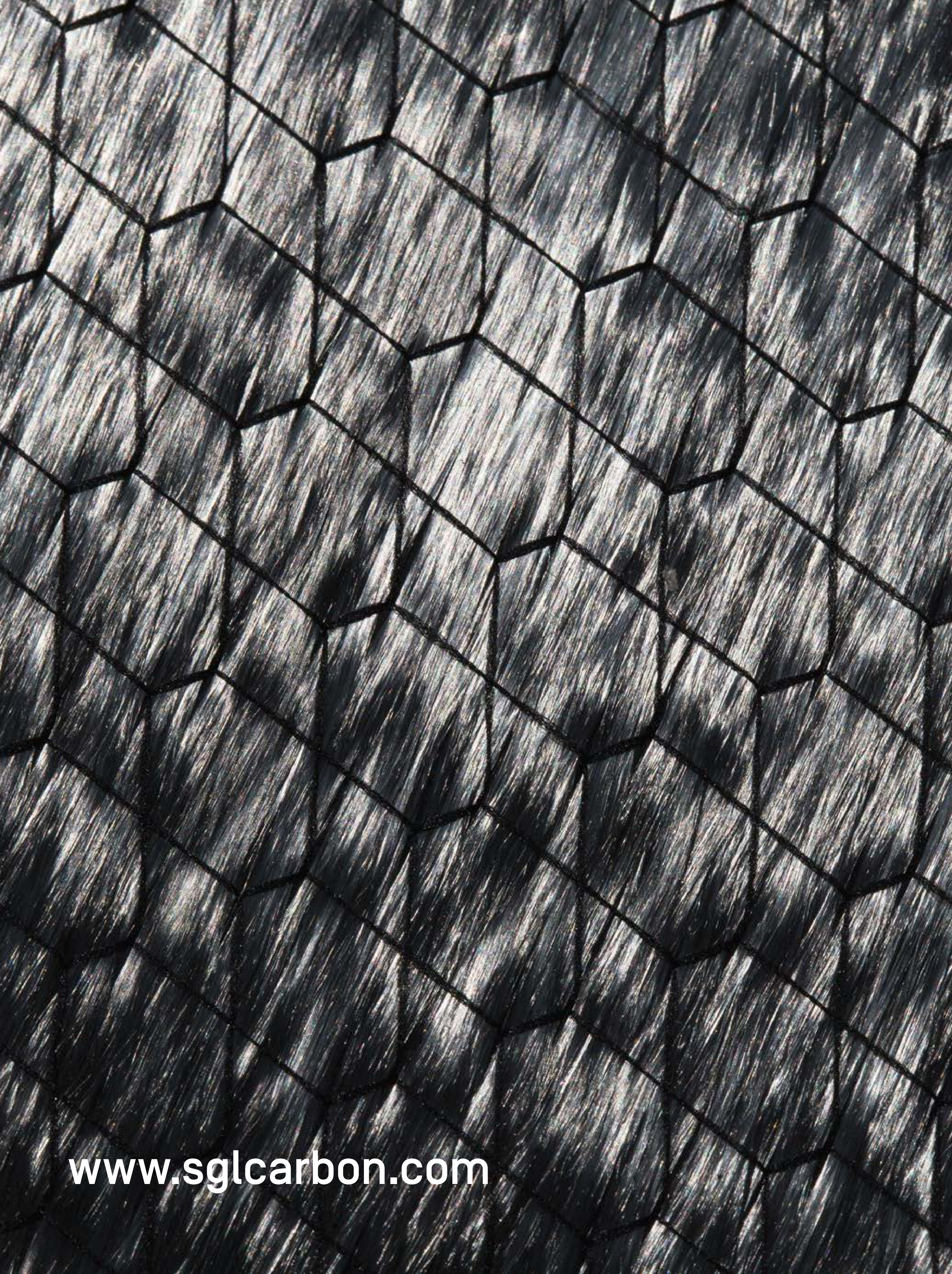

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The Magazine of SGL Carbon 02_19

thinc

holistic

Why Every Production Step Counts

sgl carbon

Zoom

The comfort of driving is in the details, like when a car shifts smoothly into the next gear. This isn't just a pleasure for the driver—it's also a treat for the transmission, because it helps protect it from wear and tear. This is where synchronizer rings come into play, briefly aligning the speeds in the transmission in both automated dual-clutch gearboxes and manual transmissions. The quality of the shifting process largely depends on the performance of the friction lining on the rings. The SIGRACOMP® carbon friction materials made of carbon-fiber reinforced plastic (CFRP) and carbon-fiber reinforced carbon (C/C) offer key advantages over sintered metal — including consistently high friction coefficients, good oil tolerance and very good compression stability, thermal stability and wear resistance. Details of the highest quality—making rings that pay for themselves over the long run.

Photo: Jan Steinhauer

#sglthinc holistic

Our world is made up of infinitely many parts: 5 continents, 195 nations, 7.6 billion people. And yet they manage to come together more and more every day. They communicate with one another, collaborate and network. **Together** they make progress possible, in an increasingly integrated and holistic way.

Such integration also creates values in business, and this is how SGL Carbon works as well. From the raw material of carbon, it develops countless solutions. From thirty facilities on three continents it supplies customers with components and materials all around the world.

In this issue we're taking a closer look at this **value creation**: in Portugal, where Andreas Witte produces the precursor for carbon fibers; in Wackersdorf, Germany, where Adam Drozny transforms carbon fibers into fabrics. And in Chedde, France, where Serge Paget produces indispensable raw materials for our modern world at the foot of Mont Blanc.

The experts at SGL Carbon follow one principle everywhere they work: collaboration is the wellspring of innovation. Smart solutions can only emerge when all the parts mesh together. If you want to succeed holistically you need an integrated approach: **thinc holistic**!

Short Breaks

Photos: Julia Sellmann (Cover and p. 06); Conny Mirbach (p. 18); Fritz Beck (p. 30)

Publication Details
Publisher: SGL Carbon SE, Söhnleinstraße 8, D-65201 Wiesbaden, Germany
Corporate Communications and Marketing
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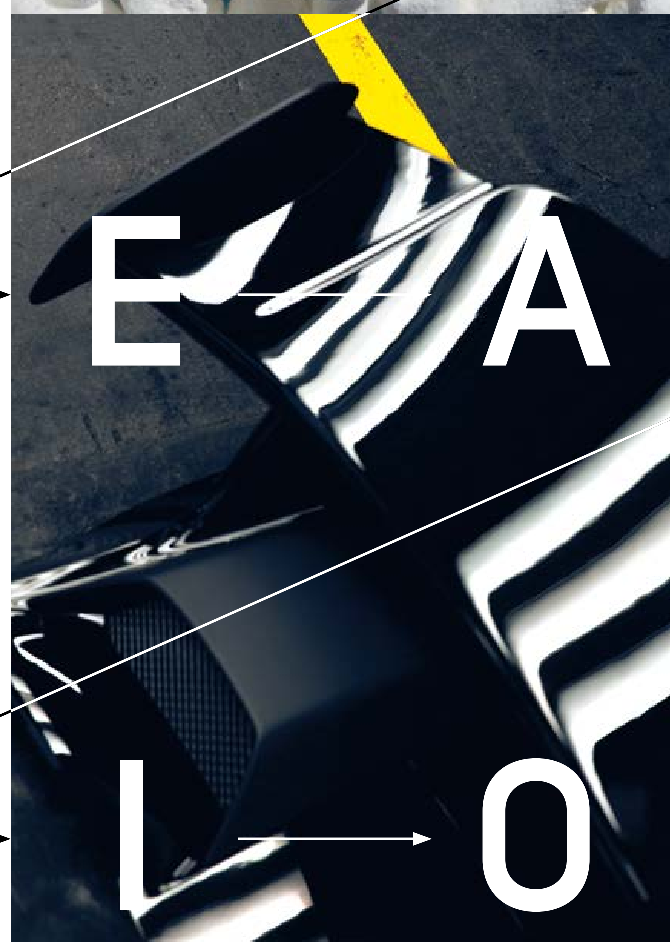
Telephone: +49 611 6029-100
Editorial Team: Andreas Pütz, Philipp Stieffenhofer

Project Management, Editorial Department, Realization und Production:
muehlhausmoers corporate communications gmbh, Invalidenstraße 112, D-10115 Berlin, Germany
www.muehlhausmoers.com, Project Management: Lisa Pommerennke, Thomas Schmelzer; Editor-in-Chief: Thomas Schmelzer; Art Direction: Anja Hamann, Conrad Wegener; Image Editing: Jan Steinhauer; English Translation: Anthony B. Heric, English Editing: Penelope Krumm

CHAIN REACTION



Photos: Julia Sellmann

Industries are familiar with materials such as steel or aluminum and have been for decades. SGL Carbon, on the other hand, is advancing the still somewhat new class of fiber-reinforced composite materials. In order to catch up to traditional materials, the company has brought **all the steps** of the production process under its own roof—thereby creating a chain reaction.

Andreas Witte oversees precursor production in Portugal for SGL Carbon.

Like pasta from a giant noodle machine, white polymer pellets are falling out of a press onto a conveyer belt in front of Andreas Witte. They pass through a meter-long oven, are dried and then shredded. "Then our polymer powder is finished," Witte says. It may sound trivial, but actuality it's just one of countless steps in the highly complex value chain required to produce carbon fibers, process them and manufacture fiber-reinforced components.

Near Lisbon, Portugal, General Manager Andreas Witte produces the raw materials required: kilometer-long silky-white polymer fibers, known as precursors. The white powder from the oven, known as polymer, forms the basic ingredient. "It's the initial recipe that determines how good the quality of the final product will be," Witte explains in front of the gigantic oven. Here is where he and his team define the initial characteristics of the final product and determine where the journey along the highly branched value chain will lead.

It's a journey during which every processing step counts. The material's shape and color will be changed as it transforms into a honey-like syrup, is oxidized as extremely thin threads to become black carbon fibers. It is then spun, laid out or woven, finally being combined with resin to become the final component.

SGL Carbon experts in the Composites—Fibers & Materials (CFM) division optimize every step of the process. Across several continents, they are constantly fine-tuning the quality of the fibers, materials and components. And they're also racing against time. "Conventional materials such as aluminum and steel have an enormous advantage over us because they've been on the market for decades," say CFM Senior Vice President for Technology Andreas Wöginger. "Our material, in contrast, is fairly new and not yet established to the same extent."

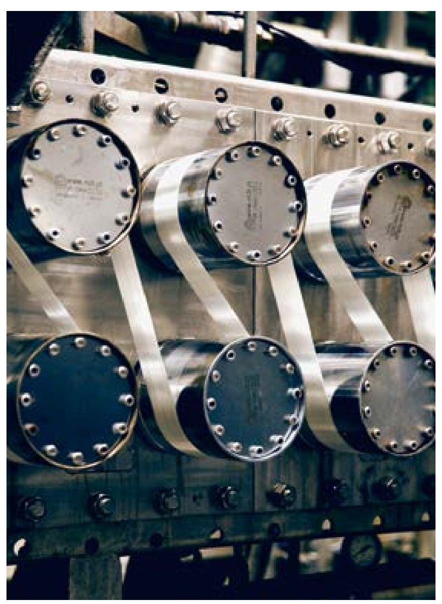
Wöginger and his coworkers have some catching up to do. And that will only be possible if they master the entire

value chain. This is because working with composite materials is different from aluminum and steel. Lightweight construction experts must completely rethink traditional development, designs and manufacturing processes, and revise existing processes: planning and installing them basically from scratch. Many companies have almost no experience with this new material. "We have to convince our customers about the added value of our material," Wöginger explains. "And then provide advice and support for implementing it, from A to Z."

To achieve this, SGL Carbon has completely integrated its value chain. Back in 2012, it bought a textile fiber plant in Portugal and since then has been transforming it bit by bit into a precursor facility. In late 2017, the company acquired the remaining shares of the Benteler-SGL joint venture in Austria for component production. The former joint venture with BMW was also absorbed by SGL Carbon. The sites for manufacturing composite fabrics in Wackersdorf, Germany, and carbon-fibers in Moses Lake in the US already belonged to the company. The established facilities in Muir of Ord, Scotland and in Meitingen and Willich, Germany, as well as additional production facilities in the US and Japan round out the production network.

