap in productivity will require a fundamental shift in per-ception. We used to talk about a laser beam hitting a material at the focal point, but experts now prefer the more precise definition of a laser wave being generated within the material and a focus that is a spatial distribution of intensities. This new way of thinking is called wave optics. The previously predominant model of ray optics describes the propagation of laser light as a ray, the far more complex model of wave optics views laser light as a wave. This is not merely a theoretical exercise. It is driven by what certain materials and specific applications actually need from laser light. Glass, for example, can be – tech term ahead – “intrinsically modified” and therefore divided by a laser (this no longer has anything to do with cutting). Thanks to wave optics, it’s even possible to split laser beams into a thousand parts. The result? Processes that are a thousand times faster. The task in the future will therefore be to form, bend, squash and stretch this coherent bundle of waves, to chop it into pieces and deliver it to the precise place where we want it to act everywhere simultaneously. That requires very different things from process development – and from optics. Put simply (and please don’t take this personally!), focusing is a beginner’s game, because over the next ten years the real interest will lie in diffraction. Constructing models for this is a highly complex task requiring Herculean mathematical efforts. But once the systems are up and running, laser operators will benefit from tremendous productivity gains and fields of application that were previously impossible to imagine.



There is a lot going on in the field of laser technology.
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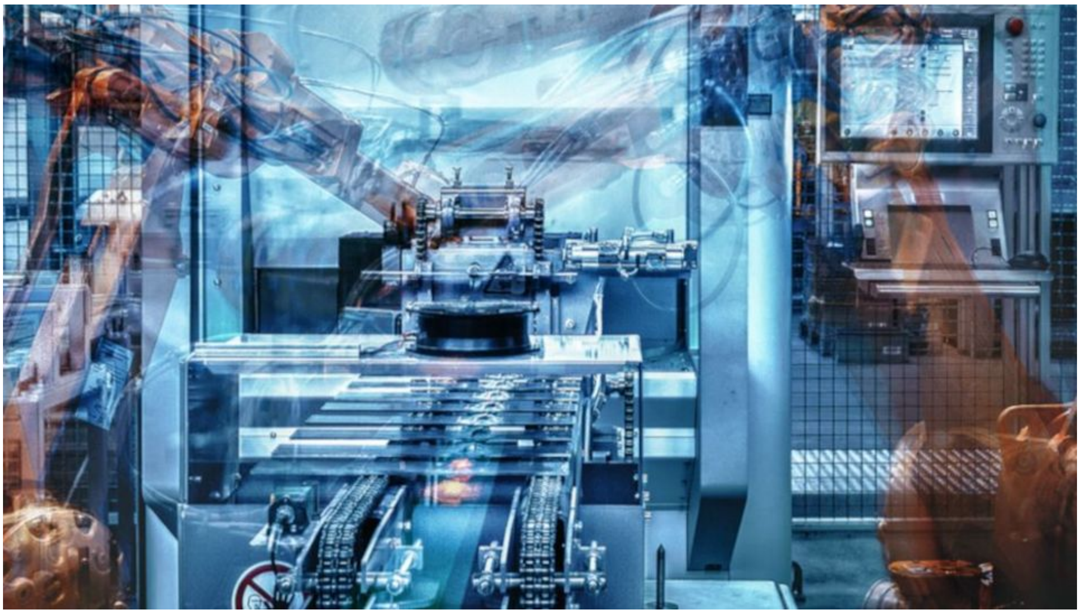
Promising new field: Sensors and process monitoring

The first five-axis machine was the pinnacle of precision engineering: it held the part under the optics in exactly the right position and at exactly the right angle, with micrometer accuracy – only for the optics to fire blindly into the chamber! So what's next? In the future, when we put part X in the machine, sensors in the optics will immediately identify the type of part, material, position and welding points, and the laser will make the welds in exactly the right places. The whole crazy complexity of high-precision clamping will suddenly become so much simpler once machines can align themselves automatically – and machine design will be turned on its head. Sensors are the logical answer to a number of questions that the industry is currently asking itself: How can we deal with ever stricter standards of quality and precision? How can we verify the results? What's the best way to obtain data for simulations or artificial intelligence? How can we increase the level of automation in order to boost productivity? The answer to all these questions is to give machines the ability to sense their environment, to perceive and interpret the world around them. So in the future, when a component is fed into a laser machine, it will automatically detect what needs to be done thanks to a large number of sensors and begin the process immediately. We're probably already close to achieving this in laser marking – and all the other laser applications will follow suit in the years ahead.

