Innovative Laserverfahren für das Schneiden, Bohren und Strukturieren von transparenten und spröden Materialien

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ROFIN Group
Key Facts

- Headquartered in Plymouth, Michigan (USA) and Hamburg (Germany)
- Sales: FY 2014: $ 530.1 million
- Worldwide > 2,300 employees
  Thereof approx. 140 sales engineers and 400 customer service personnel
- 22 production facilities in North America, Europe and Asia
- Customer service support in more than 50 countries
- Regional service experts and specialized sales engineers
The ROFIN Brand
Technologies & Markets

Technologies

**Gas lasers:**
- CO₂ lasers

**Fiber lasers:**
- CW and pulsed lasers
- Ultrashort pulse lasers

**Solid-state lasers:**
- Lamp- and diode-pumped lasers
- Ultrashort pulse lasers

**Semiconductor lasers:**
- Diode lasers by DILAS

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Laser processing of „transparent“ materials

- Ways to make the impossible possible:
  - Overcome transparency
  - To make a lot out of little
  - Melt your way through
  - Exceed thresholds
  - At the end it’s like lightning
Overcome transparency

- Use the right wavelength: **Thermal laser separation** using CO₂-lasers

Sealed-Off Lasers
100 - 600 W

Diffusion-Cooled CO₂ Lasers
1,000 – 8,000 W

To make a lot out of little

- **Multi laser-beam absorption**
  MLBA glass cutting (Rofin patented process)

Thermally Induced Cracking

- Heating
- Cooling

Tensile Stress
Compressive Stress

Fiber Lasers up to 6,000 W
Diode lasers up to 3,000 W
**Multi laser-beam absorption of solid state lasers**

**MLBA** glass cutting (Rofin patented process)

- **Fiber Lasers** up to 6,000 W
- **Diode lasers** up to 3,000 W

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**Multi laser-beam absorption of solid state lasers**

**MLBA** glass cutting

- **MLBA**: cw-IR-lasers
- Cutting speed > 20mm/s
- No burr, no splatter, no hipping
- Perfect Edge quality
- Perfect bending strength
- Challenge: cut position tolerance

- **Ultrashort pulsed lasers** up to 6 - 50 W
  - 0.55 mm chemically strengthened glass
  - Separation speed 100 mm/s
  - Challenge: contour cuts
**SmartCut™FC**
Fusion cutting of **sapphire** using pulsed fiber lasers

Excellent cutting quality in polished and unpolished material.
- Minimum cracks
- Minimum chipping
- $Ra \approx 0.8 – 1.5 \ \mu m$
- No burr on surface
- No taper

Melt your way through
Melt your way through

- **SmartCut™ FC**
  - Chamfer cutting of sapphire using pulsed fiber lasers
  - Very smooth surface
  - Feed rates >> cutting
  - Chamfer down to < 200 μm
  - Minimum chipping
  - $Ra \approx 0.8 - 1.5 \mu m$

Exceed thresholds

- Non-linear absorption
  - **Surface, bottom-up** or **inside scribing**
  - using short and ultrashort lasers

  - Ultrashort pulsed laser structuring and drilling of sapphire and glass
  - Ablation Rate @ 10 W: 3 – 4 mm³/min
  - No chipping
Exceed thresholds

- Non-linear absorption
  Surface, bottom-up or inside scribing or drilling
  using short and ultrashort lasers

  Scribe/Break: engraving of glass with ultrashort pulsed lasers, typical scribing speeds 10 – 50 mm/s

  CoreScribe™ (patented technology): 140μm thick sapphire wafer dicing with processing speeds up to 900 mm/s

  Bottom-up processing with ns-SHG and ps-SHG lasers, typical cutting speeds thickness dependent 1-10 mm/s

At the end it’s like lightning

- The laser that can make it rain:
  Researchers unveil radical system to start storms and create lightning

Researchers at the UCF and the U of A developed a new technique to aim a high-energy laser beam into clouds to make it rain or trigger lightning. Lasers can already travel great distances but “when a laser beam becomes intense enough, it behaves differently than usual – it collapses inward on itself”. At that point, the plasma immediately tries to spread the beam back out, causing a struggle between the spreading and collapsing of an ultra-short laser pulse. This struggle is called filamentation, and creates a filament or ‘light string’.

Filamentation vs. Ablation

Fusion Cutting
Ablation

CoreScribe™
Inside Scribing

ROFIN SmartCleave™ FI
filamentation

- Acquisition of Filaser Inc. assets in May 2014, inventor Dr. Abbas Hosseini now with Rofin
- IP-protected filamentation technology owned by Rofin
- 300 -1000 mm/s cutting speed single pass
- Straight, curved, angled and chamfer cut
- Glass thickness range 0.1 mm to 10 mm
- Kerfless separation process
- Chemically strengthened & tempered glass
- Glass, sapphire, crystals, ceramics etc.
- Cutting of tubular or curved parts
- Material is either separating automatically or can easily be separated by low mechanical or thermal force
ROFIN’s new ultrashort pulse lasers

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<th>Parameter</th>
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<th>StarPico</th>
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<tbody>
<tr>
<td>Wavelength</td>
<td>1030 nm</td>
<td>1064 nm</td>
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<tr>
<td>Average Power (after PoD)</td>
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<td>Max. Pulse Energy (after PoD)</td>
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<td>Pulse Width FWHM</td>
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<td>Single Pulse Selection up to</td>
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<tr>
<td>Max. Repetition Rate / 30 MHz</td>
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<tr>
<td>Pulse Peak Power [MW]</td>
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<td>&lt; 1,3</td>
<td>&lt; 1,4</td>
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</table>

Ultrashort laser processing with burst mode

- Strongly increasing removal rates
- Also allows new, non-ablative processes (e.g. filamentation)
- Exclusively licensed from University of Toronto
A huge variety of applications

Quelle: Internet

SmartCleave™FI technology

- Cuts with excellent surface quality

Ra < 0.5 µm

Ultrashort pulsed lasers up to 6 - 50 W
SmartCleave™FI technology

- Straight cuts with excellent surface quality

Ultrashort pulsed lasers up to 6 - 50 W

SmartCleave™FI technology

- The master piece: high speed production of closed (inner) contours

3 x 12 mm² slot in 0.55 mm thick non-strengthened alumino-silicate glass, \( v = 100 \text{ mm/s} \)

2 mm dia. hole in 0.55 mm thick chem. strengthened alumino-silicate glass, \( v = 100 \text{ mm/s} \)

Ultrashort pulsed lasers up to 6 - 50 W
System integration of SmartCleave™ process

Dedicated solutions:

- MPS Turnkey workstation
- SmartCleave™ Integration package

Summary

- There are multiple ways for laser processing of transparent materials, so far a single technology cannot cover all the requirements regarding material composition, speed, accuracy, quality, manufacturing task, ...
- Rofin has got a strong laser portfolio to cover all the needs of the markets for transparent and brittle materials, including dedicated high-power ultrashort pulsed lasers
- Rofin’s IP protected filamentation cutting technology (SmartCleave™FI) offers a great potential to substitute conventional processes in a wide range of applications of the consumer electronics, architectural, automotive, medical device or watch industry and many others
Thank you very much for your kind attention!

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