With this now integrated value chain, SGL Carbon is going into the running against more established materials with the goal of creating a chain reaction. An internal one, taking place within the production steps and an external one, setting the market for materials into motion. It's a global tour de force that can best be understood by moving along the value chain. It will take us halfway around the world, from a small port on the Tagus River near Lisbon, Portugal to Moses Lake in the western US, to Wackersdorf in Bavaria and on to Austria.

This is what the precursor looks like at the very beginning. Dozens of rollers stretch and pull it and bring the white band into shape—both on pilot systems [see photo] and in industrial production.



From **Raw Material** to **Fiber**

The view at the Portuguese port, where it all begins, stretches to Lisbon. Here in the Lavradio industrial area near Barreiro, tankers carrying acrylonitrile dock every few weeks and pump the chemical into SGL Carbon silos as tall as houses. The raw material forms the basis for production at the site, where it is transformed into endless white bundles of 50,000 fiber filaments, which together form the precursor.

The person who ensures that everything runs smoothly during this transformation is walking past a network of pipes and pumps that stretch across the 200,000 square meters of the premises, about the size of Grand Central Station in New York City. "Tudo bem?" asks Andreas Witte when he encounters workers—"Everything alright?" Witte, a German-Brazilian, has been running the plant in Portugal for about a year now. After more than twenty years in Brazil, he's come back to Europe for SGL Carbon. "We manage the precursor production ourselves so that we can precisely adjust it to our customer's needs and specific applications," he says.

The site's history goes back to 1973. Back then, the Portuguese textile industry needed fabrics that could be delivered quickly, so this factory for acrylic fibers was built in Lavradio. Workers at the plant continue to manufacture acrylic fibers to this day along with the carbon fiber precursors. At the same time SGL Carbon has invested more than 30 million euros in the development of precursor polymerization and spinning lines.

After SGL Carbon purchased the factory there were four years of converting and retrofitting, researching and gaining knowledge. Since 2016, one of the ten spinning lines at the site has been producing the precursors, with another two to follow soon, Witte informs us. He's well aware that they need to ramp up production quickly to catch up in the materials race. In the heart of the factory he's standing in front of Line 10, the one already producing precursors. It's hissing and steaming and heat is rising.

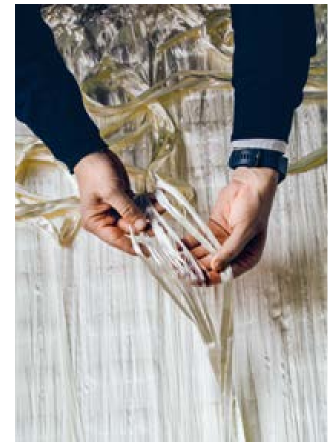
"In principle, the processes for acrylic fibers and the precursor really aren't all that different," Witte explains, while behind him rollers are stretching and pulling the precursor. Everything starts with processing the chemicals into a polymer. They are then dried into pellets, crushed and mixed with solvent to become a kind of syrup, known as the spinning material. This mixture is then pressed into a solution bath through spinnerets with 50,000 ultrafine openings. This creates the long fibers that are running over the rollers behind Witte. "We use a special recipe for the precursor and other process parameters," he says.

The plant must be continually upgraded so that everything remains successful. The quality of the final product is decided here at the beginning of the process in Portugal. "The precursor requires an exactly defined crystalline structure to be able to develop later the enormous tensile strength of the carbon fiber," Witte explains. To obtain this structure there are dozens of parameters that must be exactly adhered to: temperatures, mixing ratios, pressure values. "The better we have this under control, the more performance and quality our customers get," Witte says.

For Andreas Wöginger, an in-depth understanding of the interactions between the material and processes is also essential. "The precursor is the foundation for all the downstream production steps," he explains. "This is where we determine the pathway for various types of fibers and, moving on from those, for customized solutions." For example, Witte's team is currently working on developing a precursor for even higher-performance fibers that are considered to be the ticket into the aerospace business.

Right now it is mainly the standard precursor that is being manufactured. At the end of the production line, robot arms gently place it in boxes. These boxes are taken back to the port, and from there one of the places they go is across the Atlantic and up the Pacific to the northwest corner of the US.

Photos: Julia Sellmann (2 x); Ian Bates (black carbon fibers)



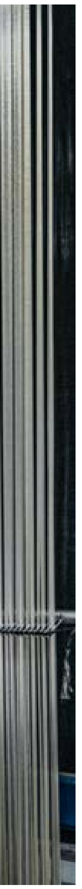
The finished product in Portugal: white bundles made up of thousands of tiny fibers. They are gently placed in boxes for transport.

Lisbon, Portugal
The SGL Carbon factory is located on the bank of the Tagus River. Acrylic fiber also rolls off the conveyor belts here along with the precursor.

In Moses Lake, the white precursor is transformed into black carbon fibers. The white bundles are first spread out to form curtains.

From **Fiber** to **Carbon Fiber**

The Moses Lake Carbon Fiber Facility in the state of Washington in the US is almost invisible in the expanse of silver-green steppe covered with grasses and desert sage. Yet the semi-trailer trucks still manage to find their way to it, delivering 40-foot containers loaded with wooden boxes weighing tons, full of silk-white precursor fibers. The fibers spent five weeks getting from Portugal to the harbor in Tacoma, near Seattle.



In Moses Lake, the white precursor strands are transformed into black carbon fibers in a fully automated process. A machine first fans out the bundle of 50,000 individual filaments before they pass through four furnaces, where the fibers are successively heated from 200 to 300 degrees Celsius, stabilizing them. Now colored black, the fiber strands are then carbonized at more than 1,000 degrees Celsius before the surface of each filament is chemically activated and then coated with a sizing to facilitate further processing. At the end of this process, the fibers are composed of around 95 percent carbon.

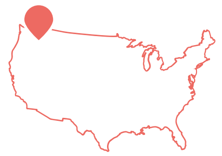
"It's all about the right mixture of three factors," says Head of Engineering and Projects Lee McKinley, who oversees the facility. "Time, temperature and the right tension." As in Portugal, the parameters in Moses Lake are also continually monitored and precisely adjusted. "After choosing the suitable precursor, it's the only way we can get the density, tensile strength, ductility and shear strength the customer desires for the material."

As Plant Manager Jennifer Smith explains, Moses Lake is the ideal location to efficiently manufacture large volumes of high-quality fibers. She has been working here since 2012 and has been familiar with the facility from the very beginning. Thanks to a nearby dam on the Columbia River, renewable energy is plentiful here and quite economically priced. "Furthermore, we have enough space here to expand further."

What started as a joint venture with BMW in 2009 will now become a site owned entirely by SGL Carbon. The first building, with two production lines, was inaugurated in September 2011, a second followed in 2014 and the third and most recent building in September 2015. The production lines run the entire year long, seven days a week, around the clock, keeping around 160 employees busy. More than 50 hectares of land, slightly larger than Vatican City, are available for further expansion on the site.

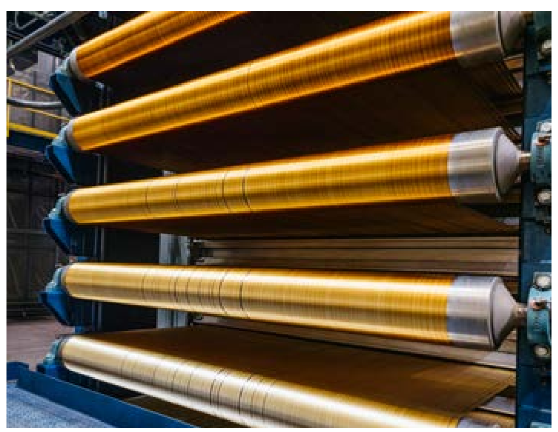
As Smith explains, the close cooperation with the facility in Lavradio is very important, allowing the company to achieve market independence and deliver consistently high-quality products. "What's even more important, though, is that we can exchange ideas, improve common processes, develop new products and react much more quickly to individual customer demands," she says. Smith thus implements specific requirements for components or carbon-fiber fabrics together with Andreas Witte, and the two are in constant communication with one another.

Once the carbon fibers have been transformed, the semi-trailer trucks load them up once again. From the harbor in Tacoma the fibers travel through the Panama Canal out into the world. Including to Hamburg, where they continue southward to the facility in Wackersdorf, Germany, where Wolfgang Koslowski is awaiting the shipment.



Moses Lake, Washington
The northwest of the US is an ideal location for SGL Carbon's carbon fiber production, not least thanks to the abundance of renewable energy.

The pretreated fibers are carbonized at more than 1000 degrees Celsius. The black fiber bundles are made up of around 95 percent carbon.



After the first run, the fibers come out of the huge furnaces fireproof, stabilized and gold brown-colored.

Photos: Ian Bates (3x); Julia Sellmann (Wackersdorf)

Jennifer Smith has been working for SGL Carbon since 2012 and is the Moses Lake plant manager.

From **Carbon Fiber** to **Fabric**

Wolfgang Koslowski listens to the buzzing of thousands of needles in front of the entrance to Hall 60. At the Bavarian site in Wackersdorf, trucks unload pallets each holding 36 carbon fiber spools from the US. Each spool contains more than four kilometers of fibers but weighs just 14 kilograms. "We check the spools, place them on creels and send them into the factory for the next part of their journey," Koslowski says. He's responsible for continually improving the production systems.

After his colleagues in Moses Lake have transformed the white precursors into black

In Wackersdorf, huge machines stitch the carbon fibers from Moses Lake into fabrics that are particularly well suited for producing large components.

Every carbon fiber textile is checked for quality before it leaves the production facility in Wackersdorf.

carbon fibers, the machines in Wackersdorf weave them into fabrics and non-woven materials. There are around 300 employees here working around the clock across an area the size of three football fields. The giant sewing machines produce several tons of material annually.

The carbon fibers are first fed into a spreading unit. The black bundles made up of 50,000 incredibly thin individual filaments are spread out across several meters in front of the machine. Inside it, the heat and vibrations help weave the filaments into wide fabric stripes, called tapes. The workers send the tapes over rollers into the next system, where giant robots dash back and forth across a three-meter-long laying table. They precisely roll the tape over glass filaments that are already placed on the table and then lay even more glass filaments on top of the tape. A conveyer belt then brings this fabric to the sewing unit, where 1,200 needles synchronously sew connecting polyester threads through it. "At the end the fabric is powdered with binding material, heated and inspected down to the last detail with optical measuring technology, all fully automated," Koslowski explains. Cameras behind him are checking the material as he speaks.

Even Plant Manager Adam Drozny remains fascinated by the precision of his machines—and by how many different materials can be manufactured from carbon fibers. He's been working for SGL Carbon for thirteen years and is intimately familiar with the Wackersdorf facility. When he took over quality management here eight years ago, mass production of the carbon fiber fabric for the i3 was just maturing in the joint venture with BMW. "We've continually increased our productivity and quality since then, significantly reduced our material waste and successfully realized new customer projects," he says.

Wackersdorf, Germany
In Wackersdorf in Upper Palatinate, SGL Carbon has completely taken over the fabric and non-woven materials production facility from the BMW joint venture.

Both fabrics and non-woven materials roll off the lines here in Wackersdorf today. "We can change the grammage and the angular alignment of our products according to the customer's demands," Drozny explains. While the extremely lightweight and robust fabrics are particularly well suited for large components in cars or planes, using an optically innovative hexagonal stitching makes more sense for particularly sophisticated visible parts.

"Our advantage is that we can plan with our customers during the initial design phase on which properties the weave, fabric or non-woven material must have," Wöginger says. "We can then incorporate the requirements into every step of the value chain and offer the material to customers in exactly the form that they need."

The carbon-fiber fabrics from Wackersdorf are sold in part directly by the meter to customers. If not, they then start the next leg of their journey to the final production step, for instance to the Innkreis facility in Austria.

