Know how and service for slurry based wafer production in photovoltaic and semiconductor industry

Technology for separation, classification, purification of solid and liquid materials, recovery of resources and industrial treatment of waste

Thomas Schicht (GM) at Semicon Russia 2015
SiC Processing (Deutschland) GmbH is a leading, worldwide operating service partner for processing of used sawing suspension (slurry) with outstanding market position and product quality. Improved process performance, lower consumption of virgin resources, significant waste reduction and finally lower total wafer costs are motivation for our customers to use our reliable slurry management capabilities.

**Photovoltaic and semiconductor industry** are using slurry to produce wafers out of mono- or multi- crystalline silicon blocks on wire saws. The suspension consists of a fine-grained, sharp edged abrasive (mainly silicon carbide) and a viscose carrier liquid (mainly glycol), whereas the latter acts as a transportation and cooling medium. During the wire sawing process the slurry is collecting the removed fine silicon (kerf) and other impurities (Fe, H2O), the cutting efficiency is decreasing and the used slurry needs to be replaced.

**Our multi-step technology** separates solid and liquid components, eliminates all residues and recovers SiC-abrasive and liquid with customized characteristics. Recovery rates of 80 to 95 % are possible for the components. We can provide the recycled materials separately or the ready to use slurry according to customer process specifications. For almost all residues applications are available to ensure waste avoidance.

**Also for other materials** our processing concept can be modified. Separation, classification and cleaning of fine solid powders as well as filtration, purification and distillation of technical liquids are part of our business. In our plant in Bautzen/ Germany it is possible to process up to 40,000 tons per year. R&D projects, lab analyses and logistics are additional services.
History - SiC Processing (Deutschland) GmbH

2000 – 2001
start Bautzen line I

2001 – 2003
start Bautzen line II

2003 – 2005
start Bautzen line III

2005 – 2009
start Bautzen line IV

2008/ – 2009
start Bautzen line V

2010
implementing R&D- center

2012
start on „new materials“
Products for Wafer- Slicing

Processing of used Slurry for the Wafer Industries

- Separation, classification, purification of liquid and solid components
- Elimination of residues from the sawing process

delivery of high-quality ready-to-use slurry or components
Process Overview SiC Processing

SLURRY SUPPLY SYSTEM onsite/offsite

1. The used slurry is shipped or piped from the wafering plant to a SiC plant.

2. Slurry is processed:
   - Liquid / solids separation
   - Recovery of SiC
   - Recovery of PEG
   - Elimination of residues / waste

3. Recovered SiC and PEG are pre-mixed or as components shipped to customer.
Utility Specifications

Demand of Utilities for a 15.000t plant; SiC - F600 (SiC - F800)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Value</th>
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<tbody>
<tr>
<td>Land Requirement</td>
<td>6,000 m²</td>
</tr>
<tr>
<td>Electric Energy</td>
<td>1,800 kW</td>
</tr>
<tr>
<td>E - Power Consumption</td>
<td>11,340 x 10³ kWh / year</td>
</tr>
<tr>
<td>Cooling water</td>
<td>∆T=10K:135m³/h; ∆T=6K:225m³/h</td>
</tr>
<tr>
<td>Additional water</td>
<td>If generated at own facility: 1.25 m³/h</td>
</tr>
<tr>
<td>Natural gas for</td>
<td>(about 75m³/ton) 247.5 m³/hour</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>4,200m³/h (at 6 bar)</td>
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<tr>
<td>Steam</td>
<td>3.3 tons / hour (at 6 bar)</td>
</tr>
<tr>
<td>Fresh Water</td>
<td>7.5 (12) m³ / hour</td>
</tr>
<tr>
<td>Waste Water</td>
<td>168 (276)m³/day</td>
</tr>
<tr>
<td>Spill</td>
<td>4 m³ / day</td>
</tr>
<tr>
<td>Output of By - product</td>
<td>(Si-SiC) 9 tons /day</td>
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</tbody>
</table>
### Product – and service portfolio

<table>
<thead>
<tr>
<th><strong>Recovery and treatment</strong></th>
<th><strong>Service and logistics</strong></th>
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<tbody>
<tr>
<td>• Recovery and treatment of SiC and PEG from used slurry</td>
<td>• Transport and logistics service from and to the customer</td>
</tr>
<tr>
<td>• Mixing service following customer recipe</td>
<td>• Waste prevention and waste disposal</td>
</tr>
<tr>
<td>• Provision and modification of virgin goods PEG and SiC</td>
<td>• Storage</td>
</tr>
<tr>
<td>• Treatment of bulk materials and liquids</td>
<td></td>
</tr>
<tr>
<td>• On-site and off-site service</td>
<td></td>
</tr>
<tr>
<td>• Continuous quality checks</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Engineering</strong></th>
<th><strong>Research + development</strong></th>
</tr>
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<tbody>
<tr>
<td>• Planning, construction, and operation of processing systems in close cooperation with partners</td>
<td>• Research and development work for the optimization of cutting processes and development of new processes</td>
</tr>
<tr>
<td>• Setup and operation of tank farms or slurry supply systems at the client's site</td>
<td>• Procedures for the processing of &quot;new&quot; materials in theory, lab and technical center dimension</td>
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<td></td>
<td>• Research projects with industry partners, institutes, universities</td>
</tr>
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**Strong partnership between customer and service provider**

