



# The Enablers

Our continuous  
carbon fiber tows

SIGRAFIL®



Carbon Fibers

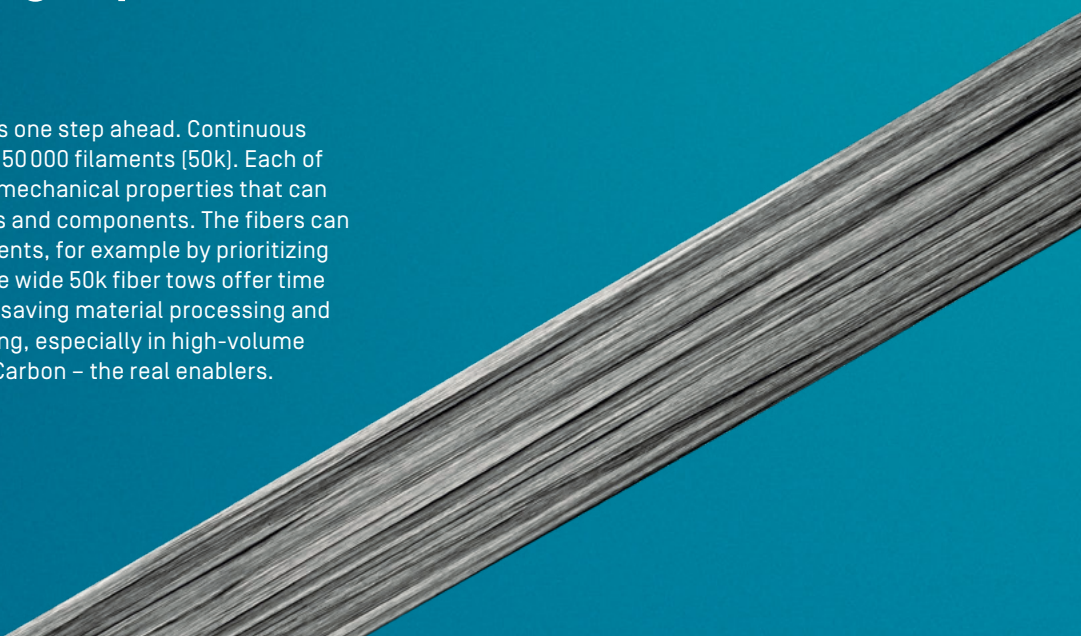


# 50,

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## **SIGRAFIL® continuous carbon fiber tows** **The basis for high-performance composites**

We focus on what keeps our customers one step ahead. Continuous carbon fiber tows are heavy tows with 50 000 filaments (50k). Each of our 50k heavy tows have outstanding mechanical properties that can be transferred to the finished products and components. The fibers can be chosen to match specific requirements, for example by prioritizing stiffness or strength. In addition, these wide 50k fiber tows offer time and cost advantages due to resource-saving material processing and energy efficient material manufacturing, especially in high-volume processes. Smart solutions from SGL Carbon – the real enablers.



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# Our continuous carbon fiber tows

Continuous carbon fiber tows from SGL form the basis of many composite applications and are used in numerous industries. To guarantee the very highest quality, we manufacture our SIGRAFIL continuous carbon fiber tows exclusively in our plants in Europe and North America. In addition, our customers benefit from our unique expertise in 50k fibers across all processing stages.



## Market segments of our Business Unit Carbon Fibers

### Typical applications

#### Automotive

- Structural components
- Design components
- Chassis components
- Drive train
- Pressure vessels

#### Industrial Applications

- Medical technology
- Robotics and automation technology
- Measuring technology and optics
- Machinery manufacture
- Sports & leisure
- Antiballistic technology
- Marine industry
- Civil engineering

### Typical products

- Pultruded profiles
- Braided components
- Filament-wound components
- Thermoplastic composite materials

- Woven, unidirectional, and multiaxial fabric/prepreg production
- Pultruded profiles
- Filament-wound components
- Thermoplastic composite materials

### Materials used from SGL Carbon

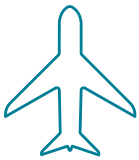
- SIGRAFIL® continuous carbon fiber tows 50k

- SIGRAFIL® continuous carbon fiber tows 50k

### Endless possibilities

For high-tech applications requiring high strength and stiffness combined with light weight, SIGRAFIL continuous carbon fiber tows are indispensable. They form the basis for carbon fiber-reinforced plastics (CFRP), are suitable for a wide variety of processing technologies, and open up new possibilities in the serial production of CFRP components.

