Capital Markets Day
Important Note

This presentation contains statements relating to the future business and financial performance of and future events or developments involving SGL Group or its businesses, including statements with respect to SGL Group’s outlook, targets and business development, expected customer demand, expected industry trends and expected trends in the business environment. You can generally identify these statements by the use of words like "may", "will", "could", "should", "project", "believe", "anticipate", "expect", "plan", "estimate", "forecast", "target", "potential", "intend", "continue" and variations of these words or comparable words. These statements are not historical facts, but rather are based on current expectations, estimates, assumptions and projections about SGL Group’s businesses and future financial results, and readers should not place undue reliance on them. Forward-looking statements do not guarantee future performance and involve risks and uncertainties. These risks and uncertainties include, without limitation, changes in political, economic, legal and business conditions, particularly relating to SGL Group’s main customer industries, competitive products and pricing, the ability to achieve sustained growth and profitability in SGL Group’s businesses, the impact of any manufacturing efficiencies and capacity constraints, widespread adoption of carbon fiber products and components in key end-markets of the SGL Group, including the automotive and aviation industries, the inability to execute additional cost savings or restructuring measures, availability of raw materials and critical manufacturing equipment, trade environment, changes in interest rates, exchange rates, tax rates, and regulation, available cash and liquidity, SGL Group’s ability to refinance its indebtedness, development of the SGL Group’s pension obligations, share price fluctuation may have on SGL Group’s financial condition and results of operations and other risks identified in SGL Group’s financial reports. Should one or more of these risks or uncertainties materialize, or should underlying expectations not occur or assumptions prove incorrect, actual results, performance or achievements of the SGL Group may (negatively or positively) vary materially from those described explicitly or implicitly in the relevant forward-looking statement. These forward-looking statements are made only as of the date of this document. SGL Group does not undertake to update or revise the forward-looking statements, whether as a result of new information, future events or otherwise.

This document includes supplemental financial measures that are or may be alternative performance measures (non-IFRS or alternative performance measures). These supplemental financial measures should not be viewed in isolation or as alternatives to measures of SGL Carbon’s net assets and financial positions or results of operations as presented in accordance with IFRS in SGL Carbon’s consolidated financial statements. Other companies that report or describe similarly titled alternative performance measures may calculate them differently.

Due to rounding, numbers presented throughout this and other documents may not add up precisely to the totals provided and percentages may not precisely reflect the absolute figures.
GMS – the hidden champion.
Active in very attractive market segments

<table>
<thead>
<tr>
<th>Market Segment</th>
<th>Battery &amp; other Energy</th>
<th>Solar</th>
<th>LED</th>
<th>Semiconductor</th>
<th>Automotive &amp; Transport</th>
<th>Chemical</th>
<th>Industrial Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2017</strong></td>
<td>19%</td>
<td>10%</td>
<td>4%</td>
<td>5%</td>
<td>7%</td>
<td>24%</td>
<td>31%</td>
</tr>
<tr>
<td><strong>2016</strong></td>
<td>16%</td>
<td>11%</td>
<td>2%</td>
<td>5%</td>
<td>7%</td>
<td>27%</td>
<td>32%</td>
</tr>
</tbody>
</table>
Agenda

1. Markets, market trends & GMS solutions
   - Energy – battery & other energy
   - Digitization – semiconductor
   - Digitization – LED
   - Energy – solar
   - Automotive & transport
   - Chemicals
   - Industrial applications

2. Importance of graphite value chain
Graphite is essential for lithium-ion batteries (LiB).
Graphite based anodes expected to remain dominant at least until 2030.

Graphite

Graphite/Carbon-Silicon

Graphite/Carbon-Silicon

Silicon/Graphite

Solid State/Li-Metal

Anode material

Cell energy density (Wh/kg)

Source: Roadmap Nationale Plattform Elektromobilität and GMS assumptions

1SiOx or carbon-silicon blended with major share of graphite; 2carbon-silicon: graphite blend ~ 1:1 3Si-dominant carbon silicon anode with graphite as additive
The shift to e-mobility drives the growth of the LiB industry. Other developments are important additional contributors.