Plant Manager Adam Drozny took over quality management in Wackersdorf eight years ago and he still remains fascinated by the precision of the machines.

Photos: Julia Sellmann

From **Fabric** to **Component**

Around sixty kilometers northeast of Salzburg, amidst dense forests and green meadows, Plant Manager Herwig Fischer and his colleagues receive the fabrics from Wackersdorf. Here in Innkreis is where SGL Carbon has integrated the last step in its value chain, where the various carbon-fiber textiles are transformed into mass-produced components made of fiber-reinforced composites.

Innkreis, Austria
Components made of carbon-fiber composites roll off the line for SGL Carbon where high-performance snow skis were once made.

"What we do here with carbon and other fibers is a little slice of the future," say Director Sales and Program Management Automotive Robert Hütter, a member of Fischer's team responsible for customer relations. He passes by the heavy presses and robots in the factory. Every day the site produces an assortment of door variants and rear spoiler systems for Porsche, rear panels for the Audi R8 (find out more in our report starting on page 18), various component sets for the BMW i3 and leaf springs for several Volvo models and other vehicles.

Like the precursor facility in Portugal, the site in Austria also had to be upgraded and developed to catch up in the race against more conventional materials. What started as a factory for high-performance snow skis became a center of excellence for lightweight construction under the aegis of Benteler-SGL. SGL Carbon recently acquired all the shares of the joint venture.

To manufacture finished components from the carbon fabrics, the machines first make a sort of template from the uncut material. Robots place it in presses and pressurized resin flows into it. Then the parts harden, and milling and water jet systems remove excess material. In series production, finished components for the BMW i3 roll off the production line every few minutes. In addition, workers still manufacture geometrically more complex pieces mostly by hand, thereby acquiring further important knowledge of the process.

For SGL Carbon, component manufacturing at the end of the value chain has become an essential part of its core business. "We can now offer our customers the appropriate product at every point of our manufacturing," says Wöginger, who, together with other colleagues of his management team, has established this new approach. It's helping in the race to catch up with conventional materials and in the acquisition of experience and knowledge. Just like his colleagues in Lavradio, Moses Lake, Wackersdorf, Innkreis and in all the other SGL Carbon facilities, Wöginger is also gaining more experience and expertise that he can share with his colleagues.

Robert Hütter and his team are constantly in contact with customers and he also interfaces with production.

Thanks to this broad knowledge and the integrated value chain, they and SGL Carbon have gained quite a bit of ground in the race with conventional materials. The chain reaction has been sparked. "Today we can offer our customers solutions, ideas and project management from a single source," Wöginger says, explaining the current breakthrough of composites. Working with its customers, every day the company distills the best from the innumerable possibilities and implements them. As Wöginger explains, "This integrated approach is fairly unique in our industry."

Interview

› The depth of integration follows the strategy ‹

Thomas Friedli has been researching the integration of **value chains** and technologies for years at the University of St. Gallen in Switzerland. Andreas Wöginger is advancing this field in practice at SGL Carbon in the division Composites—Fibers & Materials (CFM). They discussed the right amount of integration, the optimal management of value chains and the characteristics of the composites business.

Mr. Friedli, what do you recommend to companies that are wondering what degree of integration they should pursue?
Friedli — The degree of integration a company should pursue for its value chain always depends on the market it's operating in. It depends on how the company differentiates itself and the strategy it is following.

The depth of integration always follows the strategy. Why is that?
Friedli — Because the configuration and coordination of a company's own production network is just a means to an end to support the respective company's strategy. The depth of the value chain is an integral part of that configuration. If a company differentiates itself on the market through for instance good quality, constant availability and high speed, it can make sense to increase the depth of the value chain in order to be able to achieve these things independently.

You analyzed the value chain of the Graphite Materials & Systems division for SGL Carbon. What did you find?
Friedli — That's the exact situation that we found. That's why this division is so strongly integrated, both vertically and horizontally. Vertically because SGL Carbon covers all the production steps, from manufacturing the raw material to customer-specific solutions. And horizontally because many facilities are working together on the same production steps. It fits perfectly into SGL Carbon's strategy of offering its customers solutions along the entire value chain.

And what could be improved?
Friedli — It's important that the factories communicate and cooperate better with one another in places. They could take on tasks from which they and the other locations would benefit. Ideally, every site manager thinks about the entire value chain—and not just about that one site's production. That's what the division is working on right now.

Thomas Friedli is a professor for Production Management at the University of St. Gallen in Switzerland. His most important fields of research include strategic management for manufacturing companies and management of industrial services.

Mr. Wöginger, one of your jobs at SGL Carbon is the strategic alignment for the second division CFM. Are these the sorts of things you think about?
Wöginger — We're in a much different phase than our colleagues. What connects us is the complexity of our materials. But in the area of carbon fibers and composites, we have the situation where it's only now that we can work on a completely integrated production process. This inevitably poses different challenges.

And those would be?
Wöginger — Our material is still quite young and is continually evolving. It's extremely exciting and offers fascinating possibilities. However it also means that you still have to do your own groundwork in the business and must drive the expansion of process knowledge. We have to be very close to the customer and bring our knowledge to the market as good as possible.

The integration of the value chain has been completed?
Wöginger — Vertically, yes. We have set up production of our own raw materials in Portugal, the precursors. Those are the very fine threads of fibers that serve as the basic material for all of our products. Aside from that we've taken over two joint ventures and integrated them. Moses Lake, where the precursors become carbon fibers, is by the way the most state-of-the-art carbon fiber factory in the world. The location at Innkreis has one of the industry's most-automated component manufacturing facilities. Our value chain is fully integrated. It was an important step for us because it gives us a significant competitive advantage in the market.

Illustrations: André Gottschalk

Because otherwise the quality can't be guaranteed?
Wöginger — Quality is extremely important, and that's exactly why you need control over the intermediary products. Sometimes these are only available in very limited types and qualities on the open market. What's most important is that we have to offer our customers more than just intermediary products such as carbon fibers or carbon-based materials. Many customers would love to work with composites but don't yet know how to deal with the intermediate materials on their own. They're demanding solutions from us as a complete package. We can only offer this when we've fully penetrated every step of the process. It's also the only way we can open up new markets.

Friedli — It's quite similar in the specialty graphite sector. The chemical composition of the graphite determines the properties that the respective product will ultimately have.

Wöginger — In principle, you have to imagine it like an inverted pyramid. At the bottom is the narrow tip, representing the raw materials for carbon fibers and synthetic graphite. Then with each stage of production, it broadens upward with respect to processing and potential products. If you want to produce high-quality products in this sort of value chain, you inevitably must start at the very bottom with the first stages of it. We're also very well positioned regarding the other steps, which gives us enormous flexibility.

Andreas Wöginger is Senior Vice President of Technology at SGL Carbon and responsible for the technological development of composites and their applications. He holds a doctorate in mechanical engineering and has been working at SGL Carbon for eight years.

So first integrate backwards and then look forward?
Wöginger — Every value chain is different. Our benchmark is whether we can offer a good solution for our customers' needs. We definitely require this extremely broad understanding of the technology to do it.

Friedli — If you have complete control over your value chain, it provides the added benefit of being able to sell your products at the intermediary stages as well, providing additional flexibility.

Wöginger — We do that with our intermediate products, including the fibers and composites, but still a complete component solution is becoming increasingly attractive for customers. And our raw material, the precursor, is something we don't sell at all.

Isn't there the danger of getting bogged down in a value chain that is too integrated?
Friedli — As with anything, there are certain trends pertaining to this question. In the 1990s it was considered progressive to outsource a lot. Today many companies are returning to a stronger integration because they've had bad experiences with suppliers that have gone bankrupt for instance or couldn't achieve the desired quality.

Wöginger — I think it depends on the age and maturity of an industry. When an industry has been around forever, there are a lot of suppliers for each step of the value chain. Then it makes sense to specialize for certain stages of the process. For our field of carbon fibers and composites, the opposite is true: there are few suppliers and the material is still very young. At the moment we're simply more efficient and more successful being fully integrated.

In a Nutshell

News about the company, trends, products and partnerships

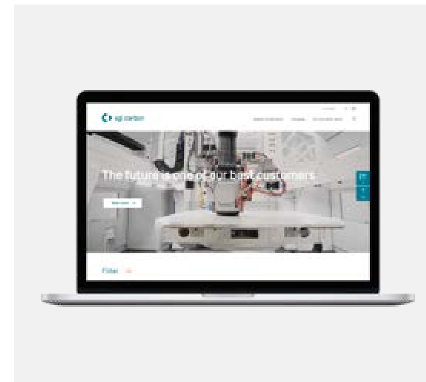
Donations for Warm Lunches

Sales employees of the Graphite Materials & Systems (GMS) division at SGL Carbon are supporting Manna Mobil, a meals-on-wheels organization in Wiesbaden, Germany, with a donation of 1,000 euros. As GMS Head of Marketing and Sales Christoph Henseler explains: “It initially started as a voluntary contribution, a kind of fine that employees had to pay whenever their cellphones went off during the Global Sales Meeting. But we were soon faced with the dilemma that everyone began to look forward to a ringing phone. At the urging of a number of colleagues, we briefly explained the excellent work that Manna Mobil does and sent our donation box around the rows once again.” Since 2007 Manna Mobil has been offering free lunches to children and teenagers in Wiesbaden and nearby Rüsselsheim. During the lunches, the project brings together young people from a wide variety of backgrounds in a relaxed atmosphere. Manna Mobil’s employees are as diverse as the people they serve, with a few full-time employees, lots of volunteers, interns, and young refugees in career counseling.

Optimal Insulation

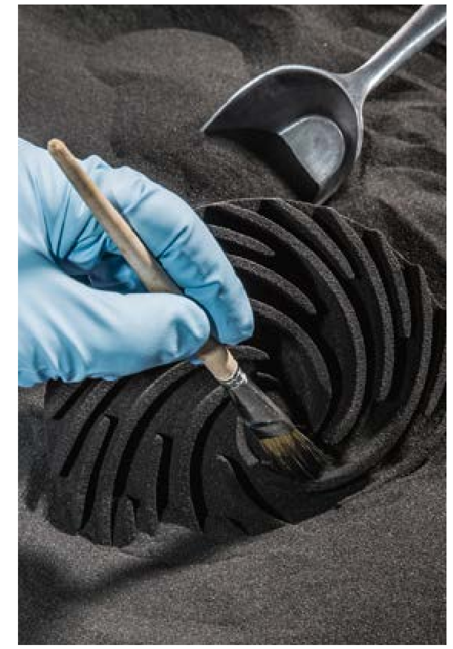
SGL Carbon continues to expand its business in high-performance insulating components for the aerospace sector. The company signed a long-term supply contract with a subsidiary of the Turkish airline Onur Air for engine cowlings for a total of 32 V2500 engines for use on its Airbus A321 fleet. In addition, Onur Materials Services will become an SGL Carbon sales partner in various countries in the Middle East with an additional sales potential of several hundred additional cowlings. “We’re pleased to have found a reliable partner with the Onur Group to expand our customer portfolio and our regional presence,” says Andreas Erber, director of the Aerospace division at SGL Carbon. The insulating components are manufactured in an American SGL facility in Arkadelphia, Arkansas. The components were certified by the Federal Aviation Administration in the US and are used by a large American airline.

