The Magazine of SGL Carbon 01_20

thinc further

The Value of Vision

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sgl carbon

Zoom

This transfer crucible for high-temperature furnaces is heat-resistant, thermally conductive and resistant to chemicals. These are all properties that this 3D-printed crucible made of silicon carbide needs, since it must withstand high temperatures! Researchers from the Fraunhofer Institute for Silicate Research (ISC) / Center HTL will use the crucible for testing high-tech materials at 1,200 degrees Celsius in it for extreme aeronautics and industrial applications. In SGL Carbon's 3D printer, the crucible is first constructed layer by layer. Subsequently, it is infiltrated with liquid silicon in a high-temperature process, which gives the crucible its robust characteristics. Thanks to 3D printing, complex or unusual designs can be realized in an efficient way. Furthermore, it saves a lot of material which would otherwise go to waste. Previously each component had to be milled out of a single block. The material loss was up to 80 percent, and some shapes were impossible to mill. Now the crucibles are produced very close to the final shape, with a ma terial waste of nearly zero percent.

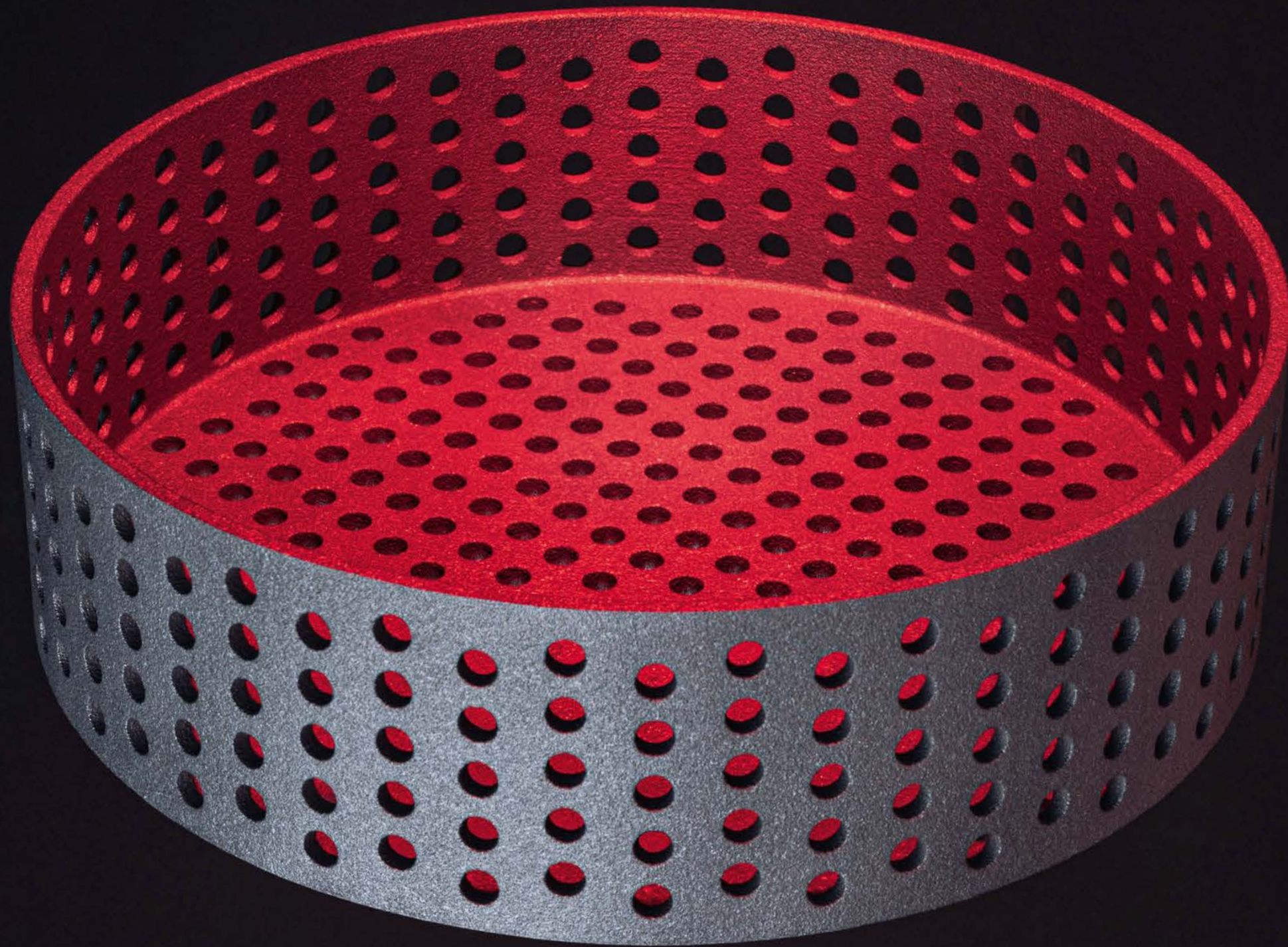


PHOTO Jan Steinhauer

#sglthinc further

Moving forward requires that decisions be made. And to make decisions, you need a good foundation—a foundation that provides both food for thought and impetus for action.

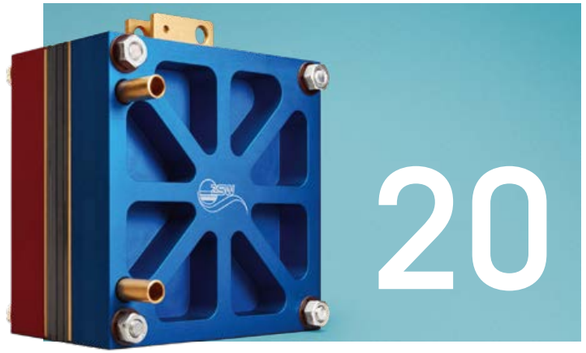
A **vision** can provide this sort of foundation. The vision defines a goal, gives the goal meaning and formulates an aspiration. It offers **orientation** in the flood of decisions and reduces complexity to a tolerable level. And it also helps when things turn out differently than expected, when an idea proves to be the wrong path or even when a simple mistake is made. In these types of situations, a vision can remind you what it's really all about.

As SGL Carbon we have also made mistakes and suffered setbacks. Our vision of a **smarter world** spurs us onward all the more: to improve ourselves every day, to continue down our path in order to win over our clients with smart solutions.

We've dedicated this issue to the value of vision. In it we introduce people who are constantly pursuing their goals just like we do. We visited our factories in Poland, where the foundation for many of our **solutions** is created. And we take a look at the fuel cell, the vision for which is in the process of becoming a reality. We're looking to the future: **thinc further!**

The Long View

Our world is more complex than ever. Moving forward requires a vision. We present five visionaries—and explore how a vision can best be realized.



Ready, Set, Go

The fuel cell is regarded as one of the most important and sustainable technologies of the future. SGL Carbon provides the necessary materials and solutions.

Simply Efficient

Flexible, reliable, innovative: our locations in Poland are constantly reinventing themselves—thus paving the way for our progress. A site visit.

PHOTOS Frederike Wetzels (p. 8, Cover); Ragnar Schmuck (p. 20); Julia Sellmann (p. 26)

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People

When SGL Carbon offered me the job in Shanghai, I was a bit hesitant because I've moved around a lot in the past. Ultimately, however, the project's appeal and my wanderlust were stronger. I grew up speaking two languages and have strong personal connections to both Germany and the US. I've worked for SGL Carbon in Meitingen and Wiesbaden in Germany, and also in the US. Asia is now the third continent that I've lived on for the company and this was the point that really convinced me. I love working in international teams and getting to know new cultures and I'd never lived in Asia before for any length of time. I'm learning Chinese right now and am starting to find my way around this huge city. Of course, there's also the exciting technology and the extremely challenging project involving experts from the US, Germany and naturally plenty of colleagues from Shanghai. Together we're building a real high-tech factory.

I've only been living in Shanghai for a few months, but I'm already feeling quite at home. My coworkers gave me a very warm welcome, showed me everything and have fully integrated me into living and working here. They've given me tips about the most important Chinese apps and interesting cultural attractions, introductions to Chinese cuisine and much more. The hospitality is fantastic and is a super foundation for successful teamwork—and we will need it. SGL Carbon is building a huge expansion of our factory here, to supply the LED industry with high-precision coated graphite components. I'm responsible for the engineering of the production facilities and infrastructure and work in close collaboration with my Chinese colleagues.

Name
Thomas Tichy (33)

Current Location
Shanghai, China

Position
Engineering Manager

What drives me at work
Large international projects, technology, working in teams across borders

What fascinates me outside of work
Music (playing guitar), gliding, drones, DIY projects and 3D printers, Latin dance

GET IN TOUCH:
Thomas Tichy

PHOTO Matjaž Tančič

Technology

Cleverly Grown

Our modern world would be unthinkable without semiconductors—computers, smartphones, autonomous vehicles and countless additional products are based on this technology. Many semiconductors are made of silicon. This metalloid is grown into single crystals, sliced into thin wafers and, finally, processed into tiny micro-electric circuits, or chips.

Growing these monocrystal ingots is one of the most important steps in the production process. It must result in a lattice structure that is as perfect as possible, thereby laying the foundation for the quality and performance of the chips produced from it. Special high-temperature furnaces first heat the purified silicon to around 1450° Celsius. Then a rod ❶ with a mounted seed crystal is lowered down into the molten mass, which is held in a crucible ❷ made of quartz. ❸ The rod and crucible rotate in opposite directions. As soon as the seed is immersed in the liquid silicon, the rod, which continues rotating the entire time, is slowly pulled out of the molten liquid. Since the surface temperature of the liquid silicon is just a little bit above silicon's melting point, the liquid silicon deposits itself on the seed crystal and then solidifies, taking on the same crystalline structure as the seed crystal in the solidification process—a monocrystal ❹ up to 30 cm in diameter begins to grow.

The temperature of the molten silicon, the speed of rotation and the speed at which the rod is pulled upward determine the crystal's diameter and quality. The entire process can last up to one hundred hours and takes place in a protective inert atmosphere so that the silicon doesn't oxidize.

SGL Carbon manufactures highly pure heat- and corrosion-resistant support crucibles ❺, heaters ❻, heat shields ❼ and insulating components ❽ made of graphite. Graphite is the material of choice because it has no problem resisting extreme temperatures and chemical processes. Since it's highly pure, it also prevents contamination of the molten silicon, thereby providing the best conditions for the highest quality.

ILLUSTRATION Laura Cattaneo

The Long View

Our world is more complex than ever. If you want to move forward you need a vision—and to implement a vision you need above all **endurance, flexibility and a comprehensive overview.** An essay about the value of having a vision—backed by examples from five real-world visionaries.

Visions bring focus to a goal and provide perspective

When John F. Kennedy appeared before a joint session of Congress in Washington DC on May 25, 1961, he brought along an idea with huge ramifications. "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the Earth," Kennedy said, declaring his vision to the legislators. Eight years later, on July 21, 1969, Neil Armstrong became the first person to walk on the moon.