Promising new field: Digitization and artificial intelligence

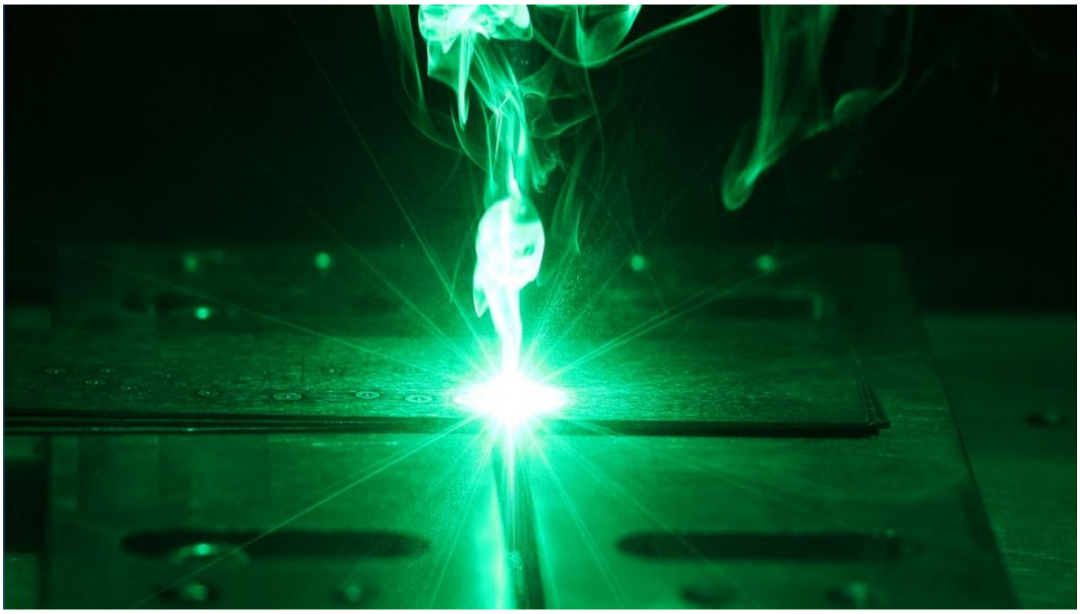
Connected manufacturing has gotten off to a good start in recent years, but the transformation of workshop and production halls into smart factories is far from over. This becomes apparent, for example, when looking at the fields of remote maintenance and remote condition monitoring. The big question is one of availability and uptime. Obviously every user wants their laser system to run reliably all the time. But things have moved up a gear since the semiconductor industry and consumer electronics threw their weight behind lasers. These two industries take system availability requirements to an almost absurd level, so their expectations are driving the entire laser technology sector forward. That's good news for all industries. Meanwhile, artificial intelligence (AI) is making its way onto the factory floor. While AI's strengths used to lie more in intangible processes such as production planning, it is now moving closer to the machines themselves. Over the next few years, these electronic brains – fed with data from sensors and simulations – will come up with completely new kinds of laser processing strategies, refining each step in the process as they learn more and eventually taking over the programming of connected machines themselves. This will lead to huge gains in productivity.



Digitized production also needs a tool that is just like it – fast, direct and flexible: laser light.
© Ralf Kreuels / Gernot Walter

Promising new field: New beam sources

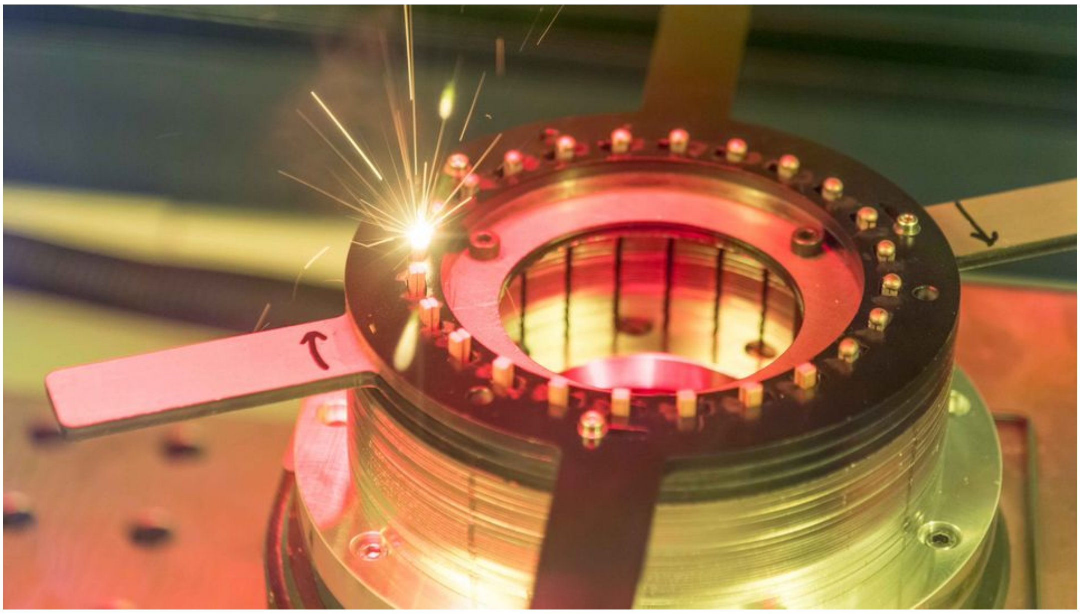
The basic beam source concepts have all been common knowledge since the 1970s – CO_2, solid state, diode, fiber. But there's still plenty of room for improvement. Engineers are constantly finding new ways of getting more out of their laser systems, from higher pulse energies and higher average power to shorter pulses and better beam quality. This looks set to continue in the years ahead. But apart from the race to set new records in this or that aspect of industrial lasers, what are the key developments that users should be keeping an eye on? First, the range of wavelengths is getting larger. In theory, we already have access to laser light at all possible wave-lengths, it's simply a question of finding the necessary power. This obstacle is gradually being overcome in all wavebands – the reliability of the disk laser has given us the tools we need to generate high-power laser light in all possible colors ready for industrial use. One of the most recent examples is green laser light, which is readily absorbed by nonferrous metals, making it the perfect choice for applications in e-mobility. Soon it will be possible to generate powerful beam sources at exactly the right wavelength for all conceivable applications. Second, lasers are getting smaller. Semiconductor lasers, direct diode lasers and other lasers are steadily shrinking into miniature formats. This makes them easier to use in all kinds of systems, from cell phones to operating rooms. It also paves the way for entirely new applications such as laser-based scanning of the environment in autonomous vehicles and quality control. The first developers are already working on ways to pack the laser medium into an optical fiber, allowing laser light to be generated "on the go." Although such beam sources are not fundamentally new, they illustrate how old concepts are revealing a level of flexibility that most people would have thought impossible.