Photos: Manna Mbbil (donation); SGL Carbon (engine); iStock/ET-ARTWORKS (Notebook; Dominik Gigler (3D print); plainpicture/photocake.de (wing)



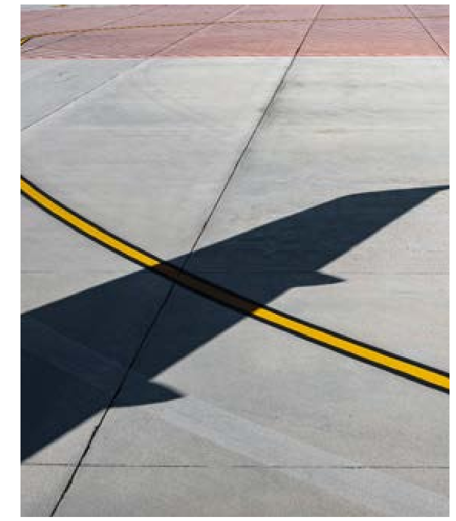
New Digital Home

In line with the new branding strategy, SGL Carbon has completely redesigned its company website from the bottom up. Site navigation has been significantly streamlined and the product area home page is now consistently oriented towards the company’s markets and applications. “Online we’re continuing exactly what we’ve defined in our new brand and are presenting ourselves as a solutions provider instead of a materials supplier,” says Communication Manager Kevin Krause, who coordinated and managed the website relaunch. Customers, applicants, investors, journalists and all other interested parties can quickly get to the desired information with just a few clicks thanks to the easier and more intuitive user guidance and an optimized search function. “We’ve additionally created a whole new content area where we want to create momentum,” Krause says. “This is accomplished with the help of stories about our materials and solutions in their respective market contexts.” In the future the website will be the centerpiece of SGL Carbon’s digital communications and a central access point for all further digital projects.”



In All Dimensions

Three-dimensional printing is an important technology trend. According to market studies such as one by Wohlers Associates, the global 3D printing market will continue to grow annually by an average of 20 to 25 percent across all material classes through 2023. SGL Carbon is also advancing its research in the area of additive manufacturing. The company recently opened its own industrial-scale 3D printing system at its site in Meitingen, Germany. A wide variety of complex components made of carbon and silicon carbide can be manufactured with computer assistance and without the need of any special tools. “3D printing is incredibly fast and offers a high degree of freedom of design,” says Oswin Öttinger Head of New Technologies at SGL Carbon. “That helps us to further accelerate the development of new solutions.”



Partnership with Wings

SGL Carbon is in cooperation with the UK’s National Composites Centre (NCC) in Bristol to further expand its knowledge in the area of carbon fibers and composites. The partnership’s focus is on the development of sustainable concepts for applications in aerospace, transportation and in the oil and gas industry. The company expects the cooperation to act as a catalyst, particularly for the aerospace business, and to strengthen the company’s regional presence in Great Britain. To this end the partners are currently developing a program at the NCC’s research institute for the further processing of carbon-fiber based textiles, which will be followed by prototypes for new airplane wings made of composites based on SGL Carbon’s carbon-fiber fabrics. The special fabrics are being produced at the SGL Carbon facility in Wackersdorf, Germany, while the carbon fibers used in the fabrics come from the facilities in Muir of Ord in the UK and Moses Lake in the US.

Backbone of Carbon

SGL Carbon manufactures extremely lightweight and robust components of composite materials for the automotive industry, including the **rear panel for the Audi R8**. Thomas Vielsecker helped develop the component from the very start. Driving the sports car, he was able to experience for himself how the backbone of carbon keeps the car perfectly on the track, even during extreme maneuvers on tight corners and under heavy acceleration.

Photo: Constantin Mirbach

Thomas Vielsecker steps through a glass door into the open air. A veil of clouds stretches across the sky above the Audi test track in Neuburg an der Donau in Bavaria. Before him awaits a gleaming gray sports car, powerful and sleek: an Audi R8. The engine's running, but Vielsecker lingers to enjoy the moment.

He slowly walks around the car, runs his fingers along the dark-gray trim of the wing mirror, over the side panels and rear spoiler, all made of layered carbon fiber. Beneath the spotless rear window is the engine, a purring monster with ten cylinders and 610 HP. Vielsecker opens the driver's door, gets in and lets himself sink down into the bucket seat. His hands on the wheel, the car in neutral, he taps the gas pedal. The engine roars. Over six hundred horses, a whole herd champing at the bit to take off galloping.

Behind Vielsecker, between his seat and the engine, is the component that he worked on for so long: the rear panel made of carbon, about two meters long and a meter tall, produced at the SGL Carbon facility at Innkreis, Austria. Carbon-fiber reinforced composites were used back in the first generation R8, introduced in 2006, in visible locations including the rearview mirror, the side panels and the rear spoiler. Back then, the car body was made completely of aluminum. Starting with the second generation, on the market since 2015, carbon-fiber reinforced composites have made it deep into the car's basic structure. The rear panel has to resist strong shear forces and absorb energy if there's a crash. As Vielsecker explains, "It's really the backbone of the car body, so to speak."

Vielsecker, who is a team leader in sales, has been with the project from the start. He knows every detail of the plans, every millimeter of the drawings, every corner of the component. Today he gets to feel the results in real life: out on the test track, riding free. He buckles up, closes the door and pushes the gearshift of the automatic transmission to D, for drive. A tingling sensation comes over him, a little like the first time he got behind the wheel of his mother's small car on his eighteenth birthday. Of course, this time it's not a compact car, it's an Audi R8 Coupé V10 in

A final check of the R8 before Vielsecker gets in and starts the test drive.

With a smile on his face, Vielsecker steers the sports car through the tight curves.

› The car hugs the road like a dream! ‹

Photos: Constantin Mirbach (p. 20); AUDI AG (p. 21)

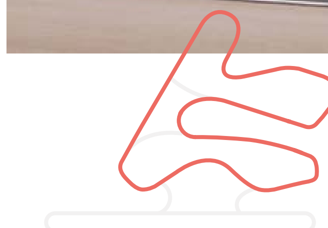
Daytona gray, with a top speed of 330 kilometers per hour that goes from 0 to 100 in 3.2 seconds. Vielsecker has always loved fast cars. He's been a spectator at the DTM motor-racing championship in Hockenheim Germany and at the Formula One on the Österreichring in Austria. He feels a sense of pride whenever he sees an R8 out on the road, knowing he's contributed his part in the sports car's development.

Staying Strong

The car slowly glides across the asphalt in front of the glass-fronted reception hall. The red-and-white barrier rises and the R8 rolls out onto 2,200-meter-long test track. After a relaxed first lap, the R8 turns the corner onto the straightaway for the first time. Vielsecker steps on the gas, the engine snarls and the thrust slams him back into his seat. In just a few seconds he accelerates to 160 kph. Vielsecker then slams on the brakes, makes a hard left and glides smoothly into the curve. The rear panel is subject to extreme forces in such moments, but it doesn't give way: the material stays strong. "The car hugs the road like a dream," he says, but then falls silent—he needs to focus for the next curve.

The veil of clouds parts and the sun shines through, illuminating the asphalt. Lap for lap, Vielsecker is getting more daring, braking later, turning harder, accelerating earlier. Since every gram of weight costs a sports car speed, it must be made as lightweight as possible. This makes the use of carbon-reinforced composites a no-brainer. They're 40 percent lighter than aluminum. Vielsecker is now taking some of the turns so tightly, he's clattering over the curbstones at the inside edge of the track. With the seat placed far forward, he's gripping the steering wheel, highly focused, his neck straining against the centrifugal forces. "It's really exhausting," he says later during a well-earned break. "I have respect for racers who do this for hours at a time."

The test track only has a short straightaway and it takes a lot of concentration to keep your orientation through the many curves. The panorama through the windshield changes jerkily, with fleeting images shooting into your field of vision left and right: crash barriers, fields of dandelions, boxy black buildings, fluttering white



The demanding Audi test track in Neuburg an der Donau requires high levels of concentration by the driver.

flags, a reckless bird, very close. A chicane, a left, another left, a hard right. Crash barriers again zoom past, stacks of tires, dandelions—it's almost like a rollercoaster.

Concentration, endurance and the desire to risk something new and put the pedal to the metal—the same qualities that make a great racing driver also helped the development team produce that rear panel. The first inquiry came from Audi in 2011, with production beginning in 2013. Since then it's been in serial production, which is planned to continue until 2022. The original, traditional aluminum design had to be transformed into one that worked for fiber composites. Because there are almost no standardized production facilities for carbon-fiber components, Vielsecker and his coworkers in Austria had to develop some 150 special tools, molds and assembly systems. The components are manufactured by placing the preformed fiber material into a heated steel tool that is filled with flowing liquid resin, which hardens through a chemical reaction. ›

The SGL Carbon rear panel, made of 25 carbon components and some 200 individual parts, is the backbone of the R8 car body. Its light weight is impressive and its pronounced stiffness guarantees the driver a high degree of safety.

The result is a process in which 25 carbon components and some 200 individual parts are assembled on a fully automated production line. By the end, they have grown into a single component weighing 22 kilograms that the customer then installs in its vehicles. There are four variations of the rear panel, one each for the coupés and convertibles of both the Audi R8 and the Lamborghini Huracán, which uses the same platform.

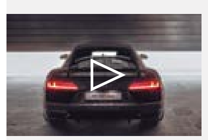
"Harder than expected"

Vielsecker really enjoys his last laps on the test track in Neuburg to the fullest. He presses the gas pedal to the floor ("The kick-down is really intense!"), slams on the brakes, rumbles over the curbstones and accelerates out of the turn with screeching tires. He goes too far in a hard-right turn, driving right over the curbs and into the asphalted run-off area. Not a problem at all, but a brief moment that points to another, crucial advantage of carbon fiber: its excellent crash properties, as impact tests and roll-over tests have proven time and again. Composite components don't deform. In extreme crashes they help absorb the energy of the impact. "There's a reason why the cockpits of Formula One vehicles have been made of carbon for decades," Vielsecker says.

At the end, the red-and-white barrier rises once again and the R8 glides off the test track. Vielsecker looks down to a display next to the speedometer: the hot-test tire, at front right, just standing there, measures 67 degrees Celsius. He steps on the brakes one last time in front of the reception hall and gets out of the vehicle. The air over the car's tail end is filled with the scent of burnt rubber and shimmers in the heat of the engine. Vielsecker looks energized. "Harder than expected," he says—naturally meaning both: the test drive and the backbone of carbon.

> It's really the backbone of the car body, so to speak. ‹

Vielsecker thoroughly checks out the component even though he knows every smallest detail inside and out.



The video of the test drive
We accompanied Vielsecker with a camera during his test drive. Fast-paced images of the track alternative with insights into the construction process:
www.sglcarbon.com/data/video/R8/

Photos: Constantin Mirbach

MIRACLE IN GREEN

Idea Factory

Algae can reduce greenhouse gases by binding and transforming carbon dioxide into oxygen. Biotechnicians from Munich are constantly working on new applications and simultaneously promoting innovations. One of them involves **carbon fibers**.

The smell of salt is thick in the air and it's as warm as a Mediterranean summer day. However the blazingly bright light isn't only from the sun: it's coming from powerful LEDs as well. They're shining down onto open tanks through which thick greenish water is flowing. The color is caused by microalgae, which are multiplying by the billions in the water. Here in the algae technical facility at the Technical University of Munich (TUM), researchers are experimenting with these water organisms to develop innovative technologies. The algae can be used to help create biofuels, vitamin products and medications. Biotechnology Professor Thomas Brück and his team of scientists have now discovered another application. The algae's rapid growth can bind climate-damaging carbon dioxide and also serve as a particular environmentally-friendly raw material for producing carbon fibers, acrylonitrile, which until now has been produced almost exclusively from crude oil and natural gas.

Algae Farms the Size of Algeria

The Munich method works in several stages. First, green algae transform carbon dioxide—from the atmosphere, power plants or exhaust fumes from the steel industry—into algae oil. One of the products derived from this is glycerin, which can be further processed into acrylonitrile. This acrylonitrile can then be used to produce precursor fibers made of polyacrylonitrile (PAN) and, ultimately, carbon fibers, as previous laboratory results from TUM have suggested. "Moreover, the system for manufacturing algae oil is easy to scale up across large areas," Professor Brück explains. "If there were algae farms worldwide that, taken together, added up to about the size of Algeria, we could theoretically offset the carbon dioxide emissions of the entire airline industry and simultaneously support lightweight construction." And there's another advantage: since saltwater algae thrive best in sunny regions such as North Africa, their cultivation wouldn't compete with agricultural land use, Brück says. The developments from the researchers in Munich have met with a positive response. SGL Carbon is preparing to enter into a cooperation with the university algae facility. The World Climate Report has classified this alternative method for manufacturing the precursors for carbon fibers as globally relevant, although the process is still in its infancy and the methodology has yet to prove itself.

