Innovative Laser Processing Technologies

Reinhard Ferstl
Director Sales & Marketing EMEA / Asia
Corning Laser Technologies

September 21, 2016
## Corning Market Segments and Additional Operations

<table>
<thead>
<tr>
<th>Display Technology</th>
<th>Optical Communications</th>
<th>Environmental Technologies</th>
<th>Life Sciences</th>
<th>Specialty Materials</th>
<th>Other Products and Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCD Glass Substrates</td>
<td>Optical Fiber and Cable</td>
<td>Emissions Control Products</td>
<td>Cell Culture and Bioprocess</td>
<td>Corning® Gorilla® Glass</td>
<td>Emerging Innovations</td>
</tr>
<tr>
<td>Glass Substrates for OLED and high-performance LCD platforms</td>
<td>Optical Connectivity Solutions</td>
<td>Light-duty gasoline vehicles</td>
<td>Display Optics and Components</td>
<td>Display Optics and Components</td>
<td>Equity Companies</td>
</tr>
<tr>
<td>Optical Cables for Consumer Networks</td>
<td>Heavy-duty non-road diesel vehicles</td>
<td>Genomics</td>
<td>Optical Systems</td>
<td>Optical Systems</td>
<td>– Eurokera, S.N.C.</td>
</tr>
<tr>
<td>Copper Connectivity Components</td>
<td>Stationary</td>
<td>Chemistry</td>
<td>Corning Laser Technologies</td>
<td>Corning Laser Technologies</td>
<td>– Samsung Corning Advanced Glass, LLC (SCG)</td>
</tr>
</tbody>
</table>
Corning Laser Technologies

- **Corning Laser Technologies GmbH**
  - CLT combines over 20-years’ experience in designing laser-based machine tools with Corning Incorporated’s deep understanding of material science.
  - In 2002 CLT began creating precision tools for the production of photovoltaic panels, and extended its market reach to include semiconductors, electronics, and precision engineering.
  - In 2012 the focus shifted to glass cutting with CLT developing novel laser cutting technologies as well as complete processing systems for flat glass panel processing, including full automation for 24/7 high volume manufacturing.

- **Corning Laser Technologies today**
  - A highly dedicated and motivated team based in Krailling near Munich, Germany.
  - CLT offers a robust portfolio of glass cutting and finishing technologies to meet growing market demands for specialty glass. Its laser technology can provide effective, low-cost, high-quality cutting solutions.
CLT’s Core Technology Capabilities

- Laser Process Development
- Electrical Design & Engineering
- Mechanical Design & Engineering
- In-House Software Development incl. Machine Vision

Link to all other Corning® Businesses & their know-how

CLT Core Capabilities

- Global Service Organization
- Scalable Manufacturing incl. Supply Chain
- CIM / MES Integration
- Industrialization of Laser Processes

... and the ability to integrate them

CLT 45G NX
Broad Experience in Various Applications

- Laser Glass Cutting
  - non-ablative nanoPerforation
  - ablative ablation by vaporization

- Selective Ablation of Various Thin Films
  - μ-seconds and picoseconds laser pulses
  - wavelength ranging from 355 – 10600 [nm]

- Laser Drilling
  - vias, blind holes, slots etc.

- Micro Materials Processing
  - cutting, drilling, structuring, welding
  - laser marking / identification (DMC, OCR)
  - processing
    - thin-film, ceramics
    - semi-conductor materials, OLED, PET
    - metals and non-metals
Developing Industrial Laser Solutions

- **Understand Laser-Material Interactions**
  - Corning material science, modeling capabilities & manufacturing
    - World-class glass & ceramics products & process know-how
  - research / applications / metrology

- **Application Specific Laser Selection**
  - using state of the art Lasers
  - wide range of laser types to choose from
  - understand and control of laser parameters / recipes

- **Process Control Expertise**
  - process capabilities
  - process window, to enable 24/7 high volume production
  - process monitoring (calibration routines, intelligent sensors etc.)

- **Build Industrial Solutions**
  - highly stable and reliable machine design proven in HVM
  - heavy duty components built in
  - highest quality optical components (special coatings, tight tolerances)
  - software + controls (PLC, in-house software development MES /CIM)

- **Customized Automation**
  - dedicated substrate / parts handling (loading / unloading)
  - automation concepts for optimized yield and throughput
Glass Cutting Technology

**Corning® nanoPerforation Glass Cutting**

- A specially tuned laser is used to perforate brittle material
- The process separates the glass substrate all the way through the entire thickness, applying a novel single pass process.
- Result: High Cut Quality
  - Near net-shape cutting
  - No taper
  - Minimal particle generation
  - Pristine edge quality
  - Minimal surface roughness
  - Highest uniformity
Glass Cutting Technology