**Reduction of costs – quality improvement – waste reduction**
Advantages and Customer benefits

<table>
<thead>
<tr>
<th>Cost savings</th>
<th>Quality requirement</th>
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<tr>
<td></td>
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<tr>
<td>More than 50 %</td>
<td>High yield rates</td>
</tr>
<tr>
<td>of slurry costs</td>
<td>SiC 75-90 %</td>
</tr>
<tr>
<td></td>
<td>PEG 85-95 %</td>
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<tr>
<td>Up to 25 %</td>
<td>Constant, consistent, high quality</td>
</tr>
<tr>
<td>on wafering costs, excl. Si</td>
<td>Restored cutting properties for slurry</td>
</tr>
<tr>
<td>15 %</td>
<td>High efficiency</td>
</tr>
<tr>
<td>on wafering costs, incl. Si</td>
<td>Particle size and purity mostly restored</td>
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<tr>
<td>Low disposal costs</td>
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Service Level

- One-stop-shop service incl. additional services
- Slurry Supply System
- Research and development/R+D for process optimization and development
- On-site and off-site service
- Reduced supply chain risk

Environmental aspect

- Complete treatment of used slurry
- Process and treatment is repeatable without limitation
- closed cycle of material; no waste on customers side
Hydrocyclone vs. Centrifuge – Cost Comparison

- Cheaper per-kg price of centrifuge slurry is compensated by more usage and less throughput of machines.
- More expensive slurry is of better quality and thus leads to cheaper wafer cost and generates more value to the customer.
- Investment in high quality slurry pays off very easily.
"New" materials – Basic ideas and approaches for action

Our complex technology for slurry treatment includes the separation of suspensions as well as the treatment of micro-grain solid mixtures and various liquid components.

- This expertise can be transferred to other materials and existing system capacities can be applied in a modified version.
- The research and development work of the Technical Center including the laboratory capacities play a central role here.

Available technologies (selection):
- Solid-liquid separation
- Wet-mechanical solid-solid grading
- Mechanical and chemical surface cleaning of powders
- Filtration with broad range of filter media
- Desalinization and the coloration through ion exchange
- Mechanical dehydration and thermal drying
- Distillation of technical fluids
- Stirring and mixing processes
Central Function of the Technical Center

- The technical center of SiC Processing GmbH was built in QIII/2009; pilot line and laboratories have been in production since 2010

- Main focus:
  - Process development and optimization with respect to quality and costs
  - Analytical service
  - Development of new business sectors and the design of corresponding processes (new materials)
  - Building of basic understanding for slurry and the cutting processes
  - Patent management

- Employees (May 2014)
  - 2 PhD chemists (employees of SAG)
  - 5 technicians for the system operation + laboratory
  - 1 assistant (part-time work for SAG and SBZ)
  - Calling in of process engineers and additional personnel resources of SBZ when needed
R+D equipment – pilot processes

- Separation/grading
  - Filter presses
  - Ceramic disc filter, membrane filter, candle filter
  - Cyclone stations
  - Decanter

- Thermal treatment
  - Paddle dryer
  - Evaporator
  - Vacuum distillation

- Cleaning
  - Ion exchanger
  - Reverse osmosis (high and low pressure)

- Additional infrastructure
  - Heated and unheated tanks
  - Agitator
  - Media supply

The systems can be manually connected and will then correspond with the production process with a factor of ~1:30
R+D equipment - fully equipped laboratories

• Standard method for particle and fluid characterization:
  • Scanning electron micrograph  
    (With energy dispersive x-ray spectroscopy)
  • Gas chromatography/mass spectrometry
  • X-ray fluorescence analysis (elementary analysis)
  • UV-Vis spectroscopy
  • Photometric identification of iron, silicon, etc.
  • Determination of grain size distribution (Cilas)
  • Water and acid index determination
  • pH-electrodes (also for organic solvents)
  • Conductivity electrodes

• Selected equipment for the recycling at the laboratory scale
  • Micro distillation, rotation evaporation
  • Pressure filtration unit
  • Temperature-controlled ovens
  • Schlenk system for working without air and moisture

• Additional infrastructure
  • Several exhausts
  • Connection of compressed air, hydrogen, nitrogen, helium
New materials

50 different waste materials have been tested since 2012

Experience with the processing of the following materials:
- ZrO$_2$ blasting materials
- FeNdB abrasion (of permanent magnets)
- Aluminum pigments
- Copper shale
- Zinc-containing dusts
- Steel-containing dusts
- Flax fibers

In addition, the following materials were developed up to market-readiness or close to market-readiness
Thank you for your attention

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