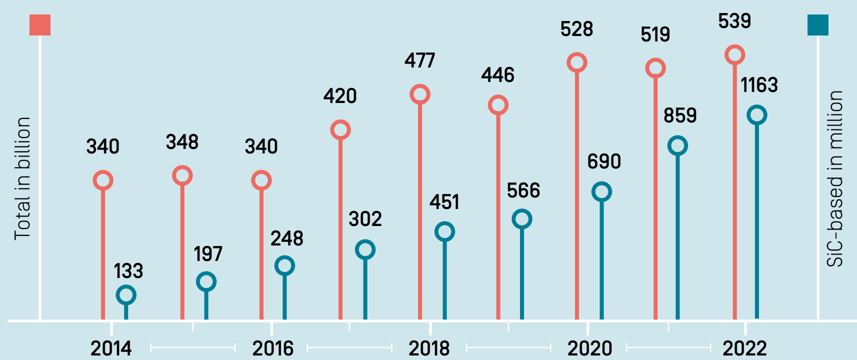
Photo: Andreas Heddergott/TUM

Tiny Chips, Huge Growth

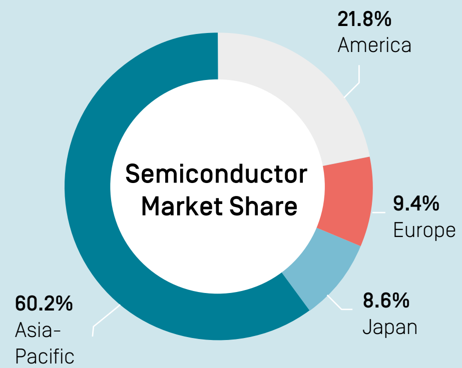
Things continue to look up for the **semiconductor industry**. Almost every technological trend requires processors and memory chips. The market continues to demand ever purer, more complex and increasingly powerful microchips based on semiconductor circuits. SGL Carbon manufactures a variety of specialty graphite solutions that play an important role in semiconductor production.

The Market and its Drivers

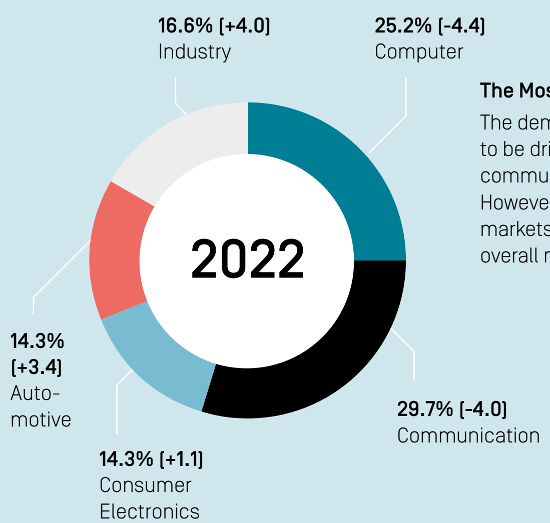
Past Sales and Forecasts in US dollars for Semiconductors based on Technology



Boundless Growth: Driven by digitization and technological innovation, the global sales forecasts for the semiconductor industry are continuing their steady upward climb. While the market used to be mainly coupled to the volatile demand for PCs, today it is increasingly being driven by structural trends including Industry 4.0, sensors and applications for autonomous driving. Despite this, the market continues its cyclical rhythms. While the niche market for silicon-carbide semiconductors (SiC) is showing consistent growth, the forecast for sales of common silicon semiconductors in 2019 is showing a slight decline due to an oversupply of memory chips. However from 2020 onward, total global sales of semiconductors are projected to exceed the 500-billion-dollar mark.

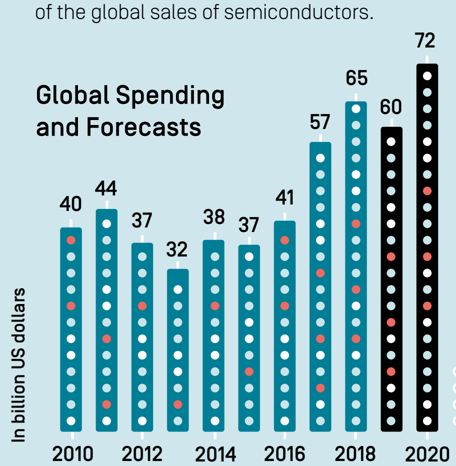


Semiconductors Worldwide: The most important sales markets for semiconductors are Asia-Pacific and America. In 2019, these regions are expected to generate more than 80 percent of the global sales of semiconductors.



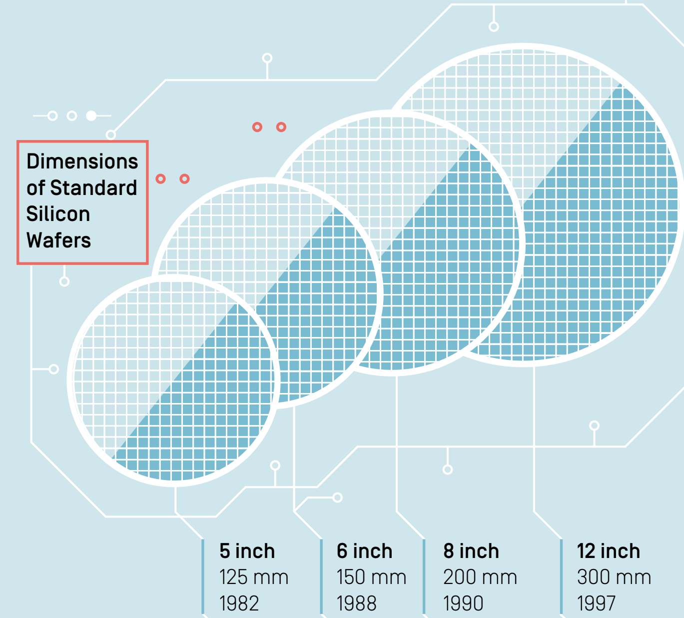
The Most Important Market Segments:
The demand for semiconductors continues to be driven by the market for communication devices and computers. However, the automotive and industrial markets will make up a greater share of the overall market in the future.

Global Spending and Forecasts

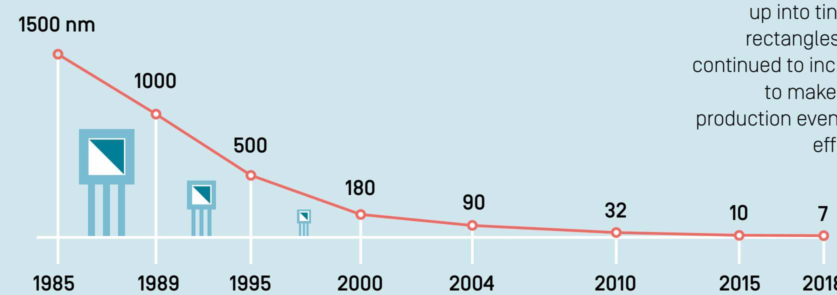


No Semiconductor Manufacturing Equipment, No Chips: Global spending on semiconductor manufacturing equipment rose sharply in 2017 and 2018. After a brief dip in 2019, it is once again expected to take a great leap upwards in 2020—by more than 20 percent.

Technology in Progress

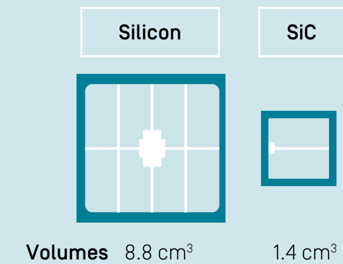


Growing Wafers: The millimeter-thin wafers made of silicon, silicon carbide and other materials form the basis for the manufacture of semiconductors. The diameter of the wafers—which are cut up into tiny little rectangles—has continued to increase, to make mass production even more efficient.



Shrinking Transistors: At the same time, the semiconductor industry keeps developing increasingly smaller microchips since this improves their application potential in electronic devices. That's why the individual semiconductor components continue to shrink in size. For transistors, which usually act as switches or amplifiers in microchips by controlling voltages and currents, dimensions well below 100 nanometers are already standard. A nanometer (nm) is one-millionth of a millimeter.

A Niche with Potential



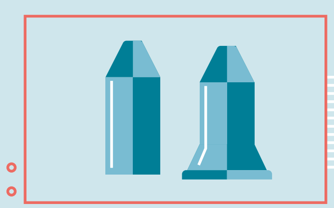
Extreme Performance: The same performance at one-quarter the size. Semiconductor components based on silicon carbide (SiC) are much more powerful, smaller and lighter than conventional silicon components.

31

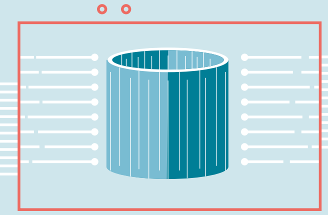
percent growth rate per annum through 2023 is the forecast for silicon-carbide semiconductors in the power electronics sector. The market share right now is around 2 percent of all power semiconductors, yet the market for especially durable and tiny SiC-based chips is growing at a much faster pace compared to conventional silicon-based chips.

SGL Carbon in the Semiconductor Value Chain

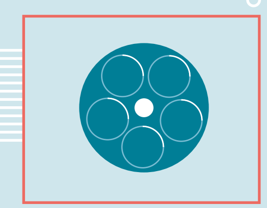
Integrated Value Creation: Components made of graphite are absolutely indispensable in the manufacture of semiconductors. SGL Carbon delivers the necessary graphite components for several stages of this production process—for semiconductors made of both silicon (Si) and silicon carbide (SiC). Graphite components specifically support the following three process steps:



Raw Material Production: SGL Carbon delivers graphite electrodes and graphite felts as well as heaters made of carbon-fiber reinforced graphite used for manufacturing high-purity silicon and silicon-carbide.



Crystal Growth: Next is the growth of single crystals, also known as monocrystalline ingots from silicon or silicon carbide. For this process SGL Carbon supplies heat- and corrosion-resistant furnace components and heating elements made of graphite.



Processing: Semiconductors also must be chemically coated. During this process, the wafers are often carried on graphite susceptor plates that are manufactured by SGL Carbon.

Infografic: Pia Bublies

Sources: Gartner 1/19 & prior reports; SEMI 9/18 for 2017, 2018 & 2019, SEMI 4/19 (and prior reports) 2019 & 2020 forecast from 12/18, SIA 2018 Factbook, IHS Markit, May 15, 2019, semi.org; Yole Development; own research.

In Harmony

Synthetic graphite is a **building block** of our modern world. Yet as is the case in many industrial sectors, its production creates exhaust emissions and a certain amount of fine particulate matter. In the Arve Valley in France, SGL Carbon is showing how production can be carried out in an environmentally friendly and sustainable way, even under very difficult conditions. An onsite visit to the foothills of Mont Blanc.

Photo: Mattia Balsamini; iStock/Queensbury (mod)

The emissions generated from the production of synthetic graphite are extracted in enormous blue pipes. Lime is then used to neutralize acic gases. As soon as the mixture flows through the filters, the dust particles, including calcium based salts, fall into collection containers.

The key ingredient of the future has to pass just one final test this April morning. Outside, snow-covered Mont Blanc glitters in the springtime sun, while inside, in one of the SGL Carbon factories in Chedde, France, Site Manager Serge Paget places a black block the size of a brick on the conveyor belt in front of him. Paget, 59 years old, presses a touchscreen and the graphite slides beneath an x-ray machine. It takes a moment before a green image appears on the screen. Paget is pleased because all of the quality parameters have been fulfilled.