**Lithium-ion batteries**
Main industry drivers

- Commercial factors
- Consumer trends
- Portable digitization
- Demographic changes
- Political drivers
- Next generation of “tools”

**Commercial factors**
- Increasing costs for internal combustion engine (oil and environmental)
- Electric vehicles (EV) becoming competitive (price and range)

**Portable digitization**
- Digitization of developing countries
- Continuing trends towards mobile/tablet computing

**Political drivers**
- CO₂ emission limits and EV quotas (e.g. in China from 2019)
- Electrification of public transport
LiB market still dominated by Asian cell producers. Large growth potential for EV market alone

Market shares of cell producers (in ~%)

Source: IHS Markit (EV market only; status July 2018)
Total market size for LiB expected to reach ~500 GWh in 2023, further increasing to almost 900 GWh by 2025.

GWh demand p.a.\(^1\)

\(^1\) Bottom-up is GMS assumption based on IHS Markit (EV figures) and Avicenne 2018 (Non-EV + E-Bus figures). Top-down based on research reports from major investment banks.
SGL opportunity supported by the regional shift of EV and cell production.

**EV LiB demand by region (in GWh)**

<table>
<thead>
<tr>
<th>Year</th>
<th>EUR</th>
<th>NA</th>
<th>Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>18</td>
<td>44</td>
<td>12</td>
</tr>
<tr>
<td>2019</td>
<td>20</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>2021</td>
<td>45</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>2023</td>
<td>77</td>
<td>107</td>
<td>50</td>
</tr>
<tr>
<td>2025</td>
<td>121</td>
<td>140</td>
<td>77</td>
</tr>
</tbody>
</table>

**CAGR 2017–2025**:
- 37% EUR
- 29% NA
- 49% Asia

**Total CAGR ‘17–’25: ~ 36%**

**Market Details**

- LiB-cell mass production will be established in Europe and America
- Center of cell production will continue to be in Asia
- Announced cell production capacity for Europe: ~100 GWh
- Opportunity for SGL to participate in European supply chain for European cell manufacturing sites
- Comparable situation and opportunity for SGL in North America

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1 IHS Markit (BEV, PHEV, Full-Hybrid, only LIB) + own research
2 IHS Markit Data max forecast until 2023: CAGR 2023–2025: 25% (own estimate)
SGL supplies artificial graphite as key component into LiB supply chain.

Value chain

- Coke
- Pitch
- Natural graphite
- Silicon carbide

Value chain to produce „bricks“:
- Green (various recipes)
- Baking
- Graphitization

- Crushing and milling
- Post-treatment (coating and/or annealing)

- Cell production (cathode, electrolyte, separator and anode)
- Assembly of battery pack (located in Tesla’s giga factory)

- Automotive OEMs
- Electronic devices
- Power tools
- ...

SGL/HCC cooperation
Customer testimonial.
Hitachi Chemical Company, Ltd.

• Hitachi Chemical is a manufacturer of chemicals, in a wide range of areas, including anode material for lithium ion batteries.

• Kazuhisa Takano, General Manager Energy Storage Business:

“I’m glad to say that our current success is fully based on SGL’s great support which has been given to our company continuously for many years. We very much appreciate our business partner SGL. […] We assure that our continuous cooperation and good relationship among us can expand our business and support healthy growth of the lithium-ion battery business.”
Redox flow batteries (RFB).
Our opportunity beyond lithium-ion
RFBs contribute to the requirement for more energy storage and smart grid solutions worldwide.

Stationary energy storage
Main industry drivers

- Unpredictable nature of renewable energies
  - Enabling renewable energy solutions

- Smart grid expansion
  - Peak shaving requirements
  - Optimized use of energy
  - Lower costs

- Micro grid formation
  - Self-sufficient operated power grids for rural areas & islands
Due to a high stationary energy storage demand, strong market growth is expected for RFB.

Market size RFB until 2025\textsuperscript{1,2}

\begin{tabular}{c c c c c}
 \hline
 Year & RFB Market (GWh/a) & BF (1,000 sqm/a) & BPP (1,000 sqm/a) \\
 \hline
 2017 & 0.1 & & & 250 \\
 2019 & 0.1 & & & 500 \\
 2021 & 0.2 & & & \\
 2023 & 0.4 & & & \\
 2025 & 1.0 & & & \\
 \hline
\end{tabular}

\textbf{CAGR ‘17–‘25: \textasciitilde 35\%}

\textbf{Market details}

- Even though the RFB market will be smaller than LiB, it is attractive due to strong growth expectations
- Market potential for SGL solutions approx. €50–60m by 2025
- Project driven market and demand

\textbf{Regional key points}

- By 2021: Main installations will continue to be in Asia and America
- Larger European installations will follow after 2021
- Asia will become largest market

\textsuperscript{1} IDTechEx RFB 2018-2028 Market Study, forecasts for new installed power per year; \textsuperscript{2} 1 MW \~{} 4 MWh/1 MW \~{} 2,000 sqm felt/1MW \~{} 1,000 sqm BPP
Graphite products are mainly required at the component level of the RFB value chain.

