3D-Micromac AG

Symposium on Smart Integrated Systems in Chemnitz
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<td>1</td>
<td>microDICE™ - TLS-Dicing for separation of SiC</td>
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<td>2</td>
<td>microPREP™ - for high-throughput microstructure diagnostics</td>
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<td>3</td>
<td>About 3D-Micromac AG</td>
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</table>
microDICE™ system

TLS-Dicing™ for separation of SiC wafers

Courtesy of Infineon AG
Current situation by using dicing saws

- **Cost**: High costs for saw blades, Reduced uptime
- **Quality**: Delamination of back-side metal, Defects by chipping
- **Speed**: 2-10 mm/s, Limited throughput
Our solution – TLS-Dicing™ with microDICE™ System

For excellent cleaving results and higher throughput
Your advantages using TLS-Dicing™ technology

- **Cost reduction**
  - Minimal CoO due to contactless processing
  - Increased yield by zero kerf

- **Function**
  - Back-side metal can be separated without delamination
  - Several wafer editable

- **Speed**
  - Dicing speed up to 300 mm/s
  - Higher throughput due the higher process speed
Advantages at a glance

- Free of residues
- Free of chipping
- Zero kerf
- Perfect sidewalls
microDICE™ system

- Up to 300 mm (12”) wafer size
- Integrated laser sources with long lifetime
- Integrated patented micro stretching function
- Automated wafer handling
- SECS / GEM interface
- Compatible with common SEMI standards
- Consumables: only DI-water
Summary

- Significant cost reduction
- Higher throughput
- Increased yield
- Damage-free back-side metal
Product roadmap TLS-Dicing 2014

<table>
<thead>
<tr>
<th>Quarter</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1/2014</td>
<td>Project Start</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tool-Spec / Design</td>
<td></td>
</tr>
<tr>
<td>Q3/2014</td>
<td>Product launch</td>
<td></td>
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<tr>
<td>Q4/2014</td>
<td>1st serial tool</td>
<td></td>
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<tr>
<td>Q1/2015</td>
<td>Customer evaluation</td>
<td>1st / 2nd / …installation @customer side</td>
</tr>
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<tr>
<td>Q3/2014</td>
<td>Semicon West</td>
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<tr>
<td>Q4/2014</td>
<td></td>
<td>TLS-Dicing™ for additional materials and applications</td>
</tr>
<tr>
<td>Q1/2015</td>
<td></td>
<td>TLS-Dicing™ with optimized yield</td>
</tr>
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</table>

Application is possible all time!
1. microDICE™ - TLS-Dicing for separation of SiC
2. microPREP™ - for high-throughput microstructure diagnostics
3. About 3D-Micromac AG
microPREP™

New vistas for targeted and high-throughput microstructure diagnostics
Transmission Electron Microscopy (TEM) – Classical ways

- Many ways to achieve electron transparency

- Grind up
- Tripod grinding
- Ultramicrotomy
- μCleave
- Ion beam etching
- Electrolytic etching
- FIB processing
One common way to achieve electron transparency - FIB

- Lamella preparation with a focused ion beam (FIB)

- FIB is a proven method, but the process is very complex
Expanding the opportunities by using laser

- Laser processing as a all-new instrument to achieve electron transparency

Diagram:
- Laser processing
  - Grind up
  - Tripod grinding
  - Ultramicrotomy
  - µCleave
  - Ion beam etching
  - Electrolytic etching
  - FIB processing

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Laser – Properties

- High power densities → Materials ablation
- Precise local delivery and focusing
- Just photons → clean in terms of contamination
- Low running costs
- High fluences → non-linear optics:
  Multi-photon absorption
  → Machining of transparent-at-the-wavelength materials feasible

Is structural damage an issue?
Laser – Induced Structural Damage? → **Controllable!**

- Silicon, laser machined with **ultrashort pulses**
- Recrystallization along flanks to a depth of 150 nm to 450 nm
- No significant changes to the bulk material beyond this depth detected (e.g., no dislocations, stacking faults etc.)
- Depth of the laser kerf > 15 µm
Motivation using laser for TEM