It is no wonder, then, that our continuous carbon fiber tows have consistently proven their value over many years: for example in the automotive industry, the aerospace industry, the energy sector, and many other industrial applications. More and more customers are making use of our comprehensive 50k expertise for trouble-free processing of 50k heavy tows.



#### Aerospace

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- Primary and secondary structural components
- Interior components

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- Woven, unidirectional, and multiaxial fabric/prepreg production
  - Filament-wound components
  - Thermoplastic composite materials

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- SIGRAFIL® continuous carbon fiber tows 50k
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#### Energy

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- Renewable energies

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- Spar caps of wind turbines
  - Pipes and risers for oil and gas production
  - Cables
  - Filament-wound components
  - Pultruded profiles for rotor blades

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- SIGRAFIL® continuous carbon fiber tows 50k
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# Fibers that transform ideas into reality

You have the idea, we have the transformers: continuous carbon fiber tows with 50 000 filaments. Our 50k tows are the ideal basis for high-performance textiles, pre-impregnated products, and composite components. We support you in developing your future-oriented solution and ensure sustainable production with high material efficiency and a low CO<sub>2</sub> footprint.



50k carbon fiber spools

# SIGRAFIL® continuous carbon fiber tows based on PAN

We manufacture SIGRAFIL on the basis of a polyacrylonitrile fiber (PAN fiber). With its high strength, high elastic modulus, and low density, SIGRAFIL is a high-performance material that makes it possible to produce very stiff yet lightweight composites.

We use heavy tows with 50 000 filaments that offer time and cost advantages in many different processes. By making application-tailored adjustments, we can provide individual solutions for different requirements and processes.

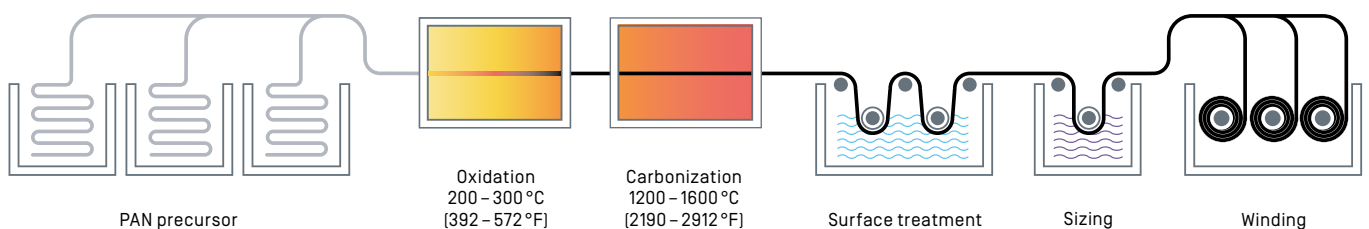
## Typical applications

- Unidirectional and multiaxial fabric/prepreg production
- Pultrusion
- Braiding and filament winding processes
- TowPreg production
- Use for C-SMC
- Production of thermoplastic composite materials

## SIGRAFIL material advantages

- Best mechanical properties
- Low density [light weight]
- Low thermal expansion
- Good electrical conductivity
- High corrosion resistance
- Excellent impregnation behavior
- Good spreadability

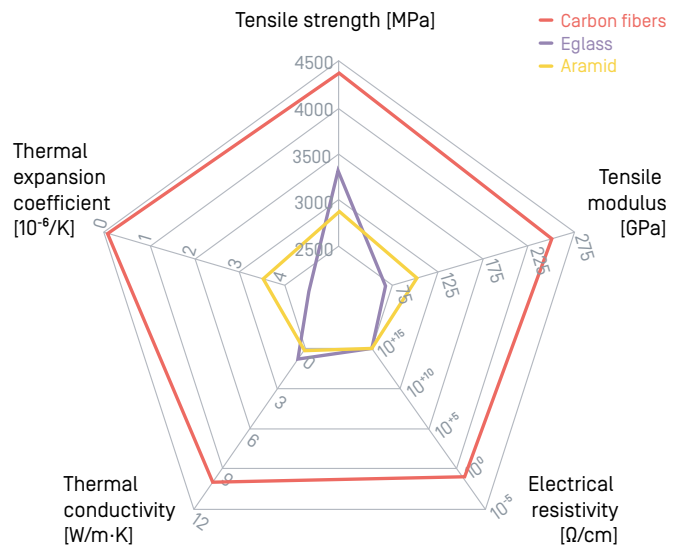
## Production process for SIGRAFIL® continuous carbon fiber tows