**Value chain**

Production of cell components
- Graphite electrodes
- Bipolar plates

Production of flow batteries
- SIGRACELL® Soft felt
- Gas diffusion layers
- SIGRACELL® Bipolar plates
- Graphite plates

Grid integration/operation

**Graphite Products**
- Graphite electrodes
- Bipolar plates

**Materials**
- SIGRACELL® Soft felt
- Gas diffusion layers
- SIGRACELL® Bipolar plates
- Graphite plates

GMS business
Our products for energy storage.

Fields of application and product examples

<table>
<thead>
<tr>
<th>Lithium-ion batteries</th>
<th>Flow and advanced batteries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialty graphite for lithium-ion battery anodes</td>
<td>Porous electrodes made from SIGRACELL® battery felt</td>
</tr>
<tr>
<td></td>
<td>SIGRACELL® bipolar plates made of expanded graphite compounds</td>
</tr>
<tr>
<td></td>
<td>SIGRACELL® graphite foils</td>
</tr>
</tbody>
</table>
Agenda

1. Markets, market trends & GMS solutions
   - Energy – battery & other energy
   - Digitization – semiconductor
     - Digitization – LED
     - Energy – solar
     - Automotive & transport
     - Chemicals
     - Industrial applications

2. Importance of graphite value chain
Semiconductor growth is driven by more and more applications in a data centric world.

**Semiconductor**
Main industry drivers

- **Digitization**
- **Data explosion**
- **Renewable energies**
- **Mobility**
- **Urbanization**
- **China 2025**

**Digitization & data explosion**
- Data creation, transmission, storage, analytics

**Mobility & urbanization**
- Communication: Wireless/5G
- Automotive: E-mobility, ADAS\(^1\)
- Urban infrastructure: Transportation, energy

**China 2025**
- Increase self sufficiency
- Large investments in fabs

**Renewable energies**
- Decentralized power generation
- Smart grids
- Battery chargers

\(^1\)ADAS: Automated Driver Assistance Systems
Semiconductor industry in super cycle supports base growth for years to come.

Market details

- Silicon wafer shipments are proportional to graphite demand
- Semi is in a super-cycle with main drivers being AI², IoT³, 5G, automotive and China 2025
- Memory for mobile and computing drive 300mm silicon wafer demand
- Power electronics and MEMS⁴ for automotive and mobile drive demand for ≤ 200mm Si wafers
- Wafer supply expected to remain short until 2020
  - Wafer prices continue to rise
  - Key players cautiously expand wafer capacity
- Increasing performance requirements

Source: SEMI, GMS estimates based on Gartner, Credit Suisse; ¹ MSI: mio square inch; ² AI: Artificial Intelligence; ³ IoT: Internet of Things; ⁴ MEMS: Sensors
Our expected double digit growth is fueled by high power applications, based on SiC¹ and GaN² semiconductors.

SiC and GaN power device market (in $m)

<table>
<thead>
<tr>
<th>Year</th>
<th>SiC</th>
<th>GaN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>23</td>
<td>75</td>
</tr>
<tr>
<td>2019</td>
<td>302</td>
<td>566</td>
</tr>
<tr>
<td>2021</td>
<td>311</td>
<td>859</td>
</tr>
<tr>
<td>2023</td>
<td>1,517</td>
<td>3,600</td>
</tr>
<tr>
<td>2025</td>
<td>900</td>
<td>23,000</td>
</tr>
</tbody>
</table>

Market Details

- Wide Band Gap semiconductors offer new options where silicon reaches its limits
- Especially in power electronics, SiC and to some extent GaN are expected to establish themselves
  - PV inverters and power supply (as existing markets)
  - Electric vehicles, supposed to reach 40–50% of the SiC device market
  - Rail and industrial motor drives
- GMS is well positioned to meet high customer demands

¹Silicon Carbide; ²Gallium Nitride
Source: Yole Development, IHS Market
Graphite solutions are mainly required along the entire silicon-based semiconductor value chain.