- Very high ablation rates using FIB-technology not achievable

<table>
<thead>
<tr>
<th>Method</th>
<th>FIB (Ga⁺)</th>
<th>High-Current FIB</th>
<th>FIB plus GIS</th>
<th>Plasma FIB (Xe⁺)</th>
<th>355-nm DPSS Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling rate of silicon [µm³/s]</td>
<td>2.7</td>
<td>30</td>
<td>250</td>
<td>2 000</td>
<td>1 000 000</td>
</tr>
<tr>
<td>Time needed to remove 0.3 mm³</td>
<td>3.5 years</td>
<td>116 days</td>
<td>14 days</td>
<td>1.7 days</td>
<td>5 min</td>
</tr>
<tr>
<td>Spot diameter (theory)</td>
<td>ca. 20 nm (@ 100 pA)</td>
<td></td>
<td></td>
<td>ca. 200 nm (@ 100 pA)</td>
<td>500 nm</td>
</tr>
<tr>
<td>Structural-damage depth [nm]</td>
<td>2-20 nm</td>
<td></td>
<td></td>
<td>2-20 nm</td>
<td>&lt; 2 ... 4 µm</td>
</tr>
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</table>

microPREP™ – Process Flow

**Step 1**
Plane-parallel thinning to 100-150 µm

**Step 2**
Assembling the plate on a flat mount

**Step 3**
Laser cutting of the base structure

**Step 4**
Transferring base structure to a dedicated clamping jig

**Step 5**
Local laser thinning of preselected areas

**Step 6**
Final thinning with Ar+ ion broad beam or FIB

Follow-up step
microPREP™ – Process Flow

- Steps 1 & 2 – Providing a plane-parallel plate and firmly fixing it to a jig

Parts of the jig
microPREP™ – Process Flow

- Step 3 – Laser cutting of the supporting base structure

Examples of base structures

Cutted base structure
microPREP™ – Process Flow

- Step 3 – Laser cutting of the supporting base structure

As-cut flank in silicon

Tomographic basic structure laser-machined into silicon
Step 4 – Transferring the supporting base structure to a dedicated clamping jig

Clamping jig

Basic structure fixed by the jig
**microPREP™ – Process Flow**

- **Step 5** – Local laser thinning of preselected areas (high-throughput screening)

![Local thinning in a box-like manner](image)

![Local thinning of multiple probing positions](image)

![Automated preparation of a pillar array](image)
Step 5 – Local laser thinning of preselected areas (high-throughput screening)

- Smooth flanks

Local thinning in an open-box manner in copper

Local thinning in an open-box manner in silicon
microPREP™ – Process Flow

- Step 6 – Final thinning with Ar⁺ broad beam or FIB (TSV’s)
microPREP™ – Process Flow

- Application for 3D-integrated Structures (TSV’s)
Key features – microPREP™

- **Machine:**
  - Use of ultra-short pulse laser
  - High target position accuracy (± 3 μm)
  - User friendly control software including recipes

- **Process:**
  - No sample drift due to charging
  - Rugged support structure allows easy sample handling
  - Suited for metals, semiconductors, ceramics, and compounds
  - Multiple probing positions

microPREP™ - Stand-alone version
Summary – microPREP™

- Low manpower requirement
- Risk minimization of sample lost
- Preparation quality less dependent on user skills
- Simple (machine-guided) usage
- High utilization of (TEM) analysing tool
- Reduces FIB capacity requirements

High preparation quality in a fast time for lower cost per sample!
microPREP™ - A machine for more than one application

- TEM: Source: FEI
- TKD: Source: Bruker
- X-CT: Source: Zeiss
- LEAP: Source: Cameca
- μ-mechanics: Source: Keysight
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First Choice in microMachining
3D-Micromac - At a Glance

- Manufacturer and service provider of
  - Laser micromachining systems and
  - Equipment for printing and coating technologies
- Design of complete machining systems as stand alone devices, integrated modules and entire production lines
- Evaluation of processes, feasibility studies, development of technologies and machine solution on customer’s demand
- Founded in 2002
Company Headquarter

3D-Micromac AG
Chemnitz, Germany

- Production area: 3 production halls with 4450 m²
3D-Micromac’s Portfolio

- Laser micromachining systems for R&D purposes
- Laser systems for machining of large panels
- Production equipment for laser machining tasks
- Roll to roll system for machining of flexible substrates
Branch Solutions – Example Systems

**Ophthalmic marking systems**
- Laser systems for engraving of eye glasses or contact lenses
- Digital printing machines for non-permanent marking of eye glasses

**Equipment for SEMI/MEMS**
- Fab equipment
- Manufacturing of inkjet nozzles
- Lab equipment
- TLS-Dicing
- Sample preparation for microstructure diagnostics

**Fab equipment PV**
- On-the-fly laser processing of silicon solar cells, e.g. PERC solar cells, selective-emitter, LFC, MWT, and EWT cells

**Medical device technology**
- Manufacturing systems for welding of implants
- Machining in highly purified environment incl. process monitoring
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