Immense forces were unleashed when Kennedy made his famous speech stating publicly this goal. NASA's budget was increased by 400 percent. Up to 400,000 people worked either directly or indirectly on the Apollo Project. The US ended up investing more than 24 billion dollars in its space program. The expression of a vision had an impact—and was regarded as a powerful tool for every organization from that point forward.

This situation was quite different in Germany: during the election campaign in 1980, former Chancellor Helmut Schmidt once said that a person with visions would be better off going to the doctor. With these words, Schmidt initially dealt a lasting blow to the notion of the vision. Visionary ideas and visionaries have thus been interpreted very differently in various countries throughout history.

Since that time, the vision has been rehabilitated in Germany and also enjoys a good reputation globally. After all, there are sound arguments for one, something Kennedy proved back in the sixties: a vision can give purpose and combine forces. It can bring focus to a goal and provide the perspective necessary in a world that's becoming more and more complex.

Everything is connected to everything

Around 500 years ago, being a successful baker required just flour, water and yeast, plus heat to transform it into loaves of bread. Some 200 years ago, getting started as a textile producer already required technical knowledge and a sales strategy. Even 50 years ago, market research, optimized supply chains and coordinated production processes had long been essential for any producer of household appliances.

All of this is no longer enough today. Even fairly straightforward products like electric toothbrushes have traveled tens of thousands of kilometers, crossed oceans, passed through dozens of factories and been advertised with the aid of data-driven marketing before they reach the consumer.

"Our world is complex," says physicist Peter Klimek. At the Complexity Science Hub in Vienna, he investigates how complex systems work: what rules they obey or whether complex systems have any rules at all. "Often, there are densely interwoven networks of interdependencies in these types of systems," he says. Put another way, it means everything is connected to everything. When one little thing changes in a complex system, it can affect everything else.

Klimek thinks that the economy also follows the mechanisms of complex systems. "Our economies are more interconnected than ever these days," he says. "If the conditions of a participant, a company for example, change, this potentially influences the conditions of many other companies, since they are connected to each other, for example through the supply chain."

This makes business decisions extremely complex these days. The technology a company relies on, the country where it builds a new production facility, the sales markets it decides to focus on—every decision has consequences for all other market participants. And that raises two very important questions: How can the right decision be made? And what do you do when the decision was the wrong one? Management science has numerous answers, theories and suggestions for these

Hans J. Steininger
CEO of MT Aerospace, Augsburg, Germany

PHOTO Frederike Wetzels

"With space travel we leave the Earth and enter into dimensions that are hard to imagine. We're suddenly talking about time periods of billions of years, about distances that can't be described with words. Questions arise that you often forget in everyday life and it's about things that are barely comprehensible with normal thoughts. Despite all this, space travel is attempting to press forward into these dimensions, to discover them and develop them. I've always been fascinated by it all. With MT Aerospace, we're now helping to at least scratch the surface of these dimensions. We design and produce highly complex components for launch vehicles around the world. We're pushing up against the limits of our materials every day and are assessing what is still physically possible.

Fortunately, this technical fascination unites the people working in our industry. We're all infected by the flight virus and we're all striving for technical perfection. We're united by the spirit of discovery and by the idea of going to the limits of what's possible."

The vision really pays off for important decisions. It helps us to keep the big goal in sight and provides guidelines for developing product ideas from our own know-how that can also earn money and keep the company going. In the day-to-day business, Tuesday morning at ten, it may play a more subordinate role. But in the long run, a shared vision is indispensable."

"Fiber reinforced composites have fascinated me since university. At the time, like many students I was working part-time and producing composite parts. The work was typically cutting semi-finished fiber products for hours on end and then laminating them, layer by layer, with resin. It was all done by hand because we were building prototypes. At some point your hands were aching, I was too slow and once a bucket of resin vaporized. I thought at the time: I don't want to have to do this forever, you should be able to automate this! I've been inspired by the idea ever since.

I was involved with basic research, then industry and finally arrived at the interface between the two at Fraunhofer IGCV. Here I was lucky to be part of Prof. Klaus Drechsler's team that built up the Composites Division from scratch. It was a wonderful experience because we were able to create something really new and through the partnership with SGL Carbon we know exactly what's needed in the real world.

We now have some automation solutions, but we're still not fast enough to keep pace with market developments. It's like a baker who wants to bake 50,000 loaves a day instead of just 50. And with more complicated ingredients than water, yeast and flour. Of course, when something goes wrong it feels terrible at first, but it quickly changes into strength. Mistakes are 'made' to learn from: how to accept help and how to grow from them. Having dependable partners who accompany you along the way, through all the stumbling blocks and detours, helps immensely—there's more action. Every partner has a completely different view of the problem. And once it's been looked at from all of the perspectives, it's as good as solved."

Lazarula Chatzigeorgiou
Department Manager Composites
at the Fraunhofer IGCV,
Augsburg, Germany

PHOTO Frederike Wetzels

A pathfinder in the jumble of constant change

questions. Yet as different as the approaches may be, they have one thing in common: they need a vision to work.

But what is a vision and what does it mean for a company? By definition, a vision is first and foremost an idea of an ideal condition in the future. So it's a strategic goal that provides orientation. A pathfinder in the jumble of constant change. A type of multifunctional tool in the jungle of complexity that can be used to overcome obstacles and head off in the right direction at the innumerable forks in the road.

Yet that's not everything. There are also aspects of what is called purpose, and for some time now this has come to mean a new concept. It brings together a company's objective with its understanding of its role in the world. It embodies the idea that employees aren't just driven by remuneration and career opportunities, but by a sense of meaning and the pursuit of a common goal. A company's purpose provides answers to the question of why: Why are we doing what we do? What do we want to achieve in the world? Why are we producing carbon and graphite in all possible variations and not metal or glass? Why do we care about sustainability? Why are we heading down this path and not another? Why do we follow values such as openness and a high degree of commitment? Why do we want to provide impetus?

A vision answers these types of questions because it presents a goal and focal point that goes well beyond mere figures and pure shareholder value. It emphasizes stakeholder value, thereby including all the relevant interest groups in its actions. And, in SGL Carbons' case, it defines an aspiration for itself: We're making our contribution to a smarter world!

Clever and flexible implementation

A vision therefore has a high value for companies. It helps guide the company and makes it easier to recruit the best employees. It transforms work by creating a common goal and serves as a reminder, in turbulent times, of what the company is really about. It shows why the hard work and efforts are worth it.

At the same time, every vision also holds a danger. Coordinating thoughts and actions towards a particular goal means an inevitable focus on just that. While searching for data that supports a given thesis, other developments are possibly overlooked, ones that might have opened up other potentials. The world may automatically be interpreted through a certain lens and exclude other potential developments with every decision made.

Every vision is therefore only of value when it is combined with clever and flexible implementation, particularly in a complex world. "It always depends on what you make of the vision," says economist Nitin R. Joglekar.

"My final project at university was to develop a new type of traffic light sequencing. I made the chip for it myself in the mini-lab at my university. When the traffic light worked, it was a pivotal moment for me—the enthusiasm to set things into motion has stayed with me until this day.

Back then, the internet and smartphones were unforeseeable. In the meantime, they've revolutionized entire industries, our whole lives. This demonstrates the power that visionary ideas can have. Real progress only becomes possible when you break free from conventional ideas and think beyond the contradictions and the small details of everyday life. And when you are prepared to accept setbacks, learn from your mistakes and just keep going—as an individual and in a team.

I believe the electronics industry is the most exciting industrial sector. Not least because, this industry generates 80% of innovations but also visionary thinking is part of everyday business. After all, it's creating technology solutions for the huge technical, economic and social challenges of the future. Medicine, mobility, energy supplies, environmental protection—smart electronics play a role in practically every area of life.

This naturally also creates its own challenges. The number of connected devices will reach the trillions by 2030 at the latest, and the amount of data they generate is growing exponentially. How can this data be put to good use? What business models have a future, where do we need new approaches? How do we manage to provide young people around the world with the necessary know-how for the digital economy? And how can all of this be achieved in a sustainable and environmentally friendly way? SEMI, the global electronics design and manufacturing industry association with over 2,100 members worldwide, is helping to find answers to these questions. For instance, by connecting all the key players and key stakeholders along the value chain. And—we hope—by providing them with visionary ideas."

Laith Altimime
President of SEMI Europe, Berlin, Germany

Sven Bauer
CEO and founder of the BMZ Group, Karlstein am Main, Germany

"Climate change is one of the greatest challenges of our time. We'll only come to grips with it if we stop using fossil fuels in the near future. We need a true energy transition for this and it will only be possible if we can provide sufficient energy storage systems.

When I was growing up, lead batteries were the be-all and end-all and cell-phone batteries were as large as briefcases. What it meant at the time was low performance for high cost. That's when my vision was born to make it better and prove otherwise. To show the world that we can power forklifts, buses, cranes, boats, wheelchairs, electric bikes and every other mobility device with efficient and affordable battery packs.

When you set such high goals for yourself, it's important not to set any limits on your thinking. It's about strategic planning and learning from the wrong decisions. We've been operating at the BMZ Group exactly like this over the past 25 years and recognized the potential of lithium-ion cells as an energy storage medium early on. Today we're the market leader in Europe and are growing around the world. We're delivering the energy for the energy transition—and exactly when it's needed."

PHOTOS Frederike Wetzels

Domenik Radeck
Research Lead TUM Hyperloop (Pod), Garching, Germany

"Even as I child I imagined that people would travel through tubes in ultrafast trains one day. That is the vision that inspires me and gives me direction. I'm studying mechanical engineering, writing my master's thesis on the topic and spending almost all of my free time in the student TUM-Hyperloop team of NEXT Prototypes e. V. Although we're not being paid for it, it feels right for me. Everyone in the team is passionate about the goal, everyone is giving their best.

Of course, when building prototypes we constantly reach points where we notice that we've made a wrong decision. That's the nature of things and is painful. But it's not tragic. We just have to take a step back at that point, analyze and continue. It's an enormous relief to know the direction we're supposed to be heading. Even if a plan doesn't work right away, you know things will go on.

The whole thing is a process in which you're constantly comparing your vision to reality. Now and again you notice that you have to fine-tune your idea to move forward. That hurts as well, but it's also worth it. In the end, the Hyperloop may not look exactly like I imagined it would as a child. But it will still be based on the same idea. And I helped make it a reality."

PHOTO Frederike Wetzels

View problems as opportunities instead of obstacles

He investigates innovation and management processes at the Boston University Questrom School of Business. In 2012, he and his colleague Edward G. Anderson published the book The Innovation Butterfly. Referring to the butterfly effect, they describe the potentially enormous effects the smallest changes can have in complex systems.

Joglekar calls such changes innovation butterflies. They can be ideas or inventions, but also changes in project plans. They first appear as inconspicuous disturbances but then expand into large-scale effects through the interwovenness of complex systems. One example Joglekar cites is Nintendo's development of the Wii game console. Instead of investing in ever better graphic simulations, Nintendo instead focused on more intuitive controls for the console, developing a completely new controller. What initially appeared to be a small change ended up turning whole areas of the industry completely upside down.