<table>
<thead>
<tr>
<th>Metallurgical silicon</th>
<th>Polysilicon</th>
<th>Si crystal growing</th>
<th>Epitaxy wafer</th>
<th>Wafer processing</th>
<th>(Chip) Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphite products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heaters</td>
<td>Heaters</td>
<td>Heaters</td>
<td>Susceptors</td>
<td>Arc slits</td>
<td></td>
</tr>
<tr>
<td>Heat shields</td>
<td>Crucibles</td>
<td></td>
<td>Liners</td>
<td>Etch electrodes</td>
<td></td>
</tr>
<tr>
<td>Reactor internals</td>
<td>Cones</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small electrodes</td>
<td>Insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Materials

- Extruded
- CFRC, felts
- CFRC
- SiC coating
- Metallurgical silicon
- Polysilicon
- Graphite products
- Waist packaging
- GMS business

1Carbon fiber reinforced carbon
Our solutions and products for the semiconductor industry.

Fields of application and product examples

<table>
<thead>
<tr>
<th>Polysilicon production</th>
<th>Silicon single crystal growth</th>
<th>Silicon epitaxy</th>
<th>Compound semiconductor epitaxy (in MOCVDs$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGRAFINE® electrodes for Siemens reactors</td>
<td>SIGRAFINE® meander heater for CZ$^1$ units</td>
<td>SIGRAFINE® SiC coated susceptors for silicon epitaxy reactors</td>
<td>SIGRAFINE® SiC coated wafer carrier for compound semi$^3$ wafer production</td>
</tr>
</tbody>
</table>

$^1$Czochralski process; $^2$MOCVD: Metal Organic Chemical Vapor Deposition reactor in which; $^3$ compound semiconductors are built by a thermo-chemical reaction of two or more semiconductor elements in gas-form
Customer testimonial. Siltronic AG.
SGL Carbon was awarded Supplier of the Year 2015

- Siltronic is a global leader in the market for hyperpure silicon wafers
- Johannes Moritz, Head of Purchasing of Siltronic:

  “We appreciate SGL Group’s high commitment in this very competitive environment, to keep their cost and innovation leadership. Together we benefit from this long-term partnership and the continuous development of SGL with regards to the topics yield, quality, and price.”
Customer testimonial. Cree, Inc.
Cengiz Balkas, SVP & General Manager at Wolfspeed

- Cree is a market-leading innovator of semiconductor products for power and radio-frequency applications, lighting-class LEDs, and LED Lighting

“We see SGL as a strong partner in graphite solutions that are needed for the expanding SiC semiconductor production activities. SGL’s position in the market and its deep technical understanding are invaluable for the commercial ramp of the industry.”
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   - Digitization – LED
   - Energy – solar
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   - Chemicals
   - Industrial applications

2. Importance of graphite value chain
Growing demand for energy efficient lighting and technology achievements drive LED growth in numerous applications.

LED
Main industry drivers

- Declining LED costs
  - Continuous decline drives LED adoption
- Climate change/legislation
  - Energy saving with efficient lighting
- Urbanization/population growth
  - Increasing urbanization
  - Growing number of households
- Mini/micro LEDs
  - Mini LEDs revive LCD\(^1\) backlight market
  - \(\mu\)LEDs to revolutionize the display market (videowalls, AR/MR/VR\(^2\), automotive, TV)
- Specialty LEDs
  - UV\(^3\) for curing and disinfection
  - IR\(^4\) for sensing (e.g. automotive ADAS\(^5\))

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\(^1\) LCD: Liquid Crystal Display; \(^2\) AR/MR/VR: Augmented/Mixed/Virtual Reality; \(^3\) UV: Ultraviolet; \(^4\) IR: infrared; \(^5\) ADAS: Advanced Driver-Assistance Systems
LED market expected to more than double by 2025.
Driven by general lighting, specialty LEDs and micro LEDs in the long-term

**Demand for packed LEDs** (in bn units/a)

<table>
<thead>
<tr>
<th>Year</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>620</td>
</tr>
<tr>
<td>2018</td>
<td>730</td>
</tr>
<tr>
<td>2019</td>
<td>840</td>
</tr>
<tr>
<td>2020</td>
<td>950</td>
</tr>
<tr>
<td>2021</td>
<td>1,050</td>
</tr>
<tr>
<td>2023</td>
<td>1,275</td>
</tr>
<tr>
<td>2025</td>
<td>1,550</td>
</tr>
</tbody>
</table>

**Market details**

- General lighting remains the LED volume driver
- LED markets are diversifying
  - LED technologies open up numerous applications
  - Specialty LEDs (e.g. IR, UV, horticultural) are booming
- China plays a key role in both supply and demand, driven by government subsidies

Sources: Strategies Unlimited; Yole Development; Merill Lynch; GMS estimates
LED production requires graphite solutions mainly upstream, in sapphire crystal growth and especially in the MOCVD\(^1\) process.