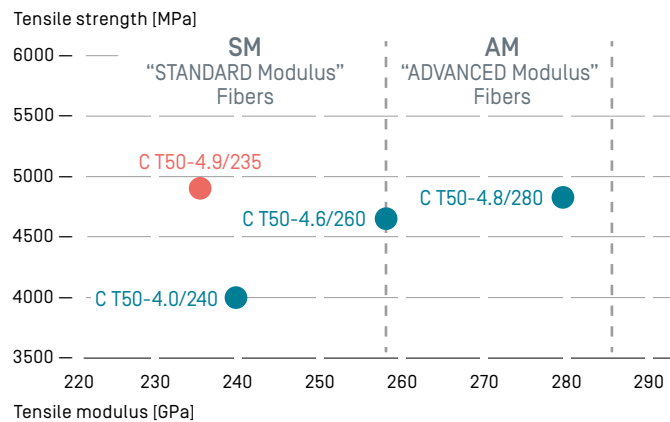
# Stronger, stiffer, more heat-resistant: carbon outperforms glass and aramids in key areas

SIGRAFIL continuous carbon fiber tows are far superior to glass and aramid fibers. Particularly when it comes to the key properties of strength and stiffness, carbon performs significantly better as a fiber material than glass and aramids. What's more, carbon fibers do not undergo temperature-dependent expansion or shrinkage. With these exceptional properties, carbon fibers are the ideal material basis for high-quality composites.

Comparison of our SIGRAFIL® continuous carbon fiber tows with other fiber materials



## Overview of SGL basic fiber types



### SIGRAFIL C T50-4.9/235

With the SIGRAFIL C T50-4.9/235, SGL Carbon is expanding its 50k fiber portfolio for new applications such as pressure vessels, which require high strength and elongation.



## Material data of our SIGRAFIL® continuous carbon fiber tows

Typical properties	Units	C T50-4.0/240	C T50-4.6/260	C T50-4.8/280	C T50-4.9/235
Number of filaments		50k	50k	50k	50k
Fineness of yarn dry	tex (g/1000 m)	3420	3420	3070	3420
Density	g/cm <sup>3</sup>	1.80	1.80	1.78	1.80
Single filament diameter	µm	7.0	7.0	6.6	7.0
Tensile strength	GPa   ksi	4.0   580	4.6   667	4.8   696	4.9   711
Tensile modulus	GPa   Msi	240   35	260   37.7	280   40.6	235   34.1
Elongation at break	%	1.70	1.70	1.65	2.0
Single filament resistivity	µΩm   µΩin	19   750	17   670	15   590	19   750

## Compatible matrix systems for our SIGRAFIL® continuous carbon fiber tows

### Matrix compatibility

Epoxy, polyurethane, phenol

Vinyl ester (and all radical-based curing systems), unsaturated polyester

Polyurethane, polycarbonate, polyester, polysulfone, cyanate ester, polyamide, BMI, PESU, PEEK, PEKK, PVC, polyimide

Polypropylene

Polyamide

### Enhanced performance by sizing

By applying different types of sizing, the carbon fibers can be optimally matched to different matrix systems. In this way, it is possible to produce application-tailored versions as well as the standard materials. So, together with our customers, we find optimized solutions for their challenges.