The product Paget has just tested, is a special synthetic graphite made by SGL Carbon that comes in different mixtures, shapes and sizes. As anode material in lithium-ion batteries, it delivers energy for the e-mobility revolution. It is used to manufacture solar cells, making the worldwide energy transformation possible. And it serves as a basic material for producing silicon semiconductors and light-emitting diodes (LEDs). The black bricks, cylinders and tubes coming from the foothills of Mont Blanc are helping advance digitization, the mobility transformation and illuminating our world.

The graphite that Paget and his more than 220 employees are producing in the Arve Valley in France has the right attributes for all of these functions. It is extremely heat resistant, highly purified, reliably conducts electricity and keeps its shape even in corrosive environments. Site manager Paget and his employees modify the structure for the respective applications. They optimize the formulation and the manufacturing process for each of these futuristic fields. “Our graphite is something like a building block for modernizing the world,” Paget says.

The graphite must undergo a long production process before LEDs can light our living rooms, lithium-ion batteries can power our smartphones and electric vehicles, or semiconductors can simplify our world. The workers in Chedde mix petroleum coke with liquid bitumen and other materials and form meter-long blocks from the mixture. In garage-sized ovens they heat the blocks to more than 850 degrees Celsius, impregnate them with bitumen, heat them up again and then transport these blocks into halls the size of football fields. There, the rods and blocks are covered with coke grains and then subjected to an electrical current. The temperature rises to more than 3,000 degrees Celsius and the carbon, the structure of which was until now disorganized, recrystallizes. Everything that isn’t carbon burns off. What remains behind is graphite, a highly pure form of carbon with an organized crystalline structure.

Clean and Efficient

It is a tried-and-tested process that has continually been improved over time. However, it is an industrial process that produces fine particulate matter and exhaust emissions, not to mention unpleasant odors, even under state-of-the-art conditions. Because of this, Paget must master two challenges at the same time: “We want to shape the future here while simultaneously operating in the cleanest, most efficient and most environmentally friendly way possible,” he says.

Sylvain Collet is supporting him in this. Behind the factory halls with the glowing electric ovens, Collet, 39 years old, leads us to a labyrinth of meter-wide blue pipes that twist out of the hall and head towards two steel equipment as tall as houses. Next to them are three silver towers and a silo reaching up to the sky. “Those are our baghouse filters, the lime injection system, three activated carbon filters and a wet scrubber,” Collet explains. “This is how we keep the emissions under control.”

Before Collet joined SGL Carbon, he studied engineering, specialized in sustainable production processes, and then began his career at a filter manufacturer. He can talk for hours about filtering systems, about threshold values for benzo(a)pyrene emissions and the best designs for filter conduits. In Chedde he works for SGL Carbon to filter out the emissions created during the process of graphite production.

Here in the foothills of Mont Blanc he is struggling with particularly difficult circumstances for achieving this goal. In winter, the climate creates a temperature inversion between the valley and the mountain. Instead of rising up into the air, the emissions spread out in the area around the factory. The mountain ranges also close off the Arve Valley from any wind that could clear the air of fine particulate emissions from industry and transport, emissions that are less easily removed. “On top of this, many people in the region heat with wood-burning stoves, which enormously increases particulate pollution during the winter,” Collet explains. In the past this resulted in emissions levels in the valley that repeatedly exceeded the government’s prescribed limits during the winter months.

Collet knows all of the exact values. And he still remembers well the consequences in the valley until recently. Climate activists accused the SGL Carbon facility of being responsible for the limits being exceeded. Angry citizens took to the internet to vent their rage on SGL Carbon’s social media channels. The French environment minister traveled to the valley with a huge delegation.

Collet understands the anger. He has no intention of glossing over anything. Yet he does point out the whole truth, which is that industry is responsible for only a small part of the air pollution. He quotes statistics that show that the region’s emissions come mainly from the residents’ wood-burning stoves and that all the industrial facilities in the region produce just 13 percent of the particulate matter. Additional surveys show that traffic is primarily responsible for the NOx pollution and that all of the industrial facilities combined are only the third largest emitter.

As Collet explains, the SGL Carbon factory is therefore responsible for just a very small portion of the emissions in Arve Valley. In the past, SGL Carbon had always complied with all limits, Collet remembers. “We naturally want to operate as cleanly as we can and emit as little pollution as possible.”

Serge Paget manages the SGL Carbon facility in Chedde. He continues the modernization process of the facility that started back in 2005.

12.6

million euros is the amount that SGL Carbon has invested in reducing pollutant emissions at the Chedde site since 2005.

89

percent reduction is what the facility has achieved in reducing the emission of fine particulate matter. Even before, the site had never exceeded the threshold values for such pollutants.

To accomplish this, in 2005 SGL Carbon started to invest in new filters in the factory, which is more than 120 years old. Over the past two years the company has again spent more than 4.5 million euros on filtering systems, dust covers, fans and activated carbon filters. The regional government has supported SGL Carbon with 1.1 million euros in subsidies. Since 2005, the company has invested more than 12.6 million euros in pollution reduction.

Always Following All the Rules

Just fifty meters from the labyrinth of blue conduits, Collet pushes open an iron door and enters a hall with eleven electric ovens. As if lying below huge flowerbeds, the graphite blocks glow beneath the covering of coke and are forming their highly pure structure. The humming of electricity fills the room. A hydraulic excavator that could easily scoop up a small car glides through the hall bringing coke grains to the ovens. Collet wants to show us how the pollutants are extracted from the air here.

His finger points up to the hall ceiling. A heavy, metal box is attached to the ceiling every fifty meters. “Those filter systems capture the diffuse dust particles,” Collet says. When the heavy excavator dumps the coke onto the graphite blocks, coke dust automatically whirls into the air throughout the room. As Collet explains, “We capture a majority of it with the ceiling filters.”

A few meters further he stops in front of one of the ovens in use. The heat radiates far out into the room. There is a 13-meter-long hood that workers have placed above the graphite blocks and coke. It covers the 3,000°C mixture down to the floor. Conduits from the hood lead to the walls, where fans draw out the emissions captured beneath the hood, delivering them to the modern filter installations behind the hall. Once they arrive there, a machine adds lime to the emissions. The mixture in the airflow then goes through the filter. In the end, the bound and separated dust particles trickle down into plastic sacks.

Later, in a conference room, Collet shows what SGL Carbon has achieved with these measures in recent years. Statistics flicker on the wall, showing the measured values for the years 2005 to 2018. The sulfur-dioxide quantities have gone down by 44 percent. The fine particulate matter has declined by 89 percent and the benzo(a)pyrene emissions by 99 percent during the same time period. The PAH (Polycyclic Aromatic Hydrocarbon) value, the most critical pollutant, has gone done by 98 percent. “We have always been below the limits and have now reduced our emissions significantly once again,” says Collet.

Left: In the production of synthetic graphite the material is heated several times–up to 3000° Celsius during the graphitization process.

Right: SGL Carbon produces as sustainably as possible in Chedde. The company has been investing in filtering systems and environmental protection for years.

Photos: Mattia Balsamini

These were important steps for Collet, Paget and the entire SGL Carbon team in Chedde, ones that even critics have noticed and acknowledged. The negative comments on SGL Carbon’s social media channels have almost subsided. There have been citizen forums and informational events. Recently the head of the regional administrative authority paid a visit to get a personal impression of the filtering systems.

Collet again comes to a halt in the heart of the filtering system, where all the conduits converge and the exhaust air passes through dozens of filters. There is still a hint of sulfur coming from raw material in the air near the filters. During the graphitizing process in the electric ovens, the sulfur gets burned out at 3,000 degrees Celsius. Tiny particles rise up into the air and, on some days, can create a slightly unpleasant smell in the immediate vicinity. “It’s completely harmless, but of course it is annoying,” Collet says. The smell of sulfur was one of the main drivers of the protests in Arve Valley two years ago.

Thanks to the three activated carbon filters, the sulfurous odor that arises due to hydrogen sulfide has disappeared. At most, the less intense smell of pure sulfur can still be smelled today in the immediate vicinity of the filters. Complaints on an internet portal about the smell from the SGL Carbon facility have dropped from more than twenty to only one suspected case per month. “And it’s usually a false alarm,” Collet says. He is pleased with what he has achieved at SGL Carbon in Chedde. Behind him, a waterfall rushes down into the depths—the snow is slowly melting on the mountaintops around the valley. In Chedde, he and site manager Paget want to achieve several goals simultaneously: economically produce graphite for the technologies of the future, secure industrial jobs and also respect the environment. “It’s not an easy task,” he says, “but here in Chedde we’re showing that it’s possible.”

THE DIGITAL CHEMIST

Photo: Fritz Beck

Real innovations usually require complicated experiments, but these are expensive, time consuming and often hinder production. That's why Denis Hinz and his team are advancing **digital alternatives** for SGL Carbon—and sometimes even they are surprised by the results.

Denis Hinz reaches into a cabinet and pulls out a cylinder wrapped in shiny black carbon fibers. "So that you get to see something real," he says. Visitors should at a minimum hold in their hands what he, Hinz, works with in virtual space—they should get a feel for the material that he disassembles and optimizes on the screen with the help of various algorithms.

As director of the Modeling and Simulation division of Central Innovation at SGL Carbon, Hinz, aged 34, is a master of the digital world. Customers and colleagues turn to him when production processes need to be changed and materials adapted, when they want to know about heat-driven turbulence in a furnace or how to adjust the temperatures in a solvent bath for a perfectly cured polymer. Hinz and his coworkers can do the calculations and create a visualization to be displayed. A laboratory? There isn't one—Hinz's laboratory is his computer.

A dozen white trolley cabinets, three island worktops and two screens per employee: the work area that Hinz took over eighteen months ago is nothing special. It's a large, open-plan office space, much like so many others, where Hinz, an engineer by training, works with his team of Bojan Jokanovic, Oleg Benevolenski and another six team members. Yet what happens in this space is incredibly important for the company and its customers. The digital future is already taking place here.

More and more testing is being replaced with computer simulations: testing that had previously been done in actual laboratories or that required blocking off equipment, preventing its more productive use during that time. Virtual testing saves on costs, is easily scalable, increases investment security and produces faster results. Quite a lot faster in fact: "Traditional analogue testing can sometimes take up to six months before any results are available," Hinz explains, "but with us it's completed overnight."

Hinz's desk is covered with sketches of perforated boxes and formulas that only specialists like him can understand. As a child he dreamed of becoming a doctor, but later he found himself even more interested in engineering, "using physics and math to make something cool," he says enthusiastically. Hinz continues to be fascinated by how mathematical models can map the processes inside a high-temperature furnace. "These are the sorts of insights that we couldn't get otherwise."

Amorphous Cavities, Strange Forms

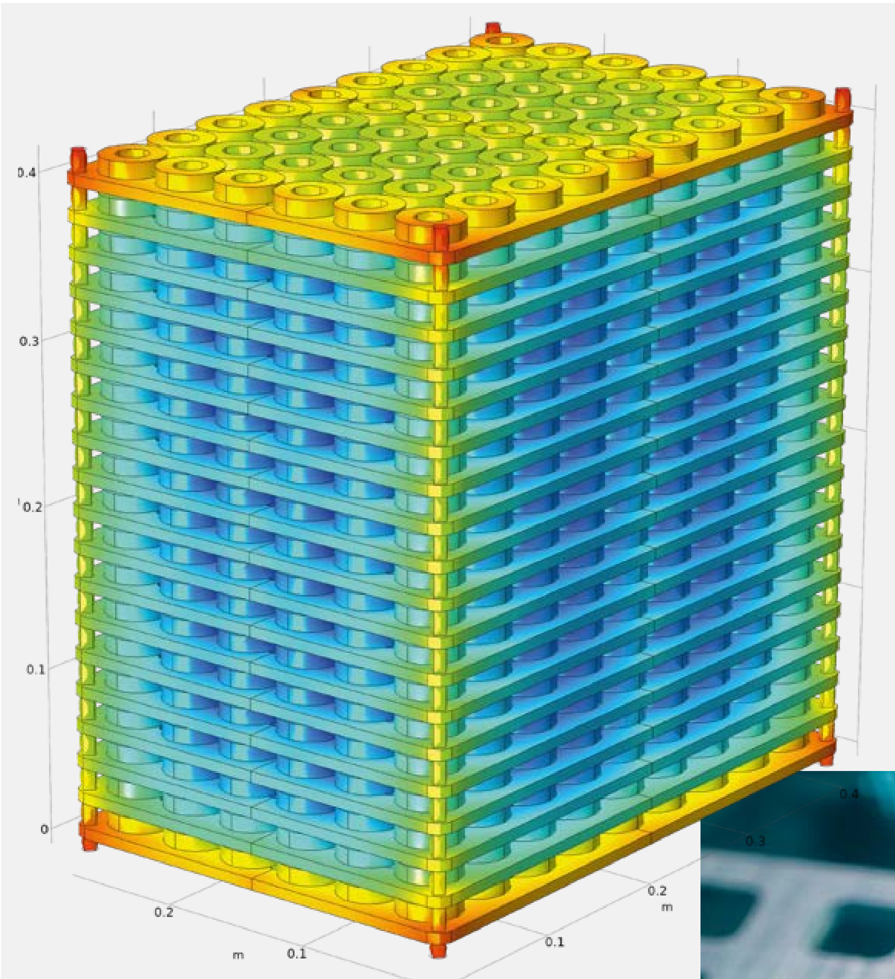
As part of SGL Carbon's digitization strategy and the company's transformation into a services provider, his division is steadily gaining in importance. "We haven't even come close to exhausting the potential," he says. Potential is a word you hear a lot from him.