### Graphite products in the LED value chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Graphite products</th>
<th>Materials</th>
</tr>
</thead>
</table>
| Crystal\(^2\) growth | • Heating elements  
• Heat shields  
• Insulation | Iso  
Extruded  
Felts |
| Substrate wafers\(^2\) | | |
| LED-wafers (MOCVD) | • Wafer carriers  
• Planetary susceptors  
• Satellite discs  
• Ceilings | Iso  
SiC-coating |
| LED chips/dies | | |
| LED module | | |

\(^1\)MOCVD: Metal Organic Chemical Vapor Deposition; key equipment for the production of LED wafers; \(^2\)> 90% of LEDs are based on sapphire substrates; \(^3\)images with courtesy of Monocrystal; \(^4\)image with courtesy of AIXTRON SE; \(^5\)ID 52110090 © Yana Bardichevska | Dreamstime.com
Our solutions for the LED industry.

Fields of application and product examples

- **Crystal growth**
  - SIGRAFINE® meander heater for crystal growth furnaces

- **Crystal growth**
  - SIGRATHERM® rigid felt insulation cylinder

- **LED (MOCVD)**
  - SIGRAFINE® SiC coated wafer carrier for LED wafer production in MOCVD reactors
Mid term innovation: Micro LEDs to become next long-term driver for LEDs, while mini-LEDs pioneer the way.

**Market details**

- Micro LEDs offer a number of benefits, e.g. high brightness, low power consumption, long lifetime
- Micro LEDs may revolutionize the display industry, e.g. in augmented reality, automotive head-up-displays, ultra-large displays
- Many technical barriers are still to overcome
- High R&D efforts of all major players
- Micro LED production is very demanding, requiring far tighter specifications → opportunity for SGL

**Mini & Micro-LED market (in bn $/a)**

- CAGR ‘18–’22: ~ 145%

**Chip size of conventional LEDs vs. mini- and micro-LEDs**

- Conventional LED chips: ≥ 1 mm, 200 µm, 100 µm, 50 µm, 30 µm, 10 µm
- Mini LEDs
- Micro LED chips

1 Source: LEDinside (June 2018)
Customer testimonial.
Advanced Micro-Fabrication Equipment Inc. (AMEC)

• AMEC is a global micro-fabrication equipment company serving customers in the semiconductor industry and adjacent high-tech sectors, focusing on plasma etching and CVD equipment.

• Dr. Gerald Z. Yin, Chairman and CEO of AMEC:
  “SGL is the only company in the world that can produce both high quality graphite susceptor substrate as well as the silicon carbide coating. This is why we choose SGL. […]

  I believe both AMEC and SGL have a bright future and business growth opportunity in this segment. We are very fortunate to have SGL as our major supplier and good partner.”
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   - Industrial applications

2. Importance of graphite value chain
Photovoltaic (PV) industry driven by growing demand for low cost renewable energy. China playing a dominant role

Photovoltaics
Main industry drivers

Population growth
Environmental protection
Technology
China

Declining PV costs
Developing/emerging countries

Population growth & emerging countries
- Growing demand for (distributed) cheap, scalable and bankable electricity

Environmental protection
- Renewable energy to mitigate global warming and pollution
- Development affected by changing governmental incentive schemes

Technology
- Advanced PV technology and economies of scale lead to grid parity costs

China
- China is largest consumer & almost sole supplier of PV and thus has a strong impact
2018 likely to see dip in PV demand but long-term growth path intact. Mono PV technology is set to dominate the growth.

Global PV installations (in GW/a)

Market details:
- China subsidy cut in May 2018 leading to a temporary market decline
- Replacement demand for graphite unaffected
- History proved PV demand to be highly price elastic, thus growth expected to continue
- Switch from multi to mono technology impacts the full PV value chain and is beneficial for graphite consumption

Graphite is required along the entire photovoltaic value chain.

