Synthetic and Natural Graphite

The relative applications and fundamentals of the synthetic and natural graphite markets

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Industrial Minerals Graphite & Graphene Conference
SGL Group Overview

SGL Carbon and the relative applications and fundamentals of the synthetic and natural graphite markets

What are the projections for growth in this market?

Can the synthetic graphite market benefit from interest in new carbon products?

What synthetic graphite producers and natural graphite consumers can do to offset the damaging effects of volatile raw material prices - coke and natural flake?
SGL Group - The Carbon Company is one of the world’s largest manufacturers of carbon-based products

SGL today

- Comprehensive portfolio ranging from carbon and graphite products to carbon fibers and composites
- 45 production sites worldwide
- Service network covering more than 100 countries
- Sales of € ~1.7 bn in 2012
- Head office in Wiesbaden/Germany
- Approx. 6,700 employees worldwide
- Listed on Deutsche Bourse’s SDAX
- Established in 1878 = 135 years old
SGL Group has a strong global footprint with 45 production sites worldwide.

### SGL Group worldwide

- **Production sites**
  - Performance Products
  - Graphite Materials & Systems
  - Carbon Fibers & Composites

### Sales by region

- **Asia**: 28%
- **Germany**: 18%
- **North America**: 23%
- **Rest of Europe**: 23%
- **RoW**: 8%

*RoW = Latin America, Africa, Australia*
Broad Base

Core competencies
- High temperature technology
- Know-how in:
  - Materials
  - Engineering
  - Applications

Comprehensive portfolio
- Coarse-grain graphite
- Fine-grain graphite
- Expanded natural graphite
- Carbon fibers and composites

Global presence
- Approx. 6,500 people worldwide
- 45 production sites
- Global network
- Near to our customers
In the following slides we’ll look at:

- The fundamentals of Graphite
- The Applications of Graphite
- The Prospects of Growth for Graphite
Carbon and Graphite growth is derived from Market Needs where other materials fail

Main properties carbon and graphite materials

- Mechanical strength
- Thermal shock resistance
- Electrically and Thermally Conductive
- Ultra High Purity
- Corrosion resistance
- Machinability

Carbon & Graphite materials
The competitive advantages of carbon

No other material is lighter ...

<table>
<thead>
<tr>
<th>Density (kg/l)</th>
<th>Steel</th>
<th>Aluminium</th>
<th>CFRP</th>
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<tbody>
<tr>
<td>7.9</td>
<td>2.7</td>
<td>1.6</td>
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... or stronger and stiffer

<table>
<thead>
<tr>
<th>Specific strength (km)</th>
<th>Specific stiffness (100 km)</th>
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<tr>
<td>500</td>
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Other ceramics would break ...

... or fail at temperatures > 1.500 °C

Other ceramics are shown failing at high temperatures.
Synthetic graphite manufacturing is complex and requires multiple steps for a total four to six months production time.

Manufacturing process of synthetic graphite:

- **Coke & graphite**
- **Grinding**
- **Binder pitch**
- **Mixing**
- **Shaping**
  - Extruding, vibration / die molding, isostatic pressing
- **Carbonizing**
- **Graphitizing**
- **Finishing**
  - Machining, purifying, SiC coating
The unique properties of natural graphite are captured in expanded graphite foils.

Manufacturing process of expanded graphite:

1. Natural graphite flakes
2. Intercalation agent
3. Graphite salt
4. Thermal expansion at 1,000°C
5. Compacting
6. Impregnated Sheets
7. Sheets
8. Foils

Time required:
- 3-5 days for each stage.
Fundamental long-term growth drivers for our businesses

Key challenges

- Changed economic environment
- Climate change
- Energy / raw materials availability

SGL Group approach

“Towards an ecologically sensitive world”

Sustainable solutions

- Energy efficiency
- Alternative energies
- Light weight
- Sustainability

Carbon contributes to all four solutions
Best Solutions: Best in class products, services and ideas to satisfy current and future needs of our customers

Iron and steel
- High-performance graphite electrodes
- Carbon and graphite lining materials for blast furnaces

Non-ferrous metals (e.g. aluminium)
- Carbon and graphite cathodes in customized designs for primary aluminum
- Fine-grain graphite for continuous casting