Hinz takes us to a large hall to demonstrate how virtual modeling is changing the way components are designed. A table contains a dozen components including pump housings, charging racks, spray nozzles and heat exchangers. There are two versions of the pump housing: one traditionally designed one, and one optimized with the help of automated algorithms. "I input the parameters into the computer, and it spits out the design idea," Hinz says. Strange forms get produced this way, with amorphous cavities and holes in unexpected places. The designs are described as "non-intuitive" because no human engineer would ever have designed them like this. Yet they are entirely material-efficient and durable. The actual production of such parts has been made possible in part by 3D printing. Advances in additive manufacturing and algorithmic design are synergistically helping to advance each other.

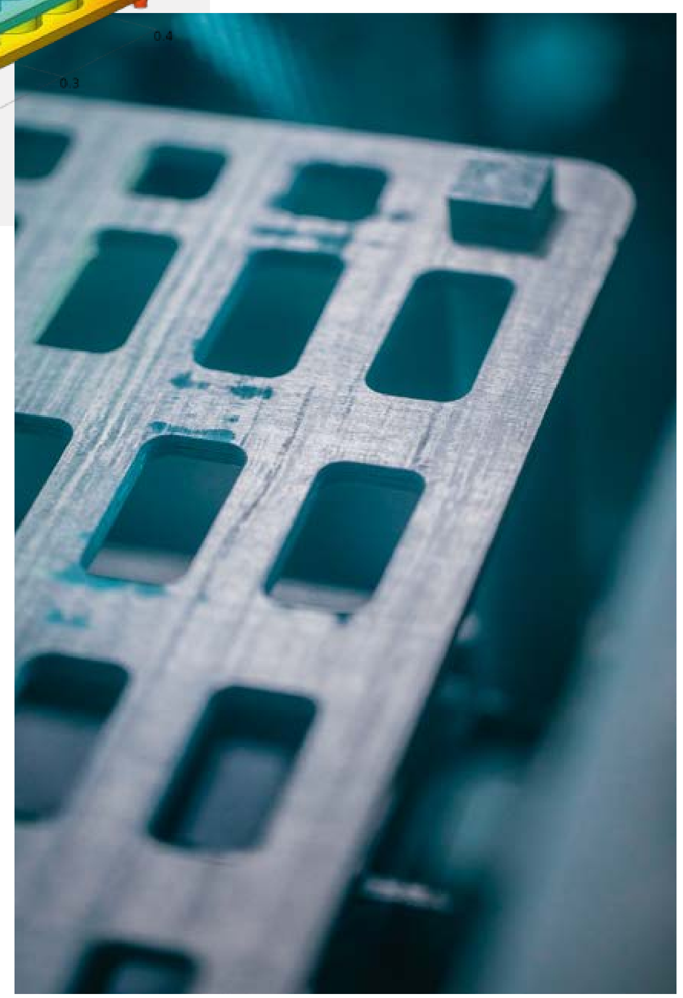
Hinz is inspired by the dynamism of his professional field and his motto is "work smarter, not harder." Time for his family is also important for him—particularly as his second child is on the way at the moment. In his first year at SGL Carbon he has already achieved quite a lot: his team is in place, the demand for their services is high and the work areas are focused. "We've always got our eyes on the optimal solutions for customers and our colleagues, which has given us a good in-house reputation," he says. Aside from which, Hinz is now offering modeling and simulation services as an independent service on the market as well.

When he was tasked with marketing his division's services, his international experience was a great help, including that from his university studies. Hinz speaks English, Spanish, French and Danish, and he's even learned a few snippets of Japanese. "You reach a different level of understanding when you speak the same language," he says.

He also needs persuasiveness. Many are skeptical at first: Will a digital solution also work in practice? Hinz could just wave off the objection with a confident gesture, but he doesn't. Instead he says, "Mistakes are possible. That's why we have to manage the uncertainty." This means questioning one's own assumptions. There is also always a test run



Denis Hinz and his team use these sorts of 3D models on his computer to optimize SGL Carbon products. Here they've simulated how charging racks distribute heat in a furnace to round components.



The charging racks—made of carbon fiber-reinforced graphite—are used during the sintering process, during which components made of pressed powder material are heated. The heat within the furnace must be distributed as evenly as possible.

Photos: Friz Beck; SGL Carbon (3D model)

› We want to find virtual recipes that don't yet exist today. ‹

before starting up any digitally planned procedures.

The more powerful the computer and more precise the algorithms, the larger the area of application. Simulations that are possible today were undreamed of just ten years ago, Hinz explains. Aside from his professional expertise, he also wins over clients with the embedment in the central innovation department of SGL Carbon and a direct line to company experts and industry experience: "We know how to put modeling results into practice."

One of Hinz's favorite projects is optimizing the recipes for graphite anode materials, like those used in lithium-ion batteries for electric vehicles—a rapidly growing and innovation-driven market. The best compositions for the material are normally analyzed using lengthy procedures in the chemistry laboratory. Working in close collaboration with SGL's in-house battery application laboratory, Hinz and his team have found a way to partially simulate these experiments. "We want to find virtual recipes that don't yet exist today. From a scientific standpoint the team is working on the frontlines."

Hinz says this with pride. He could have taken an academic career track. After finishing his studies in mechanical engineering in Munich, and adding a doctorate in fluid mechanics in Montreal, Canada, he began working in Japan at the Okinawa Institute of Science and Technology. He next went to Denmark, where he worked for the metering specialist Kamstrup—the job profile was tailor-made for him. But as Hinz explains, "There is much more to be accomplished in the industry. It's dynamic and growth-driven." The desire for change and for learning new things is also what brought him to SGL Carbon. He can contribute both his specialized knowledge of fluid mechanics and prove his talent as a business developer.

Building Teams, Developing Skills

Asked about his leadership style, he shrugs off the question. "Depends on the situation," he says. He can communicate well with his team: "We're all specialists." Building teams, developing skills and providing direction: it all comes naturally to him. Hinz is professional, friendly and endowed with the quiet self-confidence that people from the Black Forest are reputed to possess. He was born there and grew up in the town of Schopfheim, Germany, a good fifty kilometers south of Freiburg.

As Hinz explains, the real laboratory won't become redundant due to his work. This point is important to him. It's not like his team is working in a vacuum; they require dependable data in order to set up models. Hinz goes to one of the trolley cabinets and takes out a graphite cylinder with an ugly crack in it. "Our lab colleagues kept pulling it until it broke." The entire cabinet is filled with experimental material, with components and graphite samples stored in transparent bags, neatly stacked and sorted.

But there are also tasks that are completely digital nowadays. For instance, Hinz and his colleagues combine the digital documents from the process engineers with their own calculations to create virtual images of manufacturing steps. Where a layperson might only see whirling arrows on the screen, a specialist can identify material flows dependent on forms and temperatures. "There's a mathematical model behind it that depicts real flows," Hinz says. His dream is to digitally reproduce the majority of the SGL Carbon value chain, at least where it makes sense economically. "In some areas, for graphitization for example, we're already quite far along."

Artificial intelligence is also assisting his team these days. "We'll be doing a lot more computer-supported material development in the future," Hinz says. Along the way, materials and processes are becoming even more closely intertwined. Hinz is certain that customers will soon receive digital twins in addition to the actual product, so that they can control and improve the product over its entire lifespan.

While Hinz is speaking about these opportunities, his cadence is calm but there's an excitement in his voice. For the scientist in him, the future is above all an intellectual challenge. As a practitioner, he is faced with the task of transforming advances in his specialty into customer benefits—and that's what he loves most about working at SGL Carbon. "The opportunities in my field fascinate me, but in the end it's all about delivering added value for the customer," he says. ‹

Designing Smart Solutions Together

In the competition for the best specialists, SGL Carbon is going through a strategic repositioning with a fresh **employer branding**. We spoke with Head of Group Human Resources Birgit Reiter about how employers make credible promises—and how to actually keep them.

Ms. Reiter, for some years now everyone has been talking about the "skilled worker shortage" and "war for talent". How is SGL Carbon positioning itself in this arena?
We think that the "war for talent" is already over. But the winners are those being fought over: the talented people. Yet this isn't true just for engineers and others with higher degrees, it also accurately describes the situation for skilled vocational workers and even apprentices. As an employer, you need a strategy to meet this challenge.

And what is SGL's strategy as an employer?
The new corporate brand introduced a year ago, with our three corporate values, has set the tone. In employer branding, we're repeating this message to give SGL a distinctive profile as an employer. Starting with our brand values: we want to attract and retain employees who will demonstrate their full potential, work with openness and trust, and enjoy contributing their ideas. These values are the DNA for SGL Carbon as an innovative technology company. We're convinced that these values are decisive in enabling us to achieve our long-term economic goals. And above all we have to make them tangible.

How can the company bring its values to life?
By seeking dialogue with our employees, which also enables them to become ambassadors for the company. Last year we conducted a worldwide employee survey for the first time, allowing them to tell us what they appreciate about SGL Carbon and where they think there is still room for improvement. I mention the employee survey because its results were also incorporated into the concept for the employer brand. Of course, the employee survey wasn't conducted just because of the new employer branding, but the common denominator is clearly the further development of the corporate culture in the sense of openness and dialogue. It therefore made sense that the basic motif of dialogue also played a central role in the development of the employer brand.

What did this mean in practice?
We used several focus groups to discuss with employees what they specifically want from SGL Carbon as an employer and how they actually experience the corporate culture in terms of ideals and in reality. The various groups understandably had different perceptions and priorities—but in the end the similarities and commonalities prevailed, from which we were able to forge the employer brand.

What does SGL Carbon's new employer brand look like?
An employer brand is made up of several elements. These include a clearly defined visual imagery and a certain tonality in all the texts aimed at the target groups. What's important in this is consistency across all channels and media: on our career webpage, our flyers for HR marketing, and posters at our sites. The most important element of the employer brand is what's known as the employer value proposition, in other words why a person should start or remain working for us.

So why should they?
SGL Carbon's value proposition is "co-creating smart solutions"—also formulated as the slogan "Let's co-create smart solutions." The term "co-creation" refers to the fact that our solutions really are very strongly developed in partnerships—whether together with our customers or internally through cooperation among various departments and functions. The adjective "smart" expresses that these are future-oriented solutions, which is a particular characteristic of our work. What's more, our vision as a company is to contribute to a smarter world with our solutions. This combination of corporate vision, brand and employer branding was so important to us that we further visualized the claim with an icon. This consists of three curved arrows forming a circle around two employees. Each arrow represents a brand value: they all influence each other and together form the setting in which our employees design solutions together on an equal footing with one another.