Graphite products in the photovoltaic value chain

<table>
<thead>
<tr>
<th>Polysilicon</th>
<th>Silicon crystal growing</th>
<th>Cell</th>
<th>PV module</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Graphite" /></td>
<td><img src="image2" alt="Polysilicon" /></td>
<td><img src="image3" alt="Cell" /></td>
<td><img src="image4" alt="PV module" /></td>
</tr>
</tbody>
</table>

**Graphite Products**
- Heating elements
- Heat shields
- Poly chucks
- Crucibles, cones, plates
- Heating elements
- Insulation
- Wafer boats
- Wafer carriers

**Materials**
- CFRC\(^1\)
- Felts
- Extruded/Vibro
- Iso
- SiC/PyC\(^2\) coating

\(^1\)Carbon fiber reinforced carbon; \(^2\)Pyrolytic carbon-coating
Our products and solutions for the photovoltaic industry.

### Fields of application and product examples

<table>
<thead>
<tr>
<th>Field</th>
<th>Product Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polysilicon production</td>
<td>SIGRAFINE® electrodes for Siemens reactors</td>
</tr>
<tr>
<td></td>
<td>Support crucible made from SIGRABOND® CFRC</td>
</tr>
<tr>
<td>Silicon mono crystal pulling</td>
<td>SIGRATHERM® MFA graphite rigid felt sheet</td>
</tr>
<tr>
<td>Production of multicrystalline silicon</td>
<td>SIGRABOND® CFRC carrier frame for solar wafers</td>
</tr>
<tr>
<td>Anti-reflection coating</td>
<td></td>
</tr>
</tbody>
</table>
Customer testimonials. Wacker Chemie AG.
SGL Carbon was awarded for Best Global Partnership 2016

- Wacker Chemie AG is a global company with state-of-the-art specialty chemical products
- Wacker is global market leader in Polysilicon for the semiconductor and PV industries
- Jörg Krey, Head of Technical Procurement and Logistics at Wacker Chemie AG:

  "Highest reliability, exceptional flexibility, and consistent on-time delivery combined with a fair and collaborative partnership are what make SGL Group stand out."


![Image of Certificate]

SUPPLIER-AWARD
Lieferantentag 2017 – Wacker Chemie AG

SGL CARBON GMBH

KATEGORIE
BESTE „GLOBALE PARTNERSCHAFT“

AUSZEICHNUNG FÜR
weltweiter, sehr zuverlässiger, wettbewerbsfähiger und außerordentlich flexibler Partner bei der globalen Versorgung mit wichtigen Kohlenstoff- und Graphitprodukten

Burghausen im Mai 2017

Jörg Krey
Leiter Technischer Einkauf & Logistik

Dr. Tobias Brandis
Leiter WACKER POLYSILICON
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2. Importance of graphite value chain
Automotive market offers substantial growth opportunities for graphite parts produced in large scale.

**Automotive**
Main industry drivers

- Mobility
- Emission reduction
- Urbanization
- Individuality
- E-mobility
- Overall market

**Overall market**
- Growing global automotive market

**Emission reduction**
- “Diesel-Gate” and stricter environmental regulations

**E-mobility**
- Shift to e-mobility supports graphite use in automotive
Automotive industry is forecasted to grow. GMS offers solutions for both EV and internal combustion engine (ICE) powertrains

Automotive global sales (in million units/a)

Market details
- Environmental legislation/CO₂ reduction targets
- Strong growth of e-mobility
- Market shifts towards Asia

Significance for SGL
- ICE: CO₂ reduction enabled by SGL products
- EV: Significant opportunities for SGL solutions in electric water pumps for cooling and in brake assistant pumps

Sources: Diverse sources and own calculations (2017/2018)
Our solutions for the automotive industry.