Semiconductor solar and LED
- High-purity fine-grain graphite for polysilicon and monocrysal growing
- Coated graphite platters and susceptors for LED and Epitaxy
Best Solutions: Best in class products, services and ideas to satisfy current and future needs of our customers

**Automotive**
- Carbon Fiber JV with BMW & Mitsubishi
- Cylinder head gaskets
- Carbon ceramic brake discs
- Pump parts made of carbon and graphite

**Mechanical engineering**
- CFRP light weight components
- Fine-grain graphite for electrical discharge machining

**High temperature technology**
- Graphite heaters and insulation material
- C/C charging systems

**Chemicals**
- High Temp Corrosion Resistant Sealing & Gasket materials
- Thermal decomposition units
- Multi-tube heat exchangers
Best Solutions: Best in class products, services and ideas to satisfy current and future needs of our customers

**Energy and environmental technology**
- Carbon fibers for wind power plants
- Cold storage systems for truck air conditioning
- Graphite for solar wafer production and energy storage

**Aerospace**
- Primary structural CFRP components
- Carbon fibers for aircraft brakes
- C/SiC for satellite mirror support

**High performance sports**
- Carbon fiber fabrics and prepregs for high-performance sports
- C/C-brake discs for Formula 1 racing

**Automotive**
- Carbon fiber for innovative automotive manufacturing processes
- Fuel cells – automotive & stationary
New Markets and Materials: Products in their infancy with Bright Futures

- Application and Potential Applications in:
  - Electronics
  - Li-ion Batteries
  - Electrical and Thermal Storage
  - Medical
  - Construction
  - Automotive
  - Chemical and H2O Purification

- It’s not a question of IF; but WHEN

Photo Sources: 1-Hitco/SGL; 2- The Guardian; 3-Panasonic Corp
In the following slides we’ll look at:

Natural Graphite as a Raw Material and our view of the market fundamentals

Coke as a Raw Material and our view of the market fundamentals

SGL’s Current view of these two markets
Natural Graphite as a Raw Material - Market Drivers

- Small global business, acts like a commodity
- Seasonal influence
- Sovereign influence
- Family ownership = different profit motives
- Natural (from the ground) variation driving different economics
- Base industries – Refractories, Steel, Expanded Graphite
- New Market entrants – Li-ion, graphenes
- Purification technology & environment
The Scarcity of Natural Graphite

Total Mine Extraction

Typical Run of Mine Flake
3% - 8%

Typical Large Flake (80-30 Mesh)
approx 30-40%

1000 Mt Mined could equal
9 – 32 Mt of Large usable flake
Coke as a Raw Material - Market Drivers

• Global Market Drivers – Steel, Aluminum and Power

• Global Oil and Coal Economics

• Environmental drivers
  – New Pitch regulations
  – Coal for Electric Generation
  – Coke Battery Declines

• Capex constraints at Refineries that change availability

• Competition among all grades of coke…
  – Fuel grade, Met Coke, Anode grade, Pitch Coke, Needle Coke
Coke prices for Synthetic Graphite
2008 = 100

- Petroleum Anode
- Petroleum Needle
- Pitch (Isotropic)
- Pitch (Semi-Isotropic)
How we manage the raw materials pricing dynamics

- Where possible pass through cost increases

- Develop new technologies that allow us to use lower cost raw materials to produce higher value-add products.

- Develop technologies to Blend raw materials

- Improve Yields through the process technology improvements
SGL’s position on Coke and Natural Graphite

• High Purity NG and Coke are critical to our Success

• There is no shortage of either NG or Coke in the world

• SGL does Not wish to become a Miner, we plan to maintain flexibility as a Consumer

• There is economical room for 3-5 more mines to open on a global basis
  • This assumes a reasonable growth rate for Li-ion Batteries

• Graphite Anode Material for Li-ion batteries will remain a mix of synthetic and natural for the foreseeable future

• Shift in Needle Coke market (GTI and Chinese producers) should provide more favorable market conditions
Summary

New Applications

Li-ion Batteries, LEDs, New Batteries, Solar, Electronics, etc…
Will drive graphite demand, both Natural and Synthetic

New Materials such as Graphenes and Nanotubes
Will come forward over time to develop new industries

Virtually all technologies require higher purity levels, improved/increased consistency

Coating Technology open doors for growth of Carbon and Graphites
Thank you for your attention