Huge opportunities

To deal effectively with such sudden developments, companies should continually question their vision, Joglekar recommends. Not daily, not every week, but regularly. This requires flexibility, continuous change, perseverance and a comprehensive overview—only then can a company infuse a vision with the life it needs.

Joglekar describes in his book what this means in practice: companies should do everything in their power to gain as complete an overview of their industry as possible. They must learn to identify disruptive disturbances early enough with the help of large amounts of data and artificial intelligence so as to then quickly and flexibly react to them. To ensure this works, they must decentralize decision-making, create agile structures and establish a culture in which problems are viewed as opportunities instead of obstacles.

This means a lot of work for companies—but above all else also a huge opportunity. Those who recognize innovation butterflies or other market or technology changes early enough—or even drive such changes themselves—won't be overwhelmed by the later effects but can take advantage of them. Adapting a vision with agility, flexibility and at the right moment in time means emerging stronger after each change.

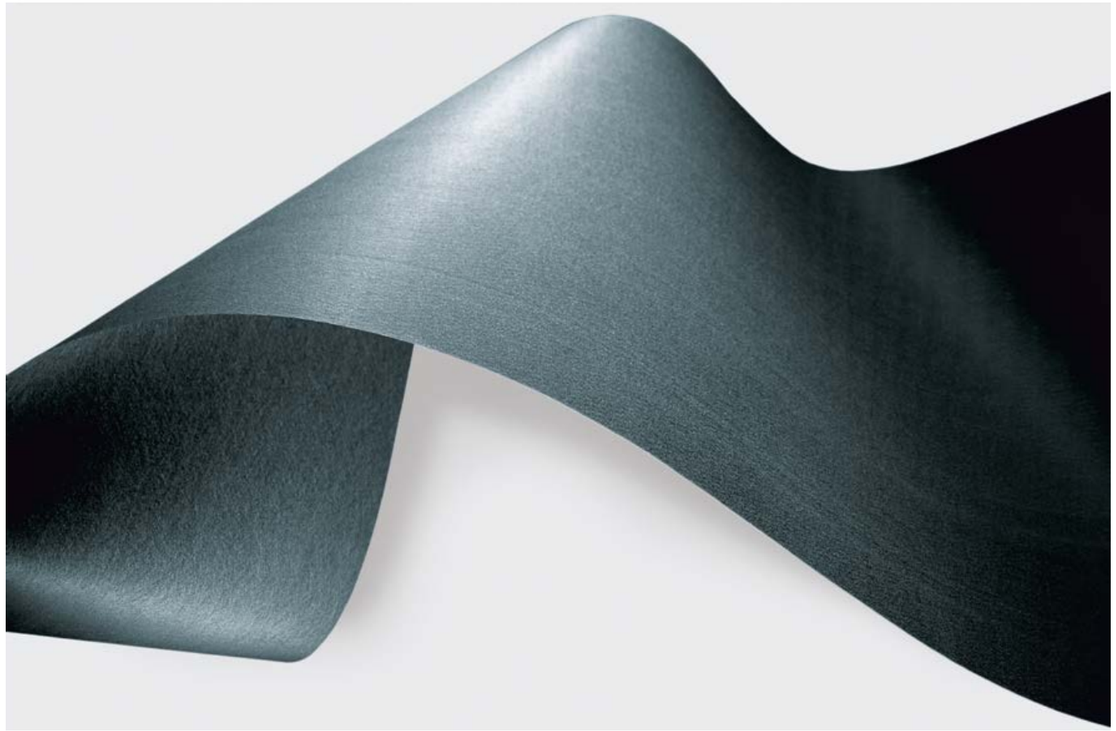
How this works in practice was demonstrated by the meat-processing company Rügenwalder Mühle in Germany. Five years ago, the family-owned company introduced a whole range of vegetarian meat-replacement products to the market. Instead of pork and chicken, the company was now also making sausage and cold cuts from peas, soy and canola oil. The company, steeped in a tradition of earning its money with meat products for more than 150 years, dared to undertake this experiment at a time when vegetarian replacement products in this field were still a niche product for organic supermarkets and health food stores. Some employees and many competitors were very surprised by the decision. Today, success has proven the company right: the vegetarian products account for almost 40 percent of the company's sales.

The experiment could naturally have also gone awry—the market for meat replacement products is complex. But the step paid off thanks to its far-sightedness, flexibility and boldness. The company hired 140 new employees for the new product line and bought an entire new building for it as well. The company's in-house cafeteria now also serves a vegetarian meal every day.

Complex systems aren't just an opportunity. They're also an invitation to try things out and advance your own ideas. They are a wide field of possibilities. Going forward with flexibility, perseverance and an overview of the surroundings gives you a good chance of turning a vision into reality.

In a Nutshell

News about the company, trends, products and partnerships



Major Order from Hyundai

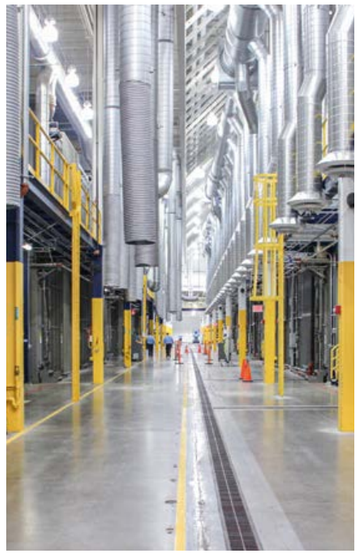
SGL Carbon and Hyundai Motor Group have agreed to an early extension of the current supply agreement for fuel cell components. The long-term contract involves a considerable increase over current production and delivery volumes for gas diffusion layers for the NEXO SUV to support Hyundai's goals in the field of hydrogen-powered vehicles. The investments necessary for this contract are not raising the total investment budget for the next two years because SGL Carbon has re-prioritized its investment projects. "The expansion of the Hyundai cooperation fits perfectly with our strategic alignment," says Dr. Michael Majerus, Spokesman of the Board of Management of SGL Carbon. "Smart solutions for the field of sustainable energy are one of our key growth drivers. Whether for powering vehicles or as a stationary energy supply, fuel cells are one of the most environmentally friendly technologies in the energy technology arena. The market for fuel cells therefore holds great potential for us." SGL Carbon plans to increase sales for fuel cell components five-fold over the medium term—to around 100 million euros annually. The company supplies around two hundred customers around the world with gas diffusion layers for use in fuel cells. In line with rising demand, the company has been successively increasing its production capacities at its site in Meitingen, Germany.

Young Talent Secured

Forty-four trainees began their careers at various German and Austrian SGL Carbon facilities in early September 2019. They're preparing for a future as industrial managers, process mechanics, cutting machine operators, machine and plant supervisors, mechatronic engineers and electronics engineers, for example. Furthermore, SGL Carbon also offers dual degree programs with a business or technical focus, such as mechanical engineering. At the start of the new training year, SGL Carbon Group Vice President Human Resources Birgit Reiter said, "The skills and knowledge of our employees are a central factor for our success as a technology company. Our in-house training is traditionally an important source for covering our personnel needs in the commercial-technical field. Our trainees and dual-program students are part of the future of SGL Carbon."

Full Load

Since the middle of last year, SGL Carbon has been mass-producing transverse leaf springs made of fiberglass-based composites for the rear axle of the Ford Transit. The leaf springs are used in conjunction with the Transit's low-frame chassis. They are thus utilized where large payloads and additional loads are required, for instance in motorhomes or in special commercial vehicle versions of the Transit. It is the first leaf spring project for Ford with mass-produced composites. The innovative components are one hundred percent compatible with conventional steel springs, offering a weight savings of around 50 percent and increased safety standards. "The composite transverse leaf springs for the Ford Transit low-frame chassis are another milestone in developing lightweight leaf springs suitable for mass production," says Sebastian Grasser, automotive director for the SGL Carbon Composites—Fibers & Materials business unit. "They are impressive not only for their special material properties and a partially automated manufacturing process that was implemented from the outset, but particularly for their high degree of compatibility with the customer's various models."



Cooperation with Solvay

SGL Carbon and the international chemical company Solvay have entered into a joint development agreement to introduce fiber composites based on large-tow carbon fibers to the market for the first time. The materials, which are based on SGL Carbon's large-tow IM carbon fibers and Solvay's resin systems for primary structures, are expected to meet all the requirements for modern commercial aircraft in the future: lower costs and carbon dioxide emissions as well as higher production and fuel efficiencies. SGL Carbon's expertise in the mass production of carbon fibers and Solvay's leading role as a supplier of advanced materials for the aerospace industry form the foundation for this cooperation. Fiber-reinforced composites in the aerospace industry are a growing billion-dollar market.

PHOTOS SGL Carbon (3 x); Ford (Transporter)

READY, SET, GO

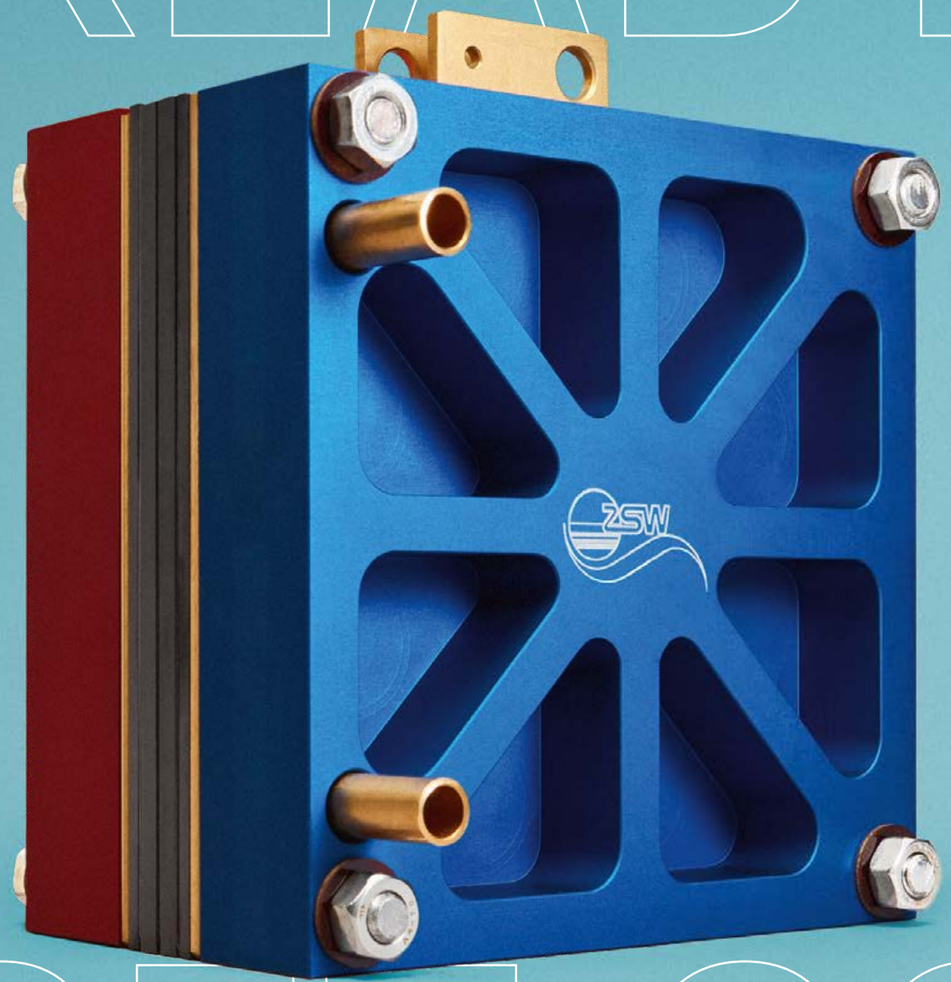


PHOTO Ragnar Schmuck

Fuel cells are regarded as one of the **most important and sustainable technologies** of the future. Yet until now teething troubles and high costs have been holding them back. Scientists and manufacturers are working on increasing their utilization—with SGL Carbon solutions and know-how.