## Nomenclature

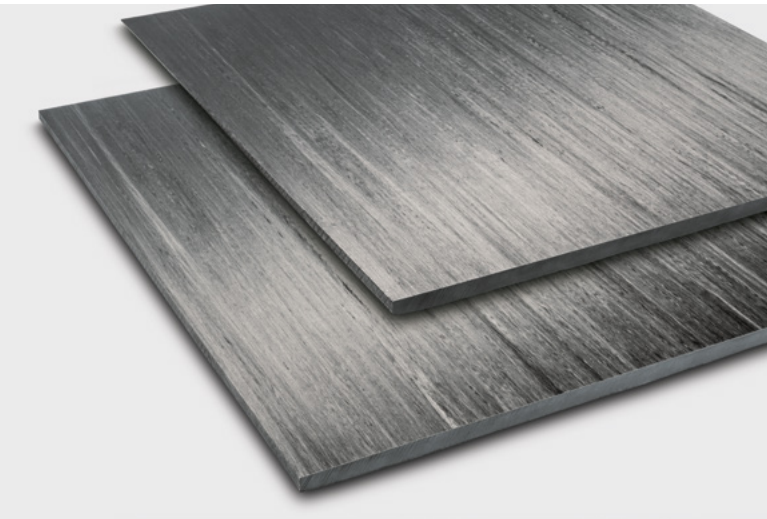


### SIGRAFIL C T50-4.0/240-E100

1 2 3 4 5 6

1 Brand name	SIGRAFIL
2 Material	C = carbon
3 Type	T = Continuous tow
4 Number of filaments	50 = 50 000
5 Mechanical properties	Tensile strength/elastic modulus in GPa
6 Sizing type	e. g. E100 = epoxy

## Maximum performance in the component: with our sizings for thermoset and thermoplastic systems



↑ CFRP sheets

### Continuous carbon fiber tows for epoxy resin matrix systems

Numerous CFRP components are based on an epoxy resin matrix. For this sector, our continuous carbon fiber tows coated with E100 sizing have been used successfully for many years in a wide variety of applications. A good example is our extensive experience in the large-scale serial production of 50k carbon fibers for high-quality automotive applications. Continuous carbon fiber tows from SGL with various resin systems ensure excellent composite properties such as tensile strength, elongation at break, and stiffness. They are a perfect basis for the production of high-performance components.

### Exemplary epoxy composite properties\*

Typical properties	Units	Test method	C T50-4.0/240	C T50-4.6/260	C T50-4.8/280	C T50-4.9/235
Tensile strength	MPa	ISO 527	2000	2250	2350	2400
Tensile modulus 0°	GPa	ISO 527	140	155	165	140
Elongation at break 0°	%	ISO 527	1.45	1.45	1.45	1.8
Compressive strength 0°	MPa	ISO 14126	1100	1150	1200	1250
Compressive modulus 0°	GPa	ISO 14126	125	130	137	125
Interlaminar shear strength	MPa	ISO 14130	82	82	82	82

\* Standardized to a fiber volume content of 60%. Compressive strength and interlaminar shear strength greatly depend on the resin system used and composite structure.

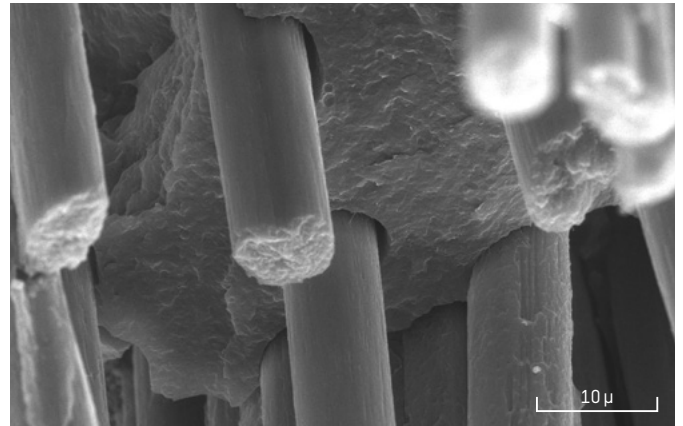
### Continuous carbon fiber tows for fiber-reinforced thermoplastics

Besides thermoset matrix systems, increasing use is being made of thermoplastic systems. To provide solutions for our customers that ensure the best possible performance of these systems in the component, we have developed two sizings specially optimized for fiber-reinforced thermoplastics: T140 for polyamide-based matrix systems and T115 for polypropylene matrix systems.

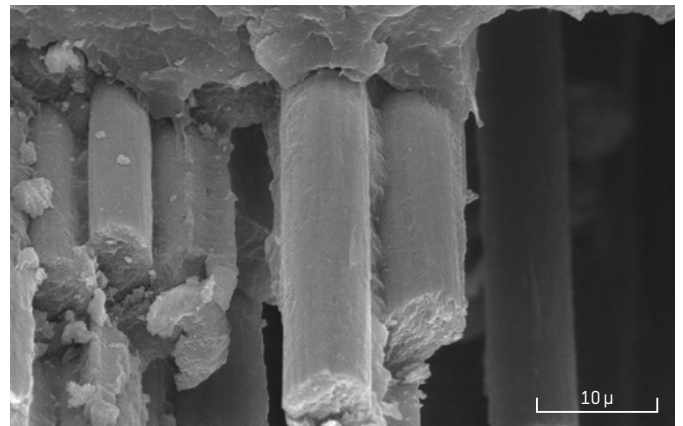
#### T140 – sizings for polyamide matrix systems

The tailored chemistry of the T140 carbon fiber surface permits an optimum fiber/matrix bond, hence enabling full utilization of fiber stiffness and strength in the final component. Compared to standard epoxy sizings, a performance enhancement of over 100 % is possible in the polyamid composite.

