Solutions for thinning, dicing and packaging of power devices made of Si, Sapphire, SiC and GaN
Contents

- Processing hard and brittle materials
  - Grinding
  - Dicing by blade or laser

- About DISCO
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- About DISCO
SiC grinding

- Thinning of SiC is necessary for further power conversion efficiency as is the case with Si

- Issues for SiC grinding: Harder material than Si

  ![Mohs hardness chart]

<table>
<thead>
<tr>
<th>Material</th>
<th>Mohs Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamond</td>
<td>15</td>
</tr>
<tr>
<td>SiC</td>
<td>13</td>
</tr>
<tr>
<td>Sapphire</td>
<td>11</td>
</tr>
<tr>
<td>Si</td>
<td>9</td>
</tr>
<tr>
<td>Iron</td>
<td>1</td>
</tr>
</tbody>
</table>

- Lower throughput
  → Grinder with four spindles is available to improve throughput

- Reduced wheel life
  → Wheels for SiC have been developed for longer wheel life
SiC grinding

- **Fine grinding finish**: Both Si and C surfaces available
  - DFG8830 (or DFG8540)
    - Rough grinding (#2000-3000)
    - Fine grinding (High mesh wheel)
  - Back Grinding

- **Dry polishing (DP) finish**: C surface available
  - DGP8761 (or DFG8540 + DFP8140)
    - Rough grinding (#2000-3000)
    - Dry Polishing
  - Back Grinding
  - Polishing
SiC grinding

- Realize good surface roughness (Ra = 2nm) after fine grinding

![Diagram showing grinding process]

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
<th>Ra = 2 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-section (C surface)</td>
<td>![Image of mid-section surface]</td>
<td>Final wafer thickness: 100 μm</td>
</tr>
<tr>
<td>Outer edge (C surface)</td>
<td>![Image of outer edge surface]</td>
<td>Final wafer thickness: 100 μm</td>
</tr>
</tbody>
</table>

* Same surface roughness (Ra = 2 nm) for Si surface
SiC Dry Polishing

- Remove grinding damage through dry polishing
- Improve die strength
- Reduce wafer warpage

<table>
<thead>
<tr>
<th></th>
<th>Grinding marks remained</th>
<th>Grinding marks removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>Ra=2 nm</td>
<td></td>
</tr>
<tr>
<td>BG+DP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Three-point-bend die strength measurement

- BG: Ra=2 nm
- BG+DP: 3 μm removal

Φ4 inch, C surface grinding
Die thickness: 100 μm
Index size: 10mm x 10mm

5.5 MPa (BG) → 300.7 MPa (BG+DP)
SiC and Sapphire grinding for wafer manufacturer

ResiFlat Process
New wafer manufacturing process for Sapphire and SiC to remove wafer waviness after wire slicing

ResiFlat Process Example

<table>
<thead>
<tr>
<th>Sliced wafer</th>
<th>Resin bonding</th>
<th>A-side grinding</th>
<th>Resin peeling</th>
<th>B-side grinding</th>
<th>Waviness removal grinding</th>
<th>A-side grinding</th>
<th>B-side grinding</th>
<th>Fine grinding</th>
<th>Next process (Polishing)</th>
</tr>
</thead>
</table>

**Full automatic**
Substitute for lapping process

**Less environment burden**
Slurry-less
Wax-less

**Process stability**
Fixed abrasive process
Single wafer process
SiC and Sapphire grinding for wafer manufacturer

- Remove wafer waviness after wire slicing

**Sapphire**

Before waviness removal grinding

- Wafer waviness: 29.64 μm

After waviness removal grinding (#320)

- Wafer waviness: 8.34 μm

72% reduction

**SiC**

Before waviness removal grinding

- Wafer waviness: 53.22 μm

After waviness removal grinding (#2000)

- Wafer waviness: 31.50 μm

41% reduction

Waviness of less than 10 μm possible after polishing
SiC and Sapphire grinding for wafer manufacturer

- Reduces the polish amount by improving surface roughness

**Sapphire**

- Before fine grinding (#320): Ra = 389 nm
- After fine grinding (#1400): Ra = 31 nm

**SiC**

- Before fine grinding (#2000): C surface Ra = 9 nm
- After fine grinding (High mesh wheel): C surface Ra = 0.67 nm
Tape secured process

- Advantages compared to wax secured process
  - Improved throughput because attachment and detachment time can be shortened
  - Reduced environmental burden since cleaning with organic solvents is not necessary

<table>
<thead>
<tr>
<th>Wax</th>
<th>Tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate</td>
<td>SiC wafer</td>
</tr>
<tr>
<td>Wax</td>
<td>Tape</td>
</tr>
<tr>
<td>Laminating</td>
<td>Laminating</td>
</tr>
<tr>
<td>Grinding(+Polishing)</td>
<td>Grinding(+Polishing)</td>
</tr>
<tr>
<td>Peeling</td>
<td>Peeling</td>
</tr>
<tr>
<td>Cleaning</td>
<td></td>
</tr>
</tbody>
</table>