Fields of application and product examples

<table>
<thead>
<tr>
<th>Vacuum pumps</th>
<th>Fuel and water pumps</th>
<th>Sealings and gaskets</th>
<th>Exhaust gas recirculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGRAFINE® PTS rotor with vanes for brake assist pumps</td>
<td>SIGRAFINE® PTS bearings made from carbon graphite</td>
<td>SIGRAFLEX® expanded graphite foil for cylinder head and recirculation gaskets</td>
<td>SIGRAFINE® graphite bearings for exhaust gas recirculation valves</td>
</tr>
</tbody>
</table>
Agenda

1. Markets, market trends & GMS solutions
   - Energy – battery & other energy
   - Digitization – semiconductor
   - Digitization – LED
   - Energy – solar
   - Automotive & transport
   - Chemicals
   - Industrial applications

2. Importance of graphite value chain
Chemicals growth is supported by various industry drivers.

**Chemicals**
Main industry drivers

- **Mobility**
  - Acids for mining (e.g. lithium)
- **Environmental protection**
  - Acid recovery, off-gas treatment
- **Population growth**
  - Fertilizers (agrochemicals) for higher agricultural output
- **Urbanization**
  - Plastics (e.g. PVC, PU) for infrastructure & construction
- **Digitization**
  - Acids for mining or recycling (e.g. rare earth)
Global chemicals market grows with global GDP.
With high dependence on China

Global chemicals demand (in €bn)

Source: Marketline, own calculations

Market details

- New entrants, mainly from China, with the effect of overcapacities and price pressure
- Volatility in exchange rates, raw material prices and margins
- Consolidation ongoing especially in the area of commodities
- High dependence on Chinese growth
SGL solutions enable many technologies and applications along various chemical value chains.

### Chemicals – General description of typical corrosive chemical processes

<table>
<thead>
<tr>
<th>Intermediates</th>
<th>Chemical process</th>
<th>Chemical products</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>

#### Process technologies & systems
- Acid production, e.g. hydrochloric or phosphoric acid production
- MDI/TDI\(^1\) production
- VCM\(^2\) production
- Various technologies, e.g. leaching, concentration, dilution, purification, desorption, absorption, distillation
- Polyurethane production
- PVC production
- Phosphoric acid purification
- Variety of end products of chemical industry, e.g. plastics, food additives, fertilizer, pigments

#### Sealing technologies
- Corrosive and high temperature processes

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\(^1\) Methylene diphenyl diisocyanate/tolyene diisocyanate; \(^2\) Vinyl chloride monomer
Our solutions for the chemical industry.

Selected product examples

- **Heat exchanger**: DIABON® graphite block heat exchanger
- **Columns**: POLYFLURON® PTFE lined column
- **Pumps**: DIABON® centrifugal pump group in graphite for hot corrosive fluids
- **HCl synthesis**: Bottom burner section of HCl synthesis unit
- **Sealing materials**: SIGRAFLEX® graphite sheet for gaskets
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2. Importance of graphite value chain
Our solutions for high temperature furnaces.

Fields of application and product examples

<table>
<thead>
<tr>
<th>Heating elements and systems</th>
<th>Thermal insulation</th>
<th>Heat shields and insulation protection</th>
<th>Charging systems and elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>High temperature furnace equipped with SIGRAFINE® graphite heating cage</td>
<td>SIGRATHERM® rigid felt boards with different coatings</td>
<td>SIGRABOND® CFRC/SIGRAFLEX® graphite foil composites</td>
<td>SIGRABOND® Performance CFRC charging plates system with higher stiffness</td>
</tr>
</tbody>
</table>
Our solutions for electrical discharge machining in toolmaking.

Fields of application and product examples

Electrical Discharge Machining (EDM) electrodes

SIGRAFINE® EDM standard ready-to-run electrode
SIGRAFINE® EDM detail electrode for precise geometries
SIGRAFINE® EDM rib electrode
SIGRAFINE® EDM electrode for turbine blade production
Our solutions for the metal industry.

Fields of application and product examples

<table>
<thead>
<tr>
<th>Continuous casting</th>
<th>Pressure sintering</th>
<th>Powder metal industry</th>
<th>Gas injection and distribution systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGRAFINE® graphite continuous casting die</td>
<td>SIGRAFINE® graphite molds</td>
<td>SIGRAFINE® graphite boat</td>
<td>SIGRAFINE® graphite rotating degassing for aluminum refining</td>
</tr>
</tbody>
</table>
Our solutions for the glass and refractory industries.

Fields of application and product examples

<table>
<thead>
<tr>
<th>Container glass</th>
<th>Float glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGRAFINE® carbon molds for producing hollow glassware</td>
<td>SIGRAFINE® profiles for tin bath walls</td>
</tr>
<tr>
<td>Conveyor channel made of SIGRABOND® CFRC</td>
<td></td>
</tr>
</tbody>
</table>

SIGRAFINE® carbon molds for producing hollow glassware
Conveyor channel made of SIGRABOND® CFRC
SIGRAFINE® profiles for tin bath walls
Mid term innovation: New markets for our graphite based solutions are continuously developing.