Under the microscope, the difference can be clearly seen: in a PA6 composite with T140-coated carbon fibers, the matrix bonds significantly better to the fibers than is the case when an E100 sizing is used. With their thermal stability of up to 300 °C, our T140 fibers cover the entire spectrum of polyamide materials from PA6 and PA66 to PPA. Their good fiber protection and spreading behavior ensure easy textile processing in a wide range of processes.



↑ Fiber/matrix bond in PA6 with E100 size

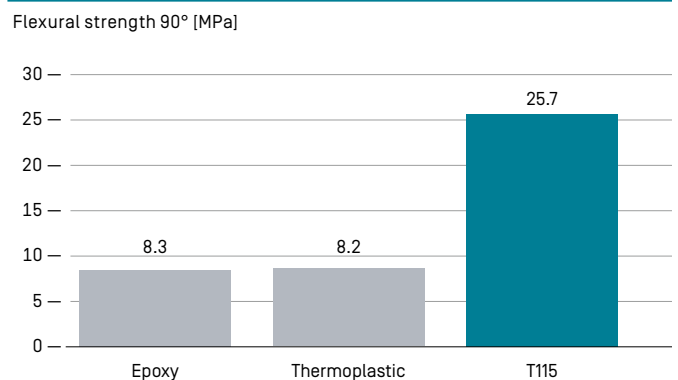


↑ Fiber/matrix bond in PA6 with T140 size

#### T115 – sizing for polypropylene matrix systems

Continuous carbon fiber tows coated with T115 sizing are our answer to the special requirements for carbon fibers when used in polypropylene. They provide an optimum matrix bond and ensure that fiber strength and stiffness are fully transferred to the components being produced. Compared with the use of other currently available carbon fiber sizings (epoxy, thermoplastic), SIGRAFIL sized with T115 provides 200 % better fiber/matrix interaction and correspondingly increased 90° flexural strength in polypropylene.

### Mechanical properties of SIGRAFIL carbon fibers sized with T115 in a polypropylene matrix




# Successful together

We don't just think about products but also about smart solutions for our customers. With continuous carbon fiber tows, for example, this means we also advise you on the special features of processing 50k fibers.

Drawing on our extensive experience with 50k heavy tows, we help our customers plan new plants or optimize existing plants for processing 50k carbon fiber tows.

In partnership with you, we find solutions ensuring a highly reliable process that is gentle on the material and provides the best possible performance of our products in the component.





## 50k – unwinding is simply no problem

50k heavy tows used in optimized processes offer time and cost advantages without compromising quality. To ensure trouble-free, gentle processing of 50k fibers, only a couple of differences in fiber guidance from processing 12k or 24k fibers need to be considered.

### Good guidance is crucial

Fiber guidance is crucial for optimally realizing the properties of the carbon fibers in the laminate. Generally speaking, the deflection angle, material surfaces, radii, fiber tension values, and type of fiber guide element are important for carbon fibers. In the case of heavy tows with 50 000 filaments, the unwinding angle and spacing between deflection points are also factors that need to be taken into account to avoid tow faults during processing. Problems such as folds, filament breakages, abrasion or varying tow widths can be avoided from the outset by optimized fiber guidance.

### Finding the optimum process together

We want our customers to obtain the best possible quality results with our products and at the same time benefit from reliable and efficient processes. We contribute many years of experience and our comprehensive know-how – especially in handling 50k fibers – to the planning or optimisation of your plants.

# Smart Solutions

Be it materials, components or production processes, we put our customers first. With our in-depth material, engineering, and application know-how, we develop customized, reliable and high-quality solutions for our customers.

The following examples show a selection of our unique product range.