The train on track 4 rolls into Bremerhaven Central Station with a quiet hum. This Monday morning, at 9:20 a.m., train RB33 is right on schedule. Outwardly there's nothing unusual about it: it's painted blue with white lettering and is several wagons long. Hidden inside, however, is a technology that could largely determine the direction of many transportation concepts of the future.

The RB33, on its route for Bremervörde via Bremerhaven to Cuxhaven, runs on hydrogen. Two fuels cells on top of the train convert the hydrogen gas and oxygen from the air into electrical energy. The only byproducts are water and electricity: not a bit of harmful fine particulate matter, not a gram of carbon dioxide, but 200 kilowatts of power per fuel cell. The two cells can propel the train at speeds reaching 140 kilometers an hour. There's enough hydrogen in the full tanks to cover up to 1,000 kilometers. Two such trains have been rolling across northwest Germany for the past eighteen months. It's the first time anywhere that hydrogen-powered trains have been running regular routes. The first results from the project are promising: hardly any technical issues, satisfied passengers, and a whole lot of attention.

The hydrogen train in northern Germany is just one of a dozen projects worldwide in which the fuel cell is experiencing the beginnings of a renaissance. In the US, Bosch and Nikola Motors are developing a fuel cell for trucks, with more than 1,000 horsepower and a range of 1,600 kilometers. Hyundai has a brought an affordable and powerful hydrogen-powered SUV to market with its NEXO model. In the aviation industry, researchers at the American space agency NASA are working with scientists at the University of Illinois on hydrogen-powered aircraft. Out on the water, fuel cells may soon be powering cruise ships, ferries and inland freighters. And bus manufacturers including Wrightbus, van Hool and Solaris are also betting on hydrogen in the meantime.

At the same time, important sales markets are shifting in this new direction. China is planning to build four hydrogen corridors and wants to shift its government subsidies away from electric vehicles and towards fuel cells; by 2030, the government hopes that a million hydrogen vehicles will be operating in the country. The German Chancellor Angela Merkel announced a national hydrogen strategy for aviation. And Japan and California have been strategically driving the development of fuel cells for years now.

After several decades as a "hidden champion," the fuel cell may finally achieve the breakthrough its advocates have been hoping for since its invention. After a number of development steps, this fascinating idea of generating clean, sustainable and efficient energy from two of our planet's most basic elements may soon be making a successful leap from niche applications to the mass market.

Best conditions

The conditions for this to happen are more favorable than ever: the climate crisis is forcing politicians, society and businesses to shift to new, more climate-friendly energy sources. Battery-based electric motors have found their place in urban transport but start to falter over longer distances and in the air, on the water and also by rail. In contrast, the fuel cell has managed to overcome its teething troubles and really shines where battery solutions have come up short. Yet there are still enormous challenges ahead. The infrastructure for comprehensive coverage in providing hydrogen supplies is still lagging behind the very ambitious plans in almost every market. And the production costs for fuel cells are much too high for many application fields.

Just a few kilometers north of Munich, Prof. Dr. Hubert Gasteiger is working to help get this technology over the final hurdles. At the Technical

University of Munich, Gasteiger holds the Chair of Technical Electrochemistry. He and his team are researching the contributions that fuel cells and lithium-ion batteries can make to solving the great sociopolitical and ecological challenges of our era.

Gasteiger is one of the few specialists who is as comfortable in the realm of lithium-ion batteries as he is in the world of fuel cells. He wrote his doctoral thesis on electrocatalysts for fuel cells and electrolysis. He later spent almost a decade advancing materials development for fuel cell stacks for General Motors and Opel. After an interlude at the Massachusetts Institute of Technology (MIT) in the field of lithium-air batteries, in 2010 he accepted the call from Munich, where he has since held a professorship in both technologies and is continuing their development.

To understand where the fuel cell stands today, it's worth going on a short excursion with Gasteiger into the past. When he started working for General Motors and Opel back in 1998, there was a "gold rush" atmosphere. There were huge expectations for the fuel cell. Opel and General Motors pumped billions into developing the technology. This naturally required results—and fast. As of 2004, Opel managers were planning for the first 100,000 cars with hydrogen fuel cells to roll off the production lines.

Towards mass production again and again

"Our team grew at a breakneck speed during this time," Gasteiger recalls. His team soon included some of the best researchers. Yet as great as the expectations were, the reality was merciless. The first fuel cells only lasted about 100 hours, consumed too much platinum and didn't produce enough energy. The target of 100,000 cars was quickly off the table. Despite this, the researchers managed to cure more teething problems with each new prototype. Each development step brought the technology just a little bit closer to maturity for mass production. As soon as the biggest hurdles seemed to have been cleared, in 2007, the financial crisis finally drove a stake through the heart of the project, marking its end. A short time later, Elon Musk entered the playing field and announced a new era of battery-based electromobility with Tesla. For now, the fuel cell was languishing in obscurity in the US and Europe.

While research and industry directed their focus onto lithium-ion batteries in the years that followed, interest in fuel cells soon began to emerge once again in certain fields. "Today I believe that both technologies will prevail," Gasteiger says. In urban traffic, electric vehicles are favored due to their low costs, higher energy efficiency and a charging infrastructure that is fairly easy to set up, at least in the beginning. For longer distances and for trains is where the assets of fuel cells come into play: much longer ranges and shorter refueling times.

Gasteiger also lists another argument for fuel cells: if countries convert their electricity supplies to renewable energies to achieve their climate goals, energy storage systems will be needed. "And from today's point of view, you simply cannot ignore the use of hydrogen for the temporary storage of large amounts of energy," he says. Once the hydrogen temporary storage systems are built, this in turn would facilitate the expansion of the entire infrastructure—thus paving the way for cars, buses, trucks and, over the longer term, for ships and airplanes as well.

But there's still another stumbling block: the more fuel cells that are built and the more powerful they become, the greater the need for valuable platinum. The precious metal is used as a catalyst in fuel cells. While years of improving the catalysts have steadily reduced the amount of platinum necessary per cell, at some point there were no more savings to be made in this area. "Then they started to increase the current density of the fuel cells," Gasteiger says.

This has made the gas diffusion layers made of carbon fibers more important than ever. They act as a buffer in the fuel cell between the bipolar plates and the catalyst, fulfilling many important functions (see the infographic). As long as the current density for the cells remained at a low level, the requirements for the gas diffusion layers were fairly manageable. Now, however, with the higher performance demands, they are rising by leaps and bounds.

The special properties of carbon fibers are up to the task.

An Idea Reinvents Itself

1839

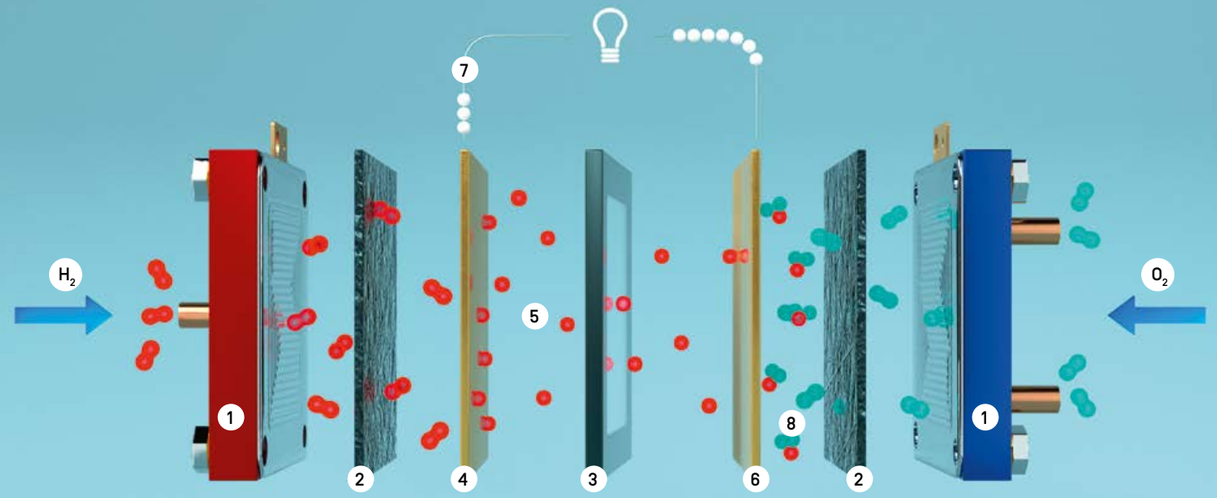
The Welsh scientist Sir William Robert Grove conducts experiments on the electrolysis of water to form hydrogen and oxygen. He also notices that the process can be reversed: hydrogen and oxygen can be used to produce electricity. He creates the first fuel cell, which he calls the "gas voltaic battery."

1937

Almost 100 years after its discovery, the technical use of hydrogen experiences a setback. Thirty-five people lose their lives in the Hindenburg disaster, causing hydrogen to fall into disrepute. Yet it wasn't actually the hydrogen that caught fire, but rather the zeppelin's outer fabric skin.

1966

The first fuel cell systems are used in spaceflight. Engineers at NASA and from General Electric develop the PEM fuel cell, but the technology takes up far too much space.



Energy from Water and Air

Fuel cells require only hydrogen and oxygen to produce electrical energy. Both gases flow in separately over bipolar plates 1 and through gas diffusion layers 2. The membrane 3 allows only protons to pass through it and is coated with platinum on both sides. The platinum serves as the catalyst and initiates the chemical reactions. The hydrogen molecules split into electrons and protons at the anode 4.

The protons 5 migrate through the membrane to the cathode 6. The electrons 7 flow through an external conductor to the cathode, providing electricity along the way. At the cathode, oxygen molecules react with the electrons and protons to form water 8, which leaves the cell via the gas diffusion layer and the channels on the bipolar plates and out of the cell.

PHOTOS Pictorial Press Ltd/Alamy Stock Photo (1839); Granger Historical Picture Archive/Alamy Stock Photo (1937); Spooky Pooka (Illustration fuel cell); Eriver Hijano (4 x)

From Shreds to Layers

1 – The starting product: short pieces of chopped carbon fibers.

2 – An elaborate process transforms them into rolls of gas diffusion layers.

3 – Before the gas diffusion layer is sent to customers, it must first undergo numerous quality checks.

4 – Rüdiger Schweiss inspects the quality of the gas diffusion layers in Meitingen and is continually advancing the product's development.

