High-Energy Picosecond Laser Systems between 10 Hz and 2 kHz for Next-Generation Laser Ranging

M. Schmidt\textsuperscript{1}, N. Graf\textsuperscript{2}, H. Huber\textsuperscript{1}, R. Kelnberger\textsuperscript{2}, J. Aus der Au\textsuperscript{1}

1. High Q Laser Innovation GmbH, Feldgut 9, 6830 Rankweil, Austria
2. InnoLas Laser GmbH, Justus-von-Liebig-Ring 8, 82152 Krailling, Germany

17. SLR Workshop
16.-20. May 2011
Outline

- Introduction
- High Q Laser/Innolas Cooperation
- System Design
- Performance Data
  - ... picoREGEN™
  - ... Spitlight PICO
- Summary
Introduction

- Application of high-energy picosecond laser systems is well established in satellite geodesy.
- Different applications in satellite geodesy require a different set of laser parameters (repetition rate, energy).
- High Q Laser - in collaboration with Innolas - offers a wide range of laser systems to cover the needs of the SLR community.
High Q Laser/Innolas Co-operation

- >11 years of experience in the development of picosecond and femtosecond laser systems
- >6 years of experience in OEM production of compact laser systems
- well-known partner in the SLR community
High Q Laser GmbH: Rankweil in Austria
New Production Facility

since Summer 2009

~ 900 m² Clean Room Space (Production and R&D)
~ 700 m² Office Space

Ready for further expansion
High Q Laser/Innolas Co-operation

- >11 years of experience in the development of picosecond and femtosecond laser systems
- >6 years of experience in OEM production of compact laser systems
- well-known partner in the SLR community

&

- >16 years of experience in the development of nanosecond high-energy laser systems
- >15 years of experience in the industrial market
InnoLas Laser GmbH: Krailing in Germany
InnoLas Laser GmbH

since 1995

1973  JK Laser Ltd. was founded in Rugby, England

1981  Lumonics Inc. (Canada) purchased JK Lasers

1997  InnoLas purchased the manufacturing rights for Lumonics scientific Lasers
High Q Laser/Innolas Co-operation

- >11 years of experience in the development of **picosecond** and femtosecond laser systems
- >6 years of experience in OEM production of compact laser systems
- well-known partner in the community

&

- >16 years of experience in the development of nanosecond **high-energy** laser systems
- >15 years of experience in the industrial market

---

**PICOSECOND HIGH-ENERGY Laser Systems**
System Design
picoREGEN™ HE Overview
picoREGEN™ HE Overview
### picoREGEN™ HE Results

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Repetition Rate</th>
<th>Pulse Energy</th>
<th>Power</th>
<th>Beam Circularity</th>
<th>M²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kHz</td>
<td>1 kHz</td>
<td>3.2 mJ</td>
<td>3.2 W</td>
<td>91.8%</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td>10 Hz</td>
<td>10 Hz</td>
<td>3.2 mJ</td>
<td>32 mW</td>
<td>96.9%</td>
<td>&lt;1.3</td>
</tr>
</tbody>
</table>
**picoREGEN™ HE Results II**

**1064-nm**

- **Pulse Energy:** 3.3 mJ
- **Repetition Rate:** 1 kHz
- **Long-Term