Co-creation is quite a high expectation. Are you sure that this can work in reality?
Like every enticing promise, it isn't always easy to keep. We're well aware that co-creation actually means a new way of talking and working with one another. Our employees demand a high degree of personal responsibility beyond rigid hierarchies. The company is working on this, for instance in numerous site-specific improvement initiatives following the employee survey. Leadership principles in the form of a culture of feedback and performance management must also be scrutinized. Take our bonus system for example. Previously our variable compensation was largely connected to personal goals. Yet we're convinced that such models no longer fit with our co-creation approach, in which there is a clear focus on team effort and interdisciplinary cooperation. That's why we've adjusted our bonus models to reflect this by giving greater weight to our common success in the future.

How do you intend to attract new employees to SGL Carbon?
"Co-creating smart solutions" is the promise, but SGL Carbon only becomes really attractive when we offer the appropriate working environment and conditions. Our hierarchies are flat, the breadth of tasks and the leeway employees have is extensive, and the opportunities to stand out with good performance and to take targeted development steps are much greater than in large corporations. Furthermore, we work with extremely exciting materials and customers on future-oriented topics such as cross-industry digitization, new energy sources and sustainable mobility. Our employees truly are very proud of all these aspects, as the employee survey confirmed. Fair compensation is another of our company's strengths.

Three arrows, two people, one message: Let's co-create smart solutions. The icon of the new SGL Carbon employer branding conveys our corporate values and underscores that all employees are working together on a level playing field to create solutions for the future.

SGL Carbon's Head of Group Human Resources Birgit Reiter worked on designing the new employer branding. She's convinced that the key to its success is to make SGL Carbon's corporate values come alive.

Photos: SGL Carbon

How are you communicating the new employer brand?
It's very important to us that the employer brand is communicated equally both within the company and to the outside. Both occur in a variety of ways and through a variety of channels, for instance in our job advertisements, on our job portal and soon through many marketing materials as well. The fact that the employer brand has been made known internally and is also accepted is an important prerequisite for its successful use externally—that's the only way employees can act as credible brand ambassadors to the outside world. Ultimately the greatest power of persuasion lies in direct personal contact. At recruiting fairs at schools and universities, for instance, we always take along colleagues who work in the specialist departments. When they speak with passion about their everyday work at SGL Carbon, that's when the employer brand really starts to come alive.

You mean emotionality beats rationality?
Both are important, but you definitely shouldn't underestimate the emotional aspect—both in the outward as well as in the in-house communication. If you want to retain your employees, then they have to feel and experience every day the contribution that their work brings: for themselves, within the team, for SGL Carbon, for customers and for a smarter world. These are important emotional anchors for everyone. They allow us as an employer to fulfill the need for meaning. As more recent studies show, this aspect is becoming increasingly important in an increasingly hectic and demanding working world.

SMART PLATE

In Focus

Without heat exchangers, there's no chemical industry: installed everywhere for heating, cooling, condensing or evaporating a wide variety of substances. **Deployable in a wide array** of applications, this tube, block or plate equipment made of graphite can be found wherever acid steams and boils. The plate heat exchanger offers particularly high efficiency.

Photo: SGL Carbon

1

How it Works: Physics is ruled by the law of entropy, which drives interacting systems towards equilibrium, and heat exchangers utilize this principle. Liquids or gases flow in separate sections past one another, and the warmer medium transfers energy to the colder. What is probably the best-known example from everyday life is the radiator, which emits warmth from its surface into the surrounding air.

2

The Material: Steel is state of the art for many applications. But in corrosive environments, there's another material that excels: graphite. It conducts heat significantly better than steel—and can withstand corrosive substances such as sulfuric, phosphoric, hydrochloric and hydrofluoric acids. SGL Carbon uses process equipment graphite known under the brand name DIABON®, which is a mixture of graphite and phenolic resin.

3

Refined: The graphite's pores are impregnated with phenolic resin or fluoropolymer, making them impervious to gases and liquids. DIABON® is thus ideally suited for manufacturing equipment used in the process industry. It's also perfect for highly pure applications in the semiconductor and pharmaceutical industries and has also been certified by the US Food and Drug Administration.

4

Fields of Application: Systems of SGL Carbon are in use on all continents and in a wide variety of industries, from polymer-foam manufacturing to semiconductor fabrication and fertilizer production. Shell and tube heat exchangers lend themselves for larger capacities, while block and plate heat exchangers are more appropriate for smaller to medium quantities. SGL Carbon has been manufacturing heat exchangers for sixty years now, and their service life often exceeds more than twenty years.

5

Highest Efficiency: Plate heat exchangers are highly efficient. They work even with very low temperature differences, can transfer large amounts of heat and can be exposed to corrosive substances on both sides. The special plate structure generates high turbulence in the flowing media, intensifying heat exchange even further.

6

Modular Expansion: The modular design—plate packages braced between two steel plates by means of tie rods—enables rapid delivery times and easy capacity expansions. A module can contain up to 96 plates, or even up to 160 plates in the case of graphite-bonded fluoropolymer known as F100. Their highly efficient transmission of heat facilitates a compact design with maximum performance in a minimum amount of space.

Functional Battery Enclosure

Carbon 360°

Weight reduction, stiffness and temperature management: using carbon in **battery enclosures** for electric vehicles comes with myriad advantages. SGL Carbon has developed prototypes for this new application for NIO, a Chinese electric vehicle manufacturer.

Electromobility's breakthrough is imminent. Along with enhancements to the infrastructure for charging stations, there is also room for improvement in the range and design of electric vehicles. One crucial technological factor in this is the battery. SGL Carbon has been working with the Chinese startup company NIO to develop battery enclosures of carbon-fiber reinforced plastic (CFRP), making the enclosures especially lightweight, stable and safe.

"Traditional battery enclosures for electric vehicles are mainly made of aluminum and steel," says Director Program Management Materials Jürgen Joos at SGL Carbon, who oversaw the production of the prototype for NIO. "Lightweight construction with carbon-fiber materials has many advantages for both gas-powered and electric vehicles. Its low weight, in particular, benefits the battery's range."

For example, the NIO ES 6, in which the innovative enclosure and other components are installed, is powered by a lithium-ion battery that consists of a large number of cells. The battery is 2 meters long and 1.6 meters wide. The battery enclosure is made mainly of CFRP plus a few aluminum components. The enclosure's characteristics depend mainly on the designs for the base and cover plates: usually a special core material is surrounded by multiple layers of carbon fiber and epoxy resin. A hybrid variant with carbon and glass fibers is also possible. As Joos explains, "The base protects the battery from shocks coming from below and also from impacts with obstacles and other vehicles."

The material has numerous advantages in addition to being lightweight: the battery enclosure's stiffness is comparable to that of an aluminum construction but uses much less material, and with a thermoconductivity that is around 200 times less than that of aluminum, CFRP better protects the battery from heat and cold. Furthermore, the composite material additionally presents optimal values for water and gas impermeability.

40

percent less weight for a battery enclosure made of CFRP than a design of aluminum and steel. This reduces energy consumption.

200

times less thermoconductivity for carbon than for aluminum. A point for greater safety.

10-18

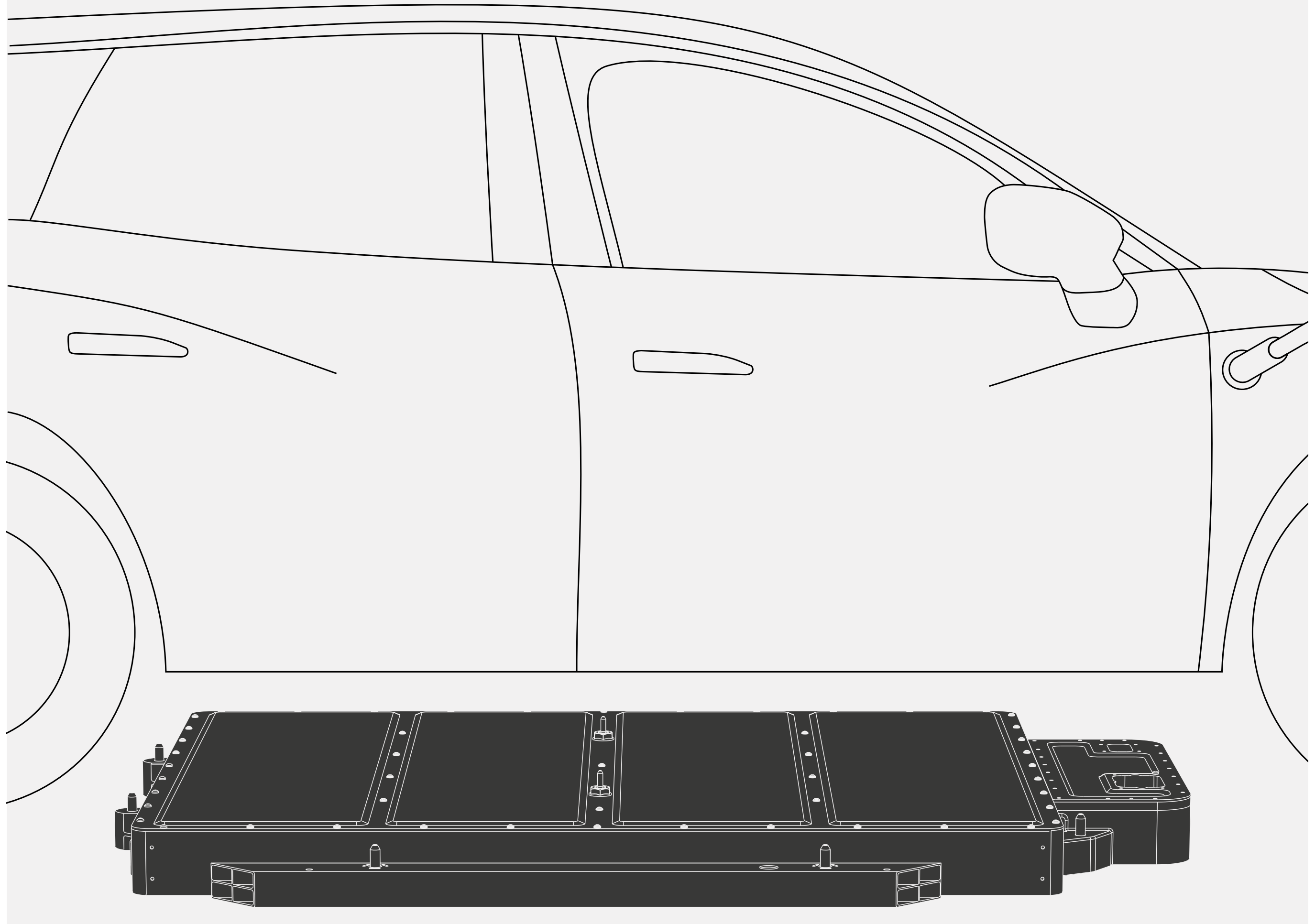
percent growth is projected for the electromobility market. This also increases the demand for carbon.

NIO also has another special feature up its sleeve: the battery can be exchanged during everyday use at NIO-owned exchange stations, many of which have already been set up along China's highways. The process of exchanging an empty battery for a fully-charged one takes just three minutes.

"Lightweight construction is one of the essential elements of the NIO technology roadmap," says Bin Wei, NIO's senior manager for lightweight engineering. "With composite materials, particularly the use of high-performance carbon fibers in battery enclosure systems, our vehicle offers better handling and a greater range."

The use of CFRP and glass-fiber reinforced plastic (GFRP) for battery enclosures is still relatively new. "Yet thanks to its many benefits and increasing electromobility, we expect a strong increase in demand for this application," says SGL Carbon Sales Manager Philipp Römer. According to a forecast by HIS Markit, the production of electric and hybrid vehicles will increase from 5.5 million in 2018 to 60 million in 2030. SGL Carbon is already working with various partners to continue developing different battery enclosures made of composites.

Illustration: SGL Carbon



Important features for battery enclosures include among others being lightweight, robust and temperature-resistant. SGL Carbon carbon-fiber reinforced composites ideally fulfill these requirements.