As Gasteiger explains, any boat is fine when the weather is good. But as soon as storm clouds approach, you'd rather be sailing in a better ship. "In the cells, the demands on the material for high energy and power densities are like a thunderstorm," he says. "That's why there's an exciting future ahead for the gas diffusion layer made of carbon."

In the Bavarian town of Meitingen, less than 150 kilometers from Gasteiger's laboratory, Tilo Hauke is standing in front of a meter-long sintering furnace and watching a batch of freshly produced gas diffusion layers roll off the production line. Hauke heads the Central Innovation research department of SGL Carbon in Meitingen. He's been studying the development of fuel cells for years. Hauke, like Gasteiger, believes that the mobility of the future will be characterized by both battery power and fuel cells. And he is also convinced: "The era of the fuel cell is dawning."

Huge growth potential

While the band of material—about as wide across as a human arm—is impregnated, coated and inspected on the rollers and in the furnace behind Hauke, he lists the advantages of carbon fibers for gas diffusion layers. "They're permeable to gases, repel water, are easily compressible and conduct both heat and electricity." All of these are important properties for gas diffusion layers. In the fuel cells, hydrogen gas, oxygen gas and electrons flow through these layers. In addition, they channel off the resulting water and also protect the catalyst membrane layer from the corners and edges of the bipolar plates at the sides of the individual cells.

When the fuel cell experienced its first peak at the end of the 1990s, SGL Carbon also entered the gas diffusion layers business. "Today we have quite a lot of experience to draw on; we rely on mature and efficient production processes and an extensive network to all important OEMs and suppliers," Hauke says. This was most recently confirmed by the expansion of the existing cooperation with Hyundai, in which SGL Carbon delivers gas diffusion layers for the NEXO SUV, which runs on fuel cells. Hauke explains that the business has grown by more than 100 percent in the past two years alone. And he is aiming for further dramatic increases in the production and delivery volumes over the next three to four years. To accomplish this, the production facilities in Meitingen are currently modernized and expanded. To continue advancing the technology and to lower the costs of fuel cells, SGL Carbon has also been involved in EU-funded research projects for a number of years, the now-completed INSPIRE project being one example. The company is working with car manufacturers, producers of bipolar plates, catalysts and membrane electrode units, and research institutions to further increase the fuel cells' performance and to remove the final hurdles to their broad commercialization.

"The goal of the INSPIRE project was to build the most durable, inexpensive and powerful stack possible," says Dr. Rüdiger Schweiss. Schweiss coordinates SGL Carbon's participation in the project and is also responsible for developing the SGL gas diffusion layers. Fuel cell stacks are units of several hundred individual cells connected in series, which together supply the power required for automotive applications. After three years of development they had a compact, 150-kilowatt stack with a power density of more than 1.3 watts per square centimeter of electrode surface. "It's a new record in terms of the performance per surface area," Schweiss says.

Along with the technical aspects, the project also made clear how intensively all the participating companies are working on fuel cells, reports Schweiss. He thinks that the technology's final challenges will be solved in the coming years and that mass production will soon get started. "We're doing everything to advance this technology," he says.

1969

The fuel cell is also used during Apollo 11, the first manned Moon landing. One of the technology's advantages is that it delivers both dependable energy and drinking water for the crew.

1994

Daimler Benz introduces the NECAR 1. It can cover up to 130 kilometers with a full tank of hydrogen at a top speed of 90 kilometers per hour. Yet the technology still takes up much too much space.

2014

After another twenty years of development, Toyota introduces the first mass-produced fuel cell car. The Mirai can cover up to 500 kilometers with a full tank, which takes just three minutes to refuel. The use of fuel cells is now also being tested for airplanes, ships and trucks.

Find Out More
Additional information and an explanatory video about fuel cells can be found here:
www.sglcarbon.com/fuelcell

PHOTOS Science History Images/Alamy Stock Photo (1969); Daimler AG (1994); Toyota (2014); SGL Carbon (Video)

Idea Factory

Diet Concrete

No building material is used as much as steel-reinforced concrete. But since steel rusts, carbon could **replace it in many areas**—saving quite a lot of both material and time

Until around 150 years ago, pure concrete suffered from its susceptibility to tensile forces. The invention of steel-reinforced concrete solved this problem but created a new one—to protect rust-prone steel from dangerous moisture, it must be encased in a centimeter-thick layer of concrete. That is why today's concrete structures consume much more material than is strictly necessary.

Carbon fibers could help in this area. As a lattice-structured textile or formed into rods, they could potentially replace steel in many applications. The new material is more flexible and saves a huge amount of concrete since carbon fibers don't rust—along with being lightweight and having a high tensile strength. Because of this, the encasing wouldn't have to be as thick. Carbon fibers would basically put steel-reinforced concrete on a diet.

One of the networks of researchers and companies working on developing this new area of application is named C^3 – Carbon Concrete Composite. In the world's largest research initiative into carbon concrete, headquartered in Dresden, Managing Director Dr.-Ing. Frank Schladitz is attempting to make this diet reinforced concrete a reality. SGL Carbon is contributing to the initiative with its expertise and the company's own materials.

Facades, bridges, silos and more

"With carbon in concrete, we can save up to eighty percent of the material used," Schladitz says. A ceiling facade, which would normally have to be seven centimeters thick, can be shrunk down to just two centimeters. The construction company Goldbeck is already planning the first multistory parking garages with carbon concrete ceiling panels that are thinner and corrosion-resistant.

Another field of application is bridges. In Germany alone there are 40,000 river crossings and autobahn bridges that must support increasingly heavy loads and are besieged by salt and snow during the winter. Carbon-reinforced concrete can easily withstand both challenges. Right now, at the TU Berlin university, a bridge component measuring twenty meters in length and built with materials from SGL Carbon is undergoing continuous testing.

In practice, aside from making construction more efficient, carbon concrete also makes construction faster. In a pilot project, the walls of a sugar silo were refurbished with a layer of carbon-reinforced concrete just a centimeter thick. The silo's capacity was almost completely preserved. And since the carbon textiles were delivered in convenient rolls instead of unwieldy steel mats, the workers were able to complete the renovation much more quickly and at a lower cost.

Yet there are a number of hurdles that must be cleared before carbon can be used in residential construction. In contrast to steel, it is less heat-resistant. Schladitz and his team are currently researching fiber coatings that can withstand temperatures of up to 500 degrees Celsius and simultaneously adhere well to concrete. The experiments thus far are promising.

The foundations for the use of carbon concrete are being laid right now. As Schladitz says, "We're still at the start of this development process, but the potential is huge."

PHOTO filmaton/Jörg Singer

Making it Efficient

Flexible, dependable, innovative: At its facilities in Poland, SGL Carbon produces very specific graphite-based materials for our modern world. The sites' more than 200 employees are constantly reinventing themselves to further develop the applications and their production methods.

Way down in southern Poland, close to the Slovakian border, the landscape suddenly resembles Scotland. The road to Nowy Sącz meanders past a lake that looks like Loch Ness against the backdrop of the panoramic Tatra Mountains. Nowy Sącz, a city with a population of 80,000 located about two hours away from Cracow by car, is home to one of the two SGL Carbon facilities in Poland.

The hall where the largest and most complex graphite components are produced is located right next to the site's main access road. Automated machining tools made of high-grade steel shape them out of graphite blocks. At first sight, the blocks with their dark grey color and their height of up to two meters seem to be unspectacular, somehow like huge pencil leads. However, they have various extraordinary material properties such as extreme resistance to heat and corrosion, electrical conductivity, and mechanical strength. Thus, they are used for many different state-of-the-art applications in the automotive, semi-conductor and chemical industries as well as in the battery sector.

One material, many applications

Site Manager Grzegorz Rogowski—buzz cut, striking face, white shirt—receives us in the machine hall. The 53-year-old has been working for SGL Carbon for almost 20 years. In 2008, he was promoted to site manager in Nowy Sącz and to managing director in 2016. As such, he's responsible for the partner facility in Racibórz as well. "Graphite has always been my passion," he says. He studied energy and fuels at Cracow University. "Depending on how you configure the material it can serve many different production fields."

Parts made of carbon have many advantages. Graphite components can be made very small and can also

PHOTOS Julia Sellmann

Artificial graphite is resistant to heat and corrosion, electrically conductive and has good self-lubricating properties and mechanical strength. It is machined out of solid blocks and is used for many different applications, for example for high-temperature industrial equipment.

The Polish sites in Nowy Sącz and Racibórz are located in southern Poland, where graphite production has a long tradition.

Along with the new larger silos, this new grinder is yet another innovation in the production of graphite materials for lithium-ion batteries.

provide lubrication. Parts for various seals and pumps in cars, for instance, may measure just a few centimeters in size. "Graphite is much better material for this than plastic, for example, mainly because it is more durable," says Wiesław Chlipała. He coordinates the industrial and automotive production areas in Nowy Sącz. "Automakers are therefore replacing more and more conventional pump equipment with graphite parts in both combustion engines and electric vehicles." SGL Carbon is currently modernizing and expanding its automotive production areas in both Bonn, Germany and in Nowy Sącz.

Grzegorz Rogowski has been working for SGL Carbon for almost twenty years. "We're proud of our development," he says.

the automotive production area, both in Bonn, Germany as well as in Nowy Sącz.

Although each piece is small, the overall quantities are huge as customers are installing millions of these parts. "At the moment, we are still producing the parts manually in small batches but, like in Bonn, we will soon be getting technical assistance," Chlipała says. In a large hall that is currently being renovated from the ground up, new machines will be installed at the site—larger and more automated so that mass production can be set up for the automotive sector.

Robot coworker helps

"Poland is an ideal industrial location," Rogowski says. Then he lists the country's advantages. Firstly, the people are well educated, eager and ambitious. Secondly, graphite production has a long tradition in Nowy Sącz and Racibórz. In other words, the conditions are favorable for the development and operating of the most innovative facilities in the SGL Carbon value chain.

The sites' potential was recognized early on at SGL Carbon. In the 1990s, shortly after the Iron Curtain fell, the company began also expanding eastward. In 1995, it acquired the factory in Nowy Sącz and the one in Racibórz in 2000. Both were officially integrated into SGL Carbon's global manufacturing network for specialty graphite in 2004.

"Our employees have know-how that our customers all over the world are eager to take advantage of," Rogowski says. High-quality, cost-efficient production has always been one of the region's competitive advantages. On top of that is a willingness to be flexible.