**Glass Cutting Performance**

- **Material**
  - Corning® Gorilla® Glass (strengthened / un-strengthened)
  - Corning® EagleXG®, Lotus NXT®, ultra-thin glass
  - High index glass
  - Soda lime glass
  - Sapphire

- **Cutting shapes**
  - High speed cutting of outline contours
  - Straight line cutting up to 1m/s
  - Automatic / touch-free separation process on many materials
  - Cut-outs, holes, home buttons, slots

**Glass Cutting - Customer Benefits**

- Low cost-of-ownership (requires no fluids, no consumables)
- Minimum to no debris generation
- Cutting of functional multi-layer-stacks
- Cutting of pre-coated substrates
- High throughput and high yield
Glass Cutting Edge Roughness Profile

- "as cut" edge roughness less than +/- 1.5 µm (no post process applied)
- "as cut" bending strength high compared to competing technologies
- less post processing required
Glass Cutting Technology

Glass Cutting of Inner Contours (Holes, Slots etc.)

- Cutting of inner contours (e.g. holes / slots)
- Fast cutting speed and minimum rework required
Glass Cutting Technology

**Multi-sheet & Laminates Cutting**

Cutting of assembled glass stacks

- Edge trimming of display panels
- Free form panel cutting
- Cutting of thin panels (single glass thickness < 0.3mm)
Glass Cutting Technology

**Corning® Ablative Glass Cutting**

- A specially tuned nanoseconds laser at 532nm allows for a very precise focus and leads to non linear absorption of the laser light
- Partially vaporization of glass; small particles excavated due to formed vapor pressure
- Minimal thermal impact due to very short nanoseconds laser pulses

Pros and Cons compared to Corning’s nanoPerforation process

+ Complex geometries can be cut
+ Enables blind hole cutting
- Challenge to cut strengthened glass at higher CT levels
- Longer process times
- Higher surface roughness
- Generation of particles, due to ablation of material
Glass Cutting Technology

Combining the Glass Cutting Technologies

- Combining high speed Corning® nanoPerforation glass cutting with Corning’s ablative glass cutting process
- Enabling high speed outline contour cutting in combination with complex inner contour cutting

Glass Substrate >> Corning® nanoPerforation Process

Blind Hole >> Corning® Ablative Process

Glass Substrate >> Corning® Ablative Process
Glass Cutting Technology

Automobile Interior Applications

Enabling introduction of complex glass parts to automobile interior

- Cutting of value added glass
- High value glass parts with touch functionality, decorative surfaces and complex shapes to be manufactured
- Freedom for future designs, flexible and clean processes are enabling new design solution
- Combination with holes and slot cutting

Laser cutting advantages

- Potential to eliminate or reduce post processes cost, such as for edge finishing
- Cycle time reduction
- Significant yield improvement

Laser processing is an enabling technology
Glass Cutting Technology

Automobile Exterior and Glazing Applications

Enabling light weight glazing for better fuel economy and CO2 emissions

- Corning® Gorilla® Glass glazing is:
  - Strong
  - Thin
  - Lightweight
- 30% lighter & 25% thinner than conventional soda-lime

Laser cutting advantages

- Potential to eliminate or reduce post processes cost, such as for edge finishing
- Cycle time reduction
- Glass utilization improved

Laser cutting enables lower cost Gorilla Glass processing
Systems - Made for 24/7 Manufacturing

**Industrial Solutions**

- Optimized for high volume manufacturing in 24/7
- High degree of factory integration through MES /CIM (SECS GEM Standard)
- Fully automated to customer needs, stand alone or inline concepts
  - Loading substrate
  - Unloading single parts
  - Scrap material management
- Heavy duty machine components
- High dimensional accuracy, using sophisticated machine vision
- Maximized yields
- Maintenance friendly
- World wide field service and applications support
Production Tool Platforms

500X Platform
- Smaller Devices / R&D
- Full-size Gen2 sheets 370x470 [mm]
- Round wafers up to 12”
- 2-direction straight-line and contour cuts

45G NX Platform
- 45G NX Platform
- Full-size Gen4.5 sheets 730x920 [mm]
- 2-direction straight-line and contour cuts

60G / 80G Platform
- High Volume Production Tool
- Full-size Gen6 1500x1850 [mm] sheets
- Full-size Gen8 2250x2500 [mm] sheets
- Straight-line down-sizing of full-size Gen6/8 sheets and edge trimming
- 2-direction straight-line and contour cuts

All machine platforms are proven in 24/7 production and can be fully automated
Near-net-shape cut parts at high accuracies
For more information on Corning Laser Technologies, please visit our website!

www.corning.com/lasertechnologies