## Mobility

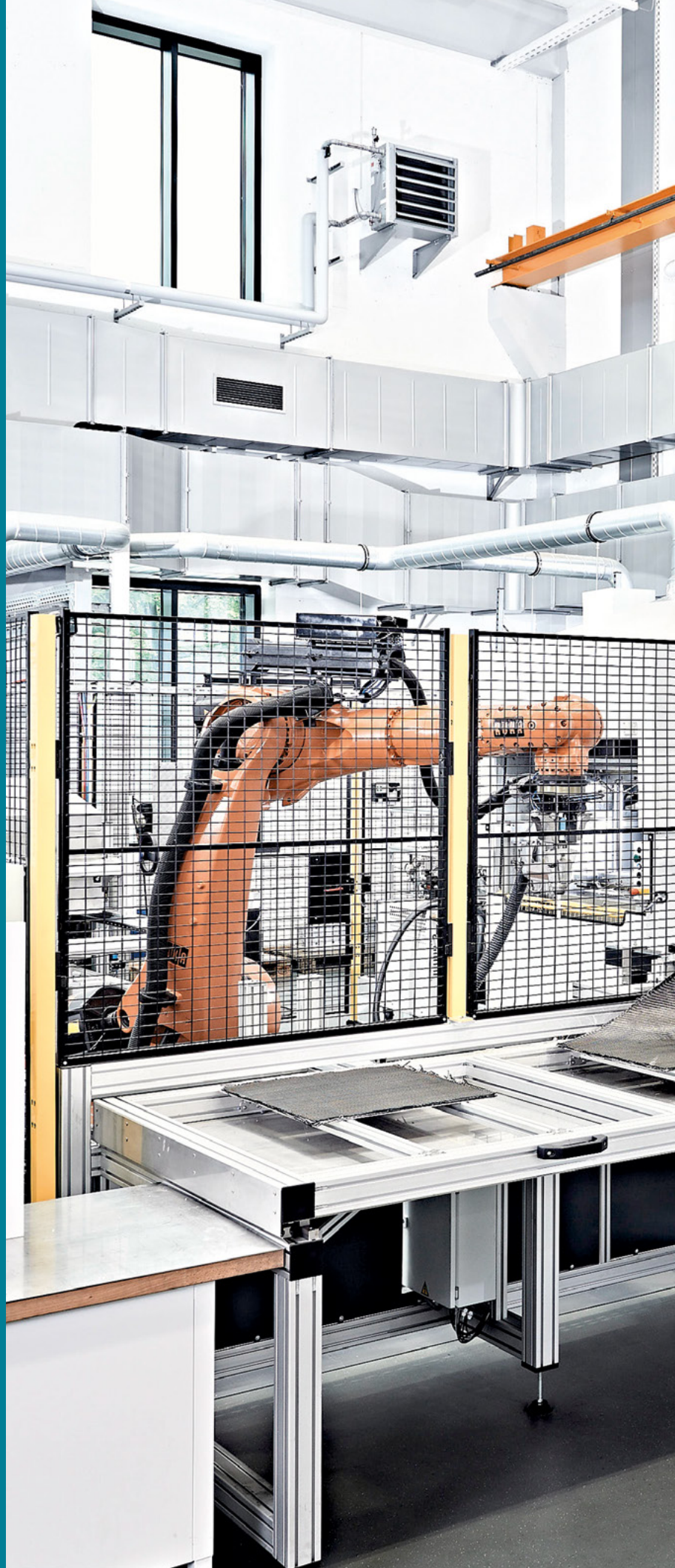
- Lightweight components and structural parts based on fiber-reinforced composites for automotive and aerospace manufacture
- Graphite anode material for lithium-ion batteries in electric vehicles
- Carbon-ceramic brake disks for sports cars and luxury sedans

## Energy

- High-temperature solutions based on specialty graphites and fiber materials for the photovoltaic industry
- Carbon fiber materials for rotor blades
- Gas diffusion layers for fuel cells
- Systems for more efficient heat exchange and heat recovery
- Carbon fibers for pressurized gas containers

## Digitization

- Carbon, graphite, and CFC components for polysilicon and monocrystal pulling in the semiconductor industry
- High precision, coated graphite carriers for the production of LEDs



# SGL Carbon

We are a global leader in the development and manufacture of carbon-based solutions. Our materials and products made from specialty graphite, carbon fibers and composites serve many industries that are shaping the trends of the future: climate friendly mobility, semiconductor technology, LED, solar and wind energy, and the manufacture of lithium-ion batteries.

We are driven to grow with products and technologies that benefit society and reduce environmental and climate impacts.

Together with our customers, we develop intelligent and sustainable solutions that contribute to a smarter world.



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