Using green light, copper welding becomes more energy efficient and of higher quality, irrespective of the properties of the material surface.

Promising new field: Electric vehicles

The transformation of the automotive industry from the internal combustion engine to electric-powered vehicles is creating a wealth of new applications – and it is, of course, lasers that make the highly efficient mass production of the new components possible. First and foremost, the battery. Although in fact, despite being succinctly referred to as a "battery," this is actually a complex structure consisting of a battery cell, battery module and battery pack. Batteries for electric cars consist of several layers of wafer-thin copper and aluminum foil that have been cut and welded by a laser. Afterwards, liquid electrolyte is poured in and then the battery is welded shut with a cap. These welds must completely seal the battery to minimize the risk of fire and injury. Second, the electric motor. Here, manufacturers are increasingly relying on what is known as hairpin technology. Normally, the stators in electric motors are equipped with coils of copper wire that create a rotating magnetic field that makes the motor run. Each individual slot in the stator is wrapped in a coil that goes in and out, in and out, almost like knitting! But due to the thick copper wires, this would be too time-consuming and too expensive for powerful electric motors that must move an entire vehicle. This explains why manufacturers are relying on hairpins. This involves using a compressed-air pistol to fire a rectangular copper wire, similar to a hairpin, into each slot. The protruding parts of the wire are then twisted together and welded using a laser – this also creates a coil. And third, the high-performance electronic components. With charging plugs, transformers and rectifiers, electric vehicles feature a whole range of new power electronics. While a 24-volt battery is enough to power all the electronics in a vehicle with a combustion engine, electric cars can easily hit 800 volts or more. This means that extremely rugged connections are required. As an excellent conductor of heat and electricity, copper is the material of choice. But copper can only be welded efficiently with a very special laser – namely a green laser (also see the section on new beam sources) – otherwise too many spatters occur and the risk of short circuits increases.



For electric vehicles manufacturers are relying on hairpins.
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Promising new field: Quantum technology

Quanta are everywhere, but the way they behave is something the human mind struggles to grasp. For example, in quantum mechanics it’s possible for something to exist simultaneously in two mutually exclusive states or occupy two different positions at the same time. This is beyond confusing, but it opens up exciting possibilities. Quanta carry specific information encoded within them, for example on their intrinsic angular momentum, or “spin.” In order to read this information and use it for calculations and other purposes, we have to make it visible, in other words amplify it to some degree. This is possible with quanta of light, i.e. photons. But not just any old photons! Depending on what you are trying to measure, these photons need to exhibit certain properties, for example a precisely defined wavelength or polarization. This requires a beam source that does exactly that, namely produces photons with a precisely defined wavelength and with a very specific polarization. The TRUMPF subsidiary Q.ANT develops and produces industrial solutions with these types of beam sources. Its potential areas of application are virtually endless. Quantum technology will play a key role in numerous different areas, from novel sensor systems for medicine and autonomous driving to new types of data encryption to new microscopes and equipment that we can’t even imagine yet!

ATHANASSIOS KALIUDIS
TLA□OVÝ HOVORCA TRUMPF LASERTECHNIK

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