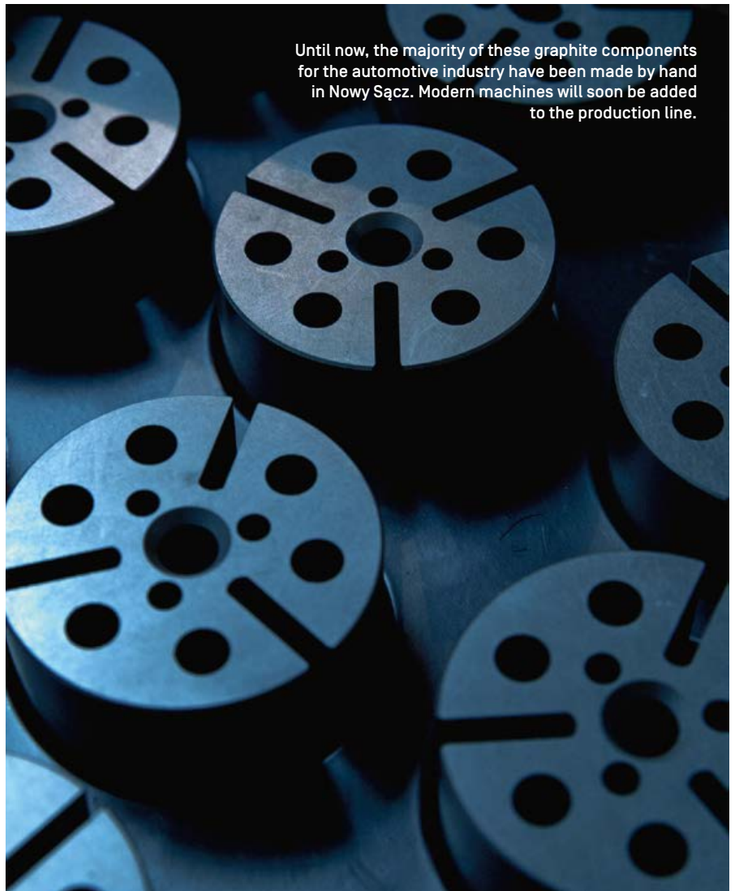
As Rogowski talks about the history and the advantages of the sites, he strolls further to the factory's largest facility: the big hall for manufacturing graphite material to be used in anodes of lithium-ion batteries. Nowy Sącz is the lead plant of SGL Carbon for this business sector and is working to improve production processes on behalf of all of the company's other involved sites.

Wojciech Pacholarz oversees the production for battery materials in Nowy Sącz. "It's a complex process," he says walking past one of the baking furnaces in the middle of the hall. He's heading toward a large hopper mounted on the wall. A lot of improvements have recently been realized at the site in this sector. The innovations have begun with the storage of the raw materials, which are kept in huge new funnel-shaped silos at the edge of the hall. The fully automatic robot arm in front of Pacholarz grabs one piece of material after another and puts it on carts the workers use to transport them to the next production step. "This is a huge efficiency gain for us," Pacholarz says. The gripper robot relieves the workers from the tedious task.

From the grinder, the blocks now go to be baked. Pacholarz and his team are still using traditional baking furnaces. But even this process will soon be accelerated. The tool for this is waiting in a hall next door: a car bottom furnace. In contrast to the traditional furnace, the car bottom furnace looks like it could be found in a giant's kitchen, as it stands a good 15 meters tall. It's called "car bottom" because the base platform can be moved.

Wiesław Chlipała coordinates the industrial and the automotive production areas in Nowy Sącz.

PHOTOS Julia Sellmann



Until now, the majority of these graphite components for the automotive industry have been made by hand in Nowy Sącz. Modern machines will soon be added to the production line.

With the production of the battery material, the Polish sites are linked to the trend towards increased e-mobility. This is bringing an enormous need for lithium-ion batteries. At the same time, the market is facing strong cost pressures along the entire value chain. So far, the market has mainly served by Asian cell manufacturers who produced in Asia. Now they are coming to Europe while an increasing number of European cell manufacturers is emerging, too, using new technologies and materials. This development could also open up new opportunities for SGL Carbon.

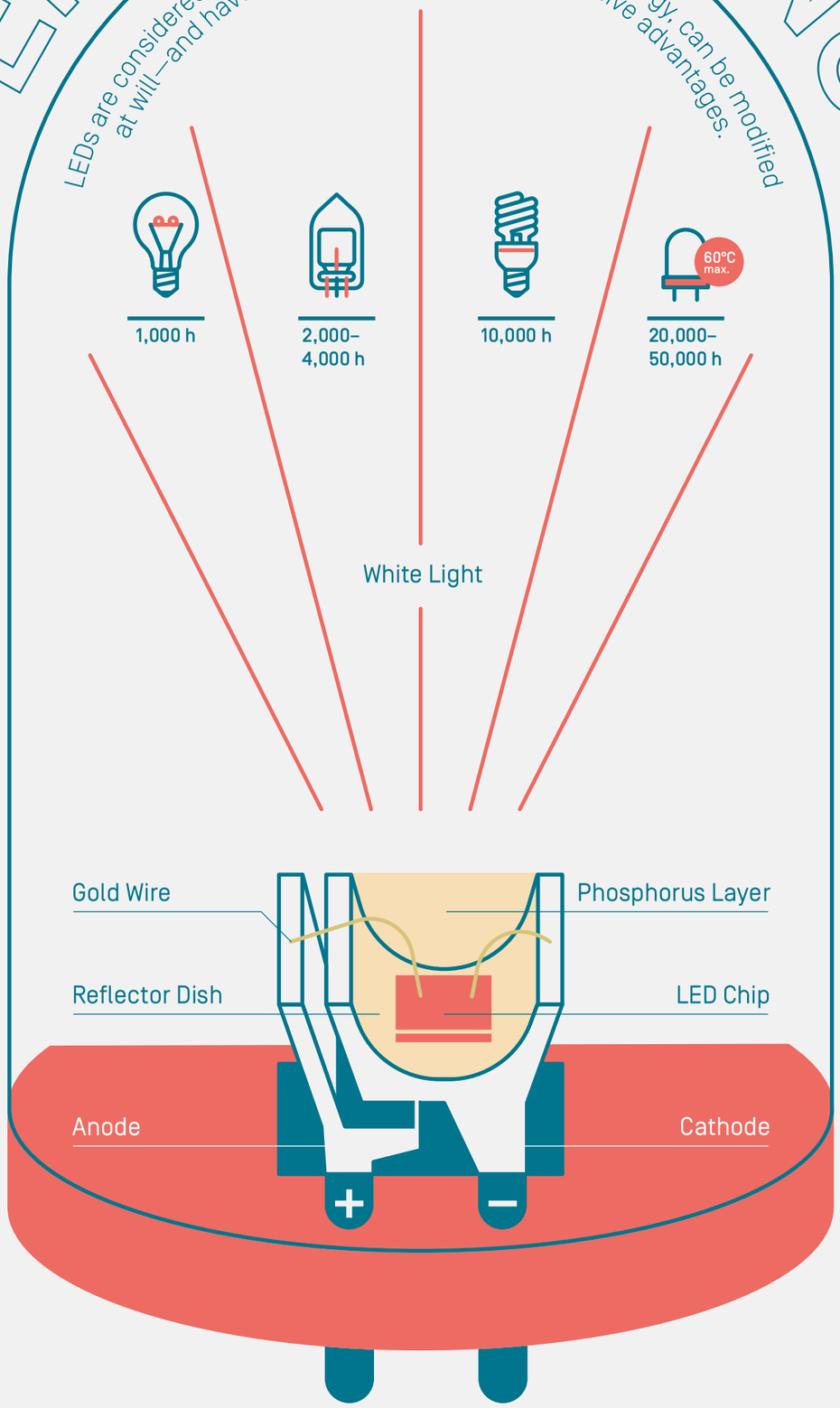
High quality and flexibility

While automation in all three production areas of the Polish sites requires fewer people, the need for more specialists is actually increasing. "We need people with a very specific skill set who we can deploy in all of the different areas," says Rogowski. Therefore, employees are regularly trained in new types of in-house training sessions. In addition, Rogowski and his team are currently setting up an in-house Apprenticeship Center in Poland. This idea is partly modelled on the dual education system in Germany. The center is planned to open in September 2020 and will be offering a three-year program to train professional CNC operators, with spaces reserved for students from local vocational schools in the region around Nowy Sącz.

"This gives us flexibility and is forward-looking," Rogowski explains. It's exactly this combination, along with the specialist expertise, that is probably the most important success factor for the work at both facilities, which is characterized by a mixture of innovation, flexibility and stability. "We've been producing graphite here for 120 years and we want to do it for the next 120," Rogowski says. "But we'll never be doing it without constantly developing ourselves further."

ENLIGHTENING

LEDs are considered the lighting of the future. They save energy, can be modified at will—and have a number of additional persuasive advantages.



Germ Killer
UV light reliably kills fungi, germs and bacteria. LEDs can produce such light particularly efficiently and inexpensively. For instance, UVC LEDs can help purify drinking water.

32,256

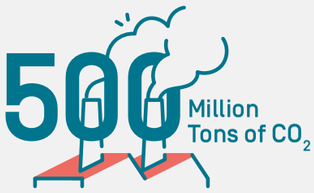
Light-Emitting Diodes
illuminate the Times Square Ball, which drops every New Year's Eve in New York City.

ILLUSTRATION Julian Burford

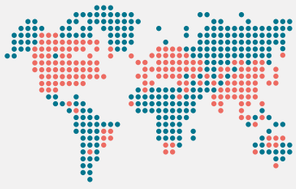
22

Billion
US dollars is the amount of sales projected in the year 2022 for what are known as packaged LEDs—LED chips encapsulated in epoxy, including the contacts for assembly.

Goodbye, Moths
In contrast to incandescent bulbs, LED light does not attract insects. LEDs don't usually emit ultraviolet light—which is exactly what attracts many bugs.

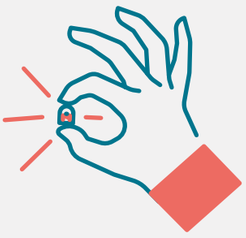


of carbon-dioxide emissions will be prevented worldwide through the use of LED lamps. That is more savings than halving the amount of automobile traffic in Germany.



A Hemisphere of LEDs
The global market penetration for LED lamps is estimated to reach 50 percent by the year 2022.

Harvest Helper
Specially adapted LEDs are ideal for use in urban farming. The light is optimized to perfectly promote photosynthesis and control plant growth.



Flexible
Some light-emitting diodes are smaller than a peppercorn, others as big as a postage stamp.

SGL Carbon's LED Business
LEDs are based on semiconductors. To manufacture them, many producers rely on system components made by SGL Carbon. For instance, the company manufactures wafer carriers made of graphite. During semiconductor production, wafer substrates are placed on these carriers and ultra-thin compound semiconductors layers are deposited onto the wafers. The deposition takes place under extreme conditions and at high temperatures in what are known as MOCVD reactors. The SGL Carbon components made of isostatic graphite easily withstand such conditions.

All Together Now

Lightweight construction, battery development, 3D printing and more: SGL Carbon is pooling its resources to advance technology research and development at the **Carbon Campus** in Meitingen, Germany. A tour with the pioneers of change.

The two arrows on the wall in front of Dr. Markus Partik are pointing the way. The dark blue arrow directing left leads to the Fiber Placement Center, the Carbon Fiber Pilot Plant and the Lightweight and Application Center. The orange arrow to the right leads to the Battery Application Laboratory, the Metrology Laboratory, to the Central Laboratory and to the Additive Manufacturing area. "All of SGL Carbon's business units and the breadth of our technological diversity come together here in Meitingen," Partik says. "And we want to demonstrate this with the new concept of our Carbon Campus, both for ourselves and for our clients."