- Applicable equipment

<table>
<thead>
<tr>
<th>Model name</th>
<th>Number of spindles</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully automatic grinders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFG8540</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>DFG8830</td>
<td>4</td>
<td>Improved throughput for thin grinding</td>
</tr>
<tr>
<td>Fully automatic polisher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFP8140</td>
<td>1</td>
<td>Available as an in-line system with grinder</td>
</tr>
<tr>
<td>Fully Automatic grinder/polisher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DGP8761</td>
<td>3</td>
<td>Combined grinding and dry polishing unit</td>
</tr>
</tbody>
</table>
Frame grinding: Handling of difficult to process workpieces

- Stable processing of workpieces with a tape frame
  - Clamps the tape frame and secure it.
  - Measures the thickness of the workpiece and the chuck table with the 2-probe height gauge and control them with a high degree of thickness accuracy in real time.

- Efficiently eliminating processing heat and handling high load processing
  - SiC chuck table with high thermal conduction
  - Supply the coolant water to the inner part of the chuck table

Diagram of securing the tape frame

- Height gauge
- Workpiece thickness
- Porous vacuum absorption
- Processing heat ablation
- Coolant water supply
- SiC chuck table
- Difficult workpiece examples
  - Sapphire
  - SiC
  - Al₂O₃TiC (Altic)

*The inner and outer circumference heights of the chuck table are aligned by self-grinding, therefore the outer circumference of the chuck table will be the chuck table height.
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SiC dicing

- Technical difficulties for SiC blade dicing compared to Si

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<th>Mohs hardness</th>
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<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

- Ultrasonic-wave Processing (US)
  - Faster or better dicing quality
  - Fine cutting for ductile materials (Backside electrodes, TEG)
  - Upgradeable for current set up

- Stealth dicing (SD)
  - Dry process which requires no water cleaning
  - High throughput
  - Greatly contributes to street reduction
Ultrasonic-wave Dicing

High-speed oscillation of the blade improves self-sharpening and flow of cutting water

- Higher throughput
  - Higher feed speed
  - Less dressing frequency
- Higher processing quality
  - Less loading and glazing
  - Substantial reduction of blade breakage and wavy cutting

Mechanism

- U09 blade
- Non-contact power feeding unit
- Normal spindle
- Dedicated mount
- Vibration direction

Processing point

- Abrasive grain
- Workpiece feeding direction
### Ultrasonic-wave Dicing: High Throughput

Ultrasonic-wave processing enables increasing the feed speed without deteriorating the processing quality.

**Backside chipping**

<table>
<thead>
<tr>
<th>Cut speed</th>
<th>2 mm/sec</th>
<th>5 mm/sec</th>
<th>10 mm/sec</th>
<th>20 mm/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard Z</strong></td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td>Blade breakage</td>
</tr>
<tr>
<td><strong>Standard ZP07</strong></td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td>Blade breakage</td>
<td></td>
</tr>
<tr>
<td><strong>Ultrasonic-wave U09</strong></td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SiC Laser processing methods

Process overview

<table>
<thead>
<tr>
<th>Processing method</th>
<th>Stealth Dicing (SD)</th>
<th>Ablation Process</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Formation of a modified layer by focusing SD laser inside</td>
<td>Scribing</td>
<td>High quality processing with almost zero kerf width</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full Cut</td>
<td>High speed processing and die separation of thick wafers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Die separation with high throughput of thin wafers</td>
</tr>
</tbody>
</table>

- **Ablation Process**
  - **Scribing**: Grooving with short pulse laser
  - **Full Cut**: Die separation by short pulse laser alone
SiC dicing case study

Visual comparison

**US_1pass_10mm/s**

- t=110µm
- Metal on top

**SD_3pass_350mm/s**

- Metal on top

**US_1pass_10mm/s**

- t=350µm
- Metal on top

**SD_6pass_350mm/s**

- Metal on top
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**Dicing (Kiru)**  
*Precision cutting*

- Blade dicing  
- Laser dicing  
- Dicing before grinding (DBG)

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**Grinding (Kezuru)**  
*Ultra thin grinding*

- Back grinding  
- TAIKO grinding  
- Dicing before grinding (DBG)  
- Surface planarization

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**Polishing (Migaku)**  
*Stress relief*

- Dry polishing  
- Plasma etching  
- CMP
DISCO HI-TEC EUROPE in Munich provides you with various services, which are suitable for small to big volume production and R&D sample making.

- Blade dicing
- Stealth laser dicing (Ablation laser dicing is possible in Japan)
- Grinding, Surface planarization
- Stress relief (Dry Polish, Dry Etching)
- Optical inspection (2D, 3D)

400 m² clean room (Class 10,000)

DGS contact:
dgs@discoeurope.com
www.dicing-grinding.com
New clean room in Munich, Germany

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- 400 m² clean room (Class 10,000)
Please visit our booth #1208 in front of the main entrance

contactsales@discoeurope.com

www.disco.co.jp
www.dicing-grinding.com

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