**Glass bending**
- Graphite needed as molds for bending of glass
- Today's applications: smart phones
- Tomorrow: automotive displays

**Optical fiber**
- Ever increasing data quantities require more fibers
- Products: heating elements, insulation & CFRC support high temperature customer processes
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2. Importance of graphite value chain
Specialty graphites come into play where other materials fail.

1 Electrical Discharge Machining
Fine grain graphite manufacturing is complex and know-how intensive with long production times.

Manufacturing process of fine grain graphite

- Coke & graphite
- Grinding
- Mixing
- Binder pitch
- Shaping: Isostatic pressing, vibration/die molding, extruding
- Carbonizing: 800 - 1,200 °C
- Graphitizing: 2,500 - 3,000 °C
- Pitch impregnating
- SiC coating
- Purifying: ≥2,700 °C
- Machining
- Finishing: ≥1,200 °C

4–5 months

2–12 weeks
GMS can offer tailored solutions for customer applications due to broadest portfolio and capabilities in the industry.

<table>
<thead>
<tr>
<th>Fine grain graphite</th>
<th>Expanded natural graphite</th>
<th>Carbon fiber-reinforced carbon and felts</th>
<th>Value-add process capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Isostatic</td>
<td>• Foils &amp; Sheets</td>
<td>• CFRC¹</td>
<td>• Base machining</td>
</tr>
<tr>
<td>• Extruded</td>
<td>• Yarns</td>
<td>• Rigid felt</td>
<td>• Advanced machining</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Panels</td>
<td>• Purification</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Additives</td>
<td>• SiC Coating</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Process &amp; product modeling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• System design</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• System assembly</td>
</tr>
</tbody>
</table>

¹CFRC: carbon fiber reinforced carbon
GMS has a significant competitive advantage by commanding entire value chain from feedstock to application ready products.
SiC coating is an example for high-value-add applications, offering premium sales prices and margins in the respective markets.

• Full leverage of GMS value chain
• Difficult to replicate by new-entrants:
  – Special iso grades applied and highly precise machining needed
  – High degree of innovation, technological expertise & process stability required
• High level of technological differentiation vs. competition
• Applications in fast growing LED and semiconductor industries
• Business opportunities with OEMs as well as aftermarket sales
GMS products are indispensable due to the specific characteristics of graphite and SGL’s technology and engineering competence.

**Battery & other energy**

Energy density of graphite anode material allows increased performance of lithium-ion batteries, supporting trends for EVs and mobile devices.

**Solar**

Graphite is needed along the entire value chain of photovoltaic cell manufacturing, enabling green energy production.

**LED**

Graphite is required for production of LEDs, enabling CO₂ emission reduction through more efficient lighting.

**Semiconductor**

Graphite is indispensable for semiconductor production, supporting widespread growth in the digital age.
GMS products are indispensable due to the specific characteristics of graphite and SGL’s technology and engineering competence.

**Automotive**

Carbon and graphite in numerous automotive components promote energy efficiency and environmental compatibility and safety.

**Chemical**

The chemical industry relies on graphite to process corrosive substances and for reliable and safe sealing technology.

**Industrial applications**

Graphite can be found in a multitude of industrial applications and increases the performance of systems and processes.
**Graphite Materials & Systems.**
Favorably positioned in high growth markets

<table>
<thead>
<tr>
<th>Market Segment</th>
<th>Battery &amp; other Energy</th>
<th>Solar</th>
<th>LED</th>
<th>Semiconductor</th>
<th>Automotive &amp; Transport</th>
<th>Chemical</th>
<th>Industrial Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term targeted CAGR in %</td>
<td>High single digit(^1)</td>
<td>Mid single digit</td>
<td>Double digit</td>
<td>Double digit</td>
<td>High single digit</td>
<td>Mid single digit</td>
<td>GDP-like</td>
</tr>
</tbody>
</table>

\(^1\)magnitude of growth dependent on CAPEX projects currently under evaluation

GMS positioning in high growth markets contribute to SGL Carbon’s 8.5% CAGR
Long-term partnerships with customers validate our strong position.

Selected customer references