Partik, aged 51, knows what he's talking about. He's been working for SGL Carbon for 22 years and now has the position of site director in Meitingen. He provides the infrastructure and organizes resources. "A lot of customers and suppliers have a hard time grasping different areas our company is active in," Partik says. "Internally, we can also benefit even more from each other's professional expertise."

This finding led to the idea for the Carbon Campus. It has been established to provide outsiders with an overview of SGL Carbon's complex and wide-ranging portfolio, as well as to promote internal cooperation across the corporate divisions. The facility in Meitingen—in Bavaria—is perfect for it: while other SGL Carbon sites are specialized in individual fields, Meitingen incorporates a wide variety of activities and applications. Much like a magnifying glass focuses sunlight, the company's expertise is amassed here: lightweight components made of composite materials, special graphite for lithium-ion batteries and the semiconductor industry, Central Innovation, start-ups—it's all under one roof.

The technological diversity is already evident at the entrance to the plant. A commercial video on an LED screen provides an initial overview of the company. Nearby exhibits show the variety of products and applications—from pump components to furnace construction and car bodies. Partik lifts the door of a Porsche 997 GT3, produced from carbon fiber materials and aramid. "Touching is allowed," he jokes, although hands-on learning is expressly encouraged. Outside on the company premises, pylons, arrows and graffiti point the way to the campus using a specially designed marking and direction system.

The first stop on the Carbon Campus is a large, brightly lighted hall, the Technikum 2, where a center for 3D printing with carbon materials is coming together. In the middle of it is Dr. Tanja Damjanovic, the project manager responsible for additive manufacturing process technology at SGL Carbon. She welcomes Partik and visitors by demonstrating how a three-dimensional component made of carbon is produced. In a machine about as tall as a person, with stylishly rounded corners and a window in the middle, a tub-shaped component is being printed. Layer by layer, a fine graphite powder is applied that then directly bonds and hardens along the outline of the CAD drawing. This process has several advantages, as Damjanovic explains. Firstly, the material is optimally used; secondly, this type of production makes completely new designs possible; and thirdly, the manufacturing is fully automatic because the engineering data is fed directly to the printer. "Digitality, individuality and velocity," she says.

More information, more cooperation

When German Federal President Frank-Walter Steinmeier visited the SGL Carbon facility in Bonn last year, a gift printed at Additive Manufacturing in Meitingen was handed over: an elephant made of carbon. A nice story that Damjanovic will be able to tell future visitors at the communication point right next door to the Additive Manufacturing hall. The mini-info point is equi-pped with a touch-screen, technology videos and exhibits and will offer visitor information while promoting cooperation among employees. Each campus unit has one of these stations.

Damjanovic is pleased with the new standard of the campus concept presented to the public. "For new innovation areas in particular, like additive manufacturing, it's important that the company presents a uniform image with focus on customers," she explains. Technical performance isn't enough on its own; you also have to be able to communicate it and talk about it.

The next stop is the recently completed Battery Application Laboratory. Christian Hammer, who is organizing the processes, leads the way through rooms with controlled humidity and laboratory stations past glove-boxes, electrode coaters and measuring instruments. Having a dedicated lab for his own research is a quantum leap forward—workplaces and equipment were previously divided among several rooms. Now fifteen employees are working

PHOTOS Ériver Hijano; SGL Carbon (Wall)

» The Carbon Campus brings our carbon know-how together «

even more closely together. They're developing and qualifying measurement methodologies for testing small-scale batteries under real-life conditions. Just like Damjanovic, Hammer finds the campus concept a win-win option for the company. "It brings our carbon know-how together."

The "Innovation Mile" was the working title as the interdisciplinary team began developing the concept for Carbon Campus in autumn 2018. The participants were breaking new ground and weren't always agreed about the direction to be taken. "A few of us only wanted a fresh coat of paint, while others wanted to change the entire corporate culture," recalls Partik. Ultimately, both ideas were incorporated into the campus concept.

Once the campus has become established, the experts at SGL Carbon will be able to use and share their expertise in carbon materials even more effectively, much like scientists at a university. Everyone is working with carbon, but they're developing solutions for different market fields and special applications. "More interfaces mean more benefits for our customers since they will be able take greater advantage of the company's full expertise," Partik says.

Places for exchange

Initial successes have already become apparent. Even the process of putting it all together opens doors. "Collaborating on the campus concept brought me into contact with many of my colleagues for the first time," says Dr. Christoph Ebel. "Today I have a better overview of what's going on in the other areas of SGL." Ebel has been working at SGL Carbon for two years and heads the company's Lightweight and Application Center. He and colleagues from Central Innovation created the "Composites Path" for the Carbon Campus: visitors learn how carbon fibers are manufactured, then processed into semi-finished products and finally into components. One of the places in a carbon fibers value chain is the Fiber Placement Center, with automated and material-friendly processing. "This combination is unique worldwide," Ebel says. "Our customers have access to the entire process." Cooperation with the Fraunhofer IGCV research institute contributes to the high technical standard and offers solid scientific foundation.

It's this innovative spirit that Ebel wants to strengthen even further and which he hopes will continue to thrive and grow in closer cooperation with other departments—to inspire not only today's customers but also tomorrow's colleagues. "The campus idea also increases SGL Carbon's attractiveness for the next generation of employees," says Partik. Specialists are in short supply, also in Meitingen.

A coworking area on the Carbon Campus will also help to fuel this new spirit: a large, open space that will become in equal parts think tank, retreat and collaboration space. The company already held an ideas campaign for the exact design of the Carbon Campus space in a two-day hackathon format with employees and architecture students from the Augsburg University of Applied Sciences. "We want to change both the rooms and our way of working," Partik says. What you won't find in the coworking space are fixed workplaces.

Opening up a public face to customers, looking outside the box, offering a better understanding of the various technologies and activities taking place: the goal is clear, the space is being created. Now the employees need to fill the Carbon Campus with life. It won't happen overnight and Calin Wurm, the manager of the Battery Application Laboratory, has no illusions about it: "We first have to live it for ourselves." Sometimes the journey is the destination. Still, it's already clear that the idea is gaining acceptance.

"It could well be that we discover common interests where we didn't suspect any would be," Hammer says. And Damjanovic from the 3D printing team is very pragmatic about it: "A campus is never really finished." The only constant is change. «

Read more
You can find further information about the Carbon Campus here:
www.sglcarbon.com/en/carboncampus

All the SGL Carbon areas of activity meet each other at the Carbon Campus. The specialists' expertise grows even closer together. The colleagues in the Fiber Placement Center with expertise in lightweight construction...

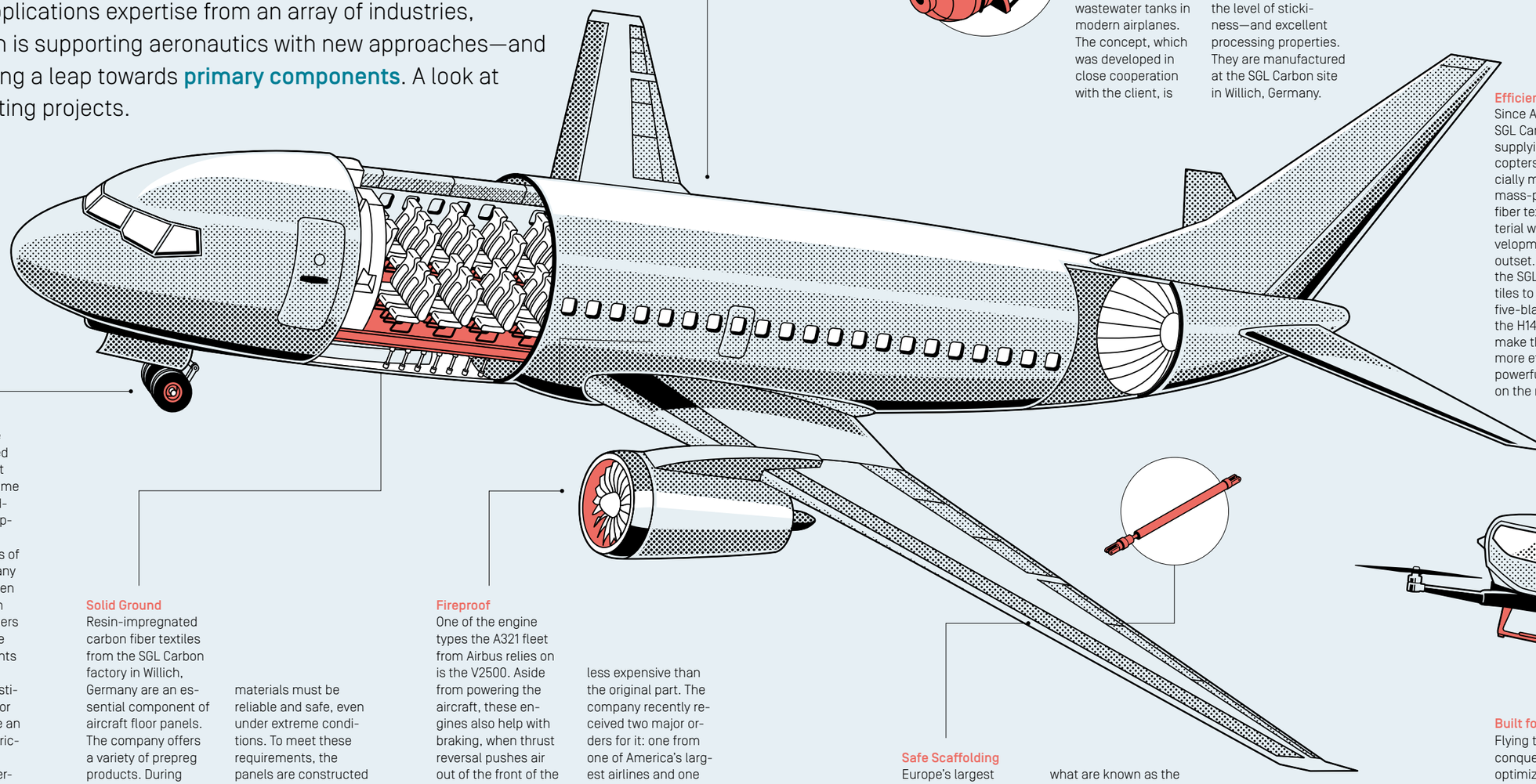
...exchange ideas, for instance with the specialists from the newly established Battery Application Laboratory. The campus also guides customers and visitors in Meitingen through the company premises and introduces them...

... to the complex product world of SGL Carbon in an easy-to-understand fashion. The company developed its own guidance system using arrows and pylons to lead the way across the entire campus. At the info points videos and exhibits manifest the complex production technology of each product area. A coworking area will further consolidate the new campus spirit and develop as a place of collaboration and inspiration.

PHOTOS Ériver Hijano (2 x); Myrzik und Jarisch (People)

Up, Up and Away

Lightness, high rigidity and greater efficiency for the aerospace industry: with its innovative lightweight materials and modern applications expertise from an array of industries, SGL Carbon is supporting aeronautics with new approaches—and is also taking a leap towards **primary components**. A look at seven exciting projects.



