Laser Vision Correction with the All-Solid-State deep UV Laser LaserSoft: Clinical Results

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ITALY

Solid-State UV Laser for Refractive Surgery

- Lasersoft (Katana Technologies GmbH, Germany)
- cw-diode-pumped all-solid-state UV laser
- laser radiation wavelength: 210 nm
- high shot-to-shot stability
- high long-term UV output stability
## Excimer vs. Solid-State

<table>
<thead>
<tr>
<th>Excimer Laser</th>
<th>Katana LASERSOFT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spot Size</strong></td>
<td></td>
</tr>
<tr>
<td>0.8-1mm</td>
<td>0.2 mm</td>
</tr>
<tr>
<td><strong>Beam Quality</strong></td>
<td></td>
</tr>
<tr>
<td>Multimode</td>
<td>Single mode (gauss.)</td>
</tr>
<tr>
<td>(Additional optics for cleaning the Excimer beam)</td>
<td>Smooth surface</td>
</tr>
<tr>
<td><strong>Repetition Rate</strong></td>
<td></td>
</tr>
<tr>
<td>50Hz-500 Hz</td>
<td>1 kHz</td>
</tr>
<tr>
<td><strong>Eye Tracking Speed</strong></td>
<td></td>
</tr>
<tr>
<td>approximately 150Hz</td>
<td>&gt;1 kHz</td>
</tr>
</tbody>
</table>

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## Why a solid-state laser?

**Laser characteristics**

**Solid-state laser crystals used as laser medium**
- Inexpensive to operate - no gas (Excimer)
- Highly stable, long lifetime

**Diode-pumping provides high efficiency**
- cw pumping, high shot-to-shot and long term stability
- Stable energy (fluence) and beam aiming (more precise rate of abl.)
- True all-solid-state approach

**High repetition rates: 1 kHz (1000 s\(^{-1}\)) or more**
- No high voltage gas discharge involved (Excimer)
- Less energy per pulse
- Less shock waves
**Why a solid-state laser?**

*Beam Characteristics*

**Small spot size without additional beam-forming optics**
- Accurate overlap of true Gaussian spots
- Very small spot size allows correction of corneal microirregularities, and thus reduction of high order aberrations
- Very homogeneous corneal surface
- Important for customized ablation
- Lower energy per pulse than in standard excimer treatments

**Flying Spot Beam Size Comparison**

<table>
<thead>
<tr>
<th>LaserSoft</th>
<th>New Excimer lasers</th>
<th>Old Excimer lasers</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
</tbody>
</table>
Flying Spot Beam Size Comparison

0.2 mm          0.750 mm

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Lasersoft and Custom Ablation

Very small spot size fits nowadays requirements for effective custom ablation

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Why a solid-state laser?

Gaussian Beam Profile

- Laser shot has a gaussian profile
- A proper overlap between shots with a gaussian profile generates a very smooth surface of treated cornea.

Why an excimer laser cannot achieve a very small size flying spot?

- Laser itself generates very inhomogenous spatially broad laser beam distribution with hot spot in the beam
- This comes from the way the excimer laser beam is generated in the gas discharge
Why an excimer laser cannot achieve a very small size flying spot?

• To generate a small spot you have to put an extra optical element in the beam pass to filtering the central part out
• This throws away a lot of energy
• This filtering process tries to achieve a gaussian beam distribution
• The additional filters are expensive and need to be replaced regularly

Why an excimer laser cannot achieve a very small size flying spot?

• You cannot filter out the hot spots because they are distributed statistically at different places for each shot of the laser
• You shape the beam in the right way in general
• The hot spots are the reasons for ablations problems because they ablate additional corneal material in an unpredictable statistical way
Why a solid-state laser can achieve a very small size flying spot?

• Laser itself generates a gaussian fundamental beam mode
• Not necessary to put additional optics for filtering the light
• You have the opportunity to transmit less energy on the cornea

Why a solid-state laser?

*Beam Characteristics*

**Excellent (Gaussian) beam spot distribution**
- High quality of the ablated surface

**Highly collimated beam**
- Fast scanning, no highly accurate focusing necessary, increased beam precision

Diode Solid-State Laser are excellent candidates for true scanning small spot lasers
**Smaller transition zone**

LaserSoft’s beam means true optical and well-defined tissue-saving transition zone

- Smaller transition zone
  - LaserSoft’s beam means true optical and well-defined tissue-saving transition zone

**Solid-State UV Laser**

**Ablation Algorithm**

- Ablation profiles designed to preserve the strongly aspherical feature of normal cornea
- Minimal induction of spherical aberration
- Optimized to allow better stability of fluency even on peripheral cornea (more spots)

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Better Performance in Hyperopic Eyes with LaserSoft

- pre-op. corneal shape
- post-op. corneal shape

LaserSoft

Excimer Laser

Why a solid-state laser?

Eye Tracker

- eye-tracker latency: 1 ms
- monitoring centration of ablation with very high repetition rate
- Acting on the x-y axes as well as well as on ocular rotation.

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Ablation Not Influenced by H_2O or BSS
(experimental results)

Why a solid-state laser?

Stability and Longevity

- surgical performance with reduced variability
- fluence stability unrelated to wearing out of gas
- no gas exchange / discharge
- solid-state UV laser and diode pumping system mean long lifetime and efficiency
- reduced maintenance costs

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Why a solid-state laser?

**Patient Comfort**

- high repetition rate (1kHz)
- ablation with significantly reduced stress waves
- ablation or laser firing generates no audible sound
- treatment in a silent, patient-reassuring environment
  - no sudden patient movement as laser starts

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**Solid-State UV Laser**

**Clinical Data**

- 37 eyes
- age: mean 38 (from 18 to 60)
- sex: female 21 eyes  
  male 16 eyes
- eye: left 18 eyes  
  right 19 eyes

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**Solid-State UV Laser**

**Preoperative Refraction**  
(mean ± SD)

- **SE**: mean -1.71 D ± 3.71 D  
  (from -8.00 to 6.75)

- **Sphere**: mean -1.46 D ± 3.32 D  
  (from -8.00 to 6.00)

- **Cylinder**: mean -0.51 D ± 1.97 D  
  (from -3.75 to 6.50)

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**Solid-State UV Laser**

**Postoperative Refraction - Six Month**  
(follow-up rate 81.1 %, 30 eyes)

- **SE**: mean -0.04 D ± 0.26 D  
  (from -0.50 to 0.75)

- **Sphere**: mean -0.01 D ± 0.21 D  
  (from -0.25 to 0.75)

- **Cylinder**: mean -0.07 D ± 0.28 D  
  (from -1.00 to 0.50)

**Attempted vs Obtained, SE:**  
-0.04 D ± 0.26 D

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Refractive Stability

STABILITY: Achieved Change in Refr. over Time

6-Month Refraction, SE
Attempted vs. Obtained

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Refraction, SE
% within attempted correction
six months follow-up - LASIK

Refraction, SE
% within attempted correction
one year follow-up

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**Solid-State UV Laser**

Applying less energy to the cornea, using a small flying spot of 0.2 mm this solid-state UV laser appears as an effective solution for refractive surgery. A more homogeneous treatment has the potential of inducing less scarring.

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**Lasersoft - Conclusions**

A safe, reliable, stable, more compact, and less costly alternative to gas-operating excimer lasers for refractive surgery

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