Light and Simple
No larger aircraft is allowed to take off without its own water and wastewater systems. SGL Carbon supplies pre-impregnated carbon fiber bundles (TowPregs) that are used to construct the water and wastewater tanks in modern airplanes. The concept, which was developed in close cooperation with the client, is very lightweight and has a more efficient production than previous processes, because the fibers can simply be wrapped around a pre-shaped core. The TowPregs also score points with their adjustable tack—the level of stickiness—and excellent processing properties. They are manufactured at the SGL Carbon site in Willich, Germany.

Efficient Rotors
Since August 2019, SGL Carbon has been supplying Airbus helicopters with two specially manufactured, mass-produced glass fiber textiles. The material was a joint development from the outset. Airbus uses the SGL Carbon textiles to strengthen the five-blade rotors of the H145 model to make them even more efficient and powerful. The strain on the material is enormous. Due to the rotor blade's rapid rotation, it is subject to a very powerful outward acceleration. The SGL Carbon textiles, which are manufactured unidirectionally, manifest their maximum reinforcement in this direction and thereby withstand the load. Without this resistance, the rotors couldn't function.

Strong Brakes
Giant airplanes like the Boeing 777 need strong and resilient brakes to safely come to a stop after landing. SGL Carbon supplies an important part for these types of brakes. The company produces non-woven materials based on oxidized carbon fibers that are used in the form of subsegments in the brake disc. These non-combustible oxidized fibers or subsegments have an impressively high friction coefficient, among other properties. SGL Carbon can thus offer its customers the complete value chain from a single source—from the original material to the intermediate product to the final brake disc.

Solid Ground
Resin-impregnated carbon fiber textiles from the SGL Carbon factory in Willich, Germany are an essential component of aircraft floor panels. The company offers a variety of prepreg products. During operations, the panels must be lightweight and stable: countless passengers, hand luggage, flight attendants and trolleys walk and roll over them every day. That is why the composite materials must be reliable and safe, even under extreme conditions. To meet these requirements, the panels are constructed from SGL Carbon carbon fiber prepregs using sandwich construction methods. The quality pays off: in July 2019, a contract for these parts was extended by one year to the end of 2020.

Fireproof
One of the engine types the A321 fleet from Airbus relies on is the V2500. Aside from powering the aircraft, these engines also help with braking, when thrust reversal pushes air out of the front of the engine. To prevent the engine cowlings from burning they have a special insulation that must be regularly replaced. SGL Carbon manufactures the relevant component, which is considerably less expensive than the original part. The company recently received two major orders for it: one from one of America's largest airlines and one from Turkey's Onur Air. SGL Carbon's Arkadelphia plant in the state of Arkansas in the US is responsible for the design and construction of the component in accordance with aviation regulations.

ILLUSTRATION Manuel Bortoletti

Safe Scaffolding
Europe's largest aircraft manufacturer, Airbus, assembles the A330 in France. To mount the center wing box, the company relies on SGL Carbon technology. In Meitingen, Bavaria, SGL Carbon produces what are known as the connection rods—special supports that are similar to scaffolding. Due to the material's high rigidity and low density, the elements can be built in a more compact form and with a much lower weight.

Built for the Future
Flying taxis may soon conquer the skies. To optimize the range of such taxis, every gram of weight counts. Since the beginning of 2020 SGL Carbon is mass producing landing gear made of braided carbon fiber material. The frames will be used worldwide in around 500 flying taxis in the next two years. The finished component will be shaped in SGL Carbon's component factory in Ried im Innkreis, Austria. SGL Carbon developed the special tools and molds especially for producing this frame.

X-Ray View

Carbon 360°

Operating tables, cots, head holders: medical technology is increasingly using **carbon-fiber reinforced** materials in a targeted way. They're very transparent to X-rays and quite lightweight. SGL Carbon is driving development in close cooperation with its customers.

Everything is prepared. The operating instruments are sterilized and at the ready, the patient is under anesthesia and on the operating table. Above the patient, two arms stretch out to perform the surgery. Yet the arms aren't human: they are two metal robotic gripper arms that will operate on the patient. They are being controlled by doctors with a precision measured in millimeters. This or something like it takes place daily in specialized hospitals all around the world.

So that the surgery robot can see what it's doing during the operation, the patient is X-rayed numerous times throughout the procedure. "And that's exactly where we come in, with our composite materials," says Jürgen Klinger from SGL Carbon. Products made of carbon fiber composites are very permeable to X-rays and very lightweight as well. "The high transparency to X-rays means you only need a very low dose of radiation, which is good for patients," Klinger explains. Additionally, the composites cast barely any shadows on the X-ray images, which is important because shadows can sometimes lead to misdiagnoses. "With carbon fibers, we can minimize this risk," says Klinger.

Along with operating tables, SGL Carbon in Meitingen, Germany, also manufactures accessories that can be attached to X-ray devices, including head holders and what are known as clip-on boards that extend the length of operating tables. The company's expertise along the entire value chain is impressive, and this experience pays off for SGL Carbon customers. "Our clients often have very exact ideas and detailed requirements for their components," Klinger says. He and his colleagues work through the challenges with the customers in SGL Carbon's in-house Lightweight and Application Center (LAC). "In the past, we mainly just advised our customers in materials selection," Klinger explains. "Today, in contrast, we offer everything from engineering to the right material combination to manufacturing, all from a single source."

1

millimeter or less is how thin aluminum needs to be to provide the same X-ray transparency as carbon reinforced composites.

10

million imaging procedures are conducted annually in Germany (figure from 2016).

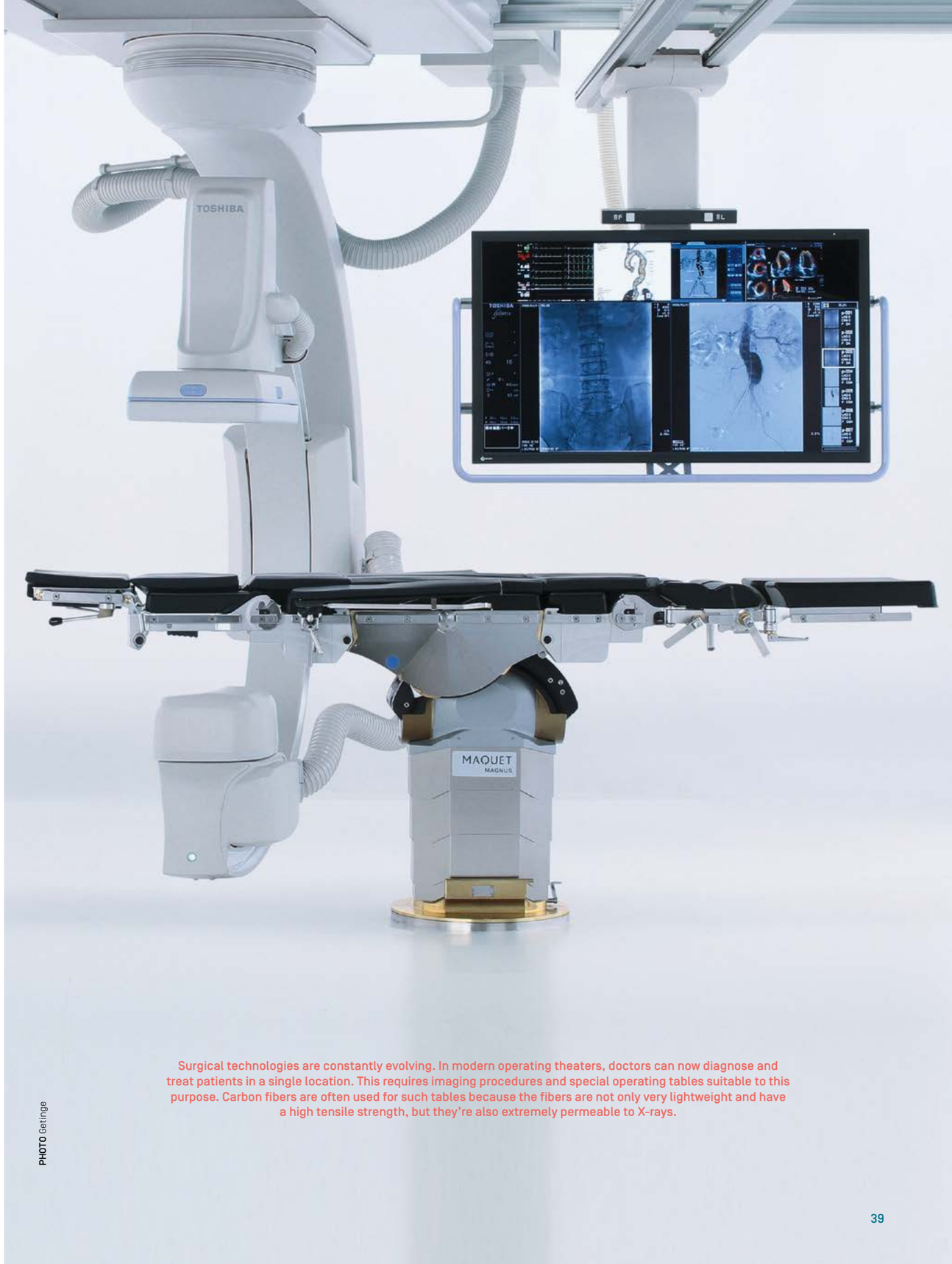
10

percent of misdiagnoses on X-ray images are due to the image's quality.

This was the case for the cooperation with Getinge, a medical technology manufacturer headquartered in Baden-Württemberg, on its Maquet series of operating tables. Klinger recalls, "We worked closely together from the very start to find the optimal design for the component." It was a collaboration that paid off for both partners, not to mention patients as well. Bernhard Kulik, the senior product manager for operating table systems at Getinge, explains, "Intraoperative X-rays can improve results for patients and also allow for more complex interventions. Since X-ray technicians require specialized infrastructure for precise visualizations, we at Getinge worked with SGL Carbon to develop an operating table with a carbon fiber table top that offers nearly unimpeded radiation transparency for cardiovascular, orthopedic and traumatological procedures."

In addition to providing X-ray-transparent products for operating theaters, carbon fiber-reinforced composites are also ideal for prosthetic and orthosis devices due to their extreme stability and very light weight. While these types of components have long been custom-made, particularly in small manufactories, 3D printing is opening up new business opportunities for larger industrial companies such as SGL Carbon. In our research center in Meitingen, colleagues from the Composites Division and Central Innovation are already working on an in-house startup in precisely this area.

Aside from prosthetic devices and X-ray applications, stretchers are also more commonly being made of carbon fiber composite materials these days. The material properties of these composites really pay off here as well. "The amount of time saved thanks to the reduced weight can save lives," Klinger says.



Surgical technologies are constantly evolving. In modern operating theaters, doctors can now diagnose and treat patients in a single location. This requires imaging procedures and special operating tables suitable to this purpose. Carbon fibers are often used for such tables because the fibers are not only very lightweight and have a high tensile strength, but they're also extremely permeable to X-rays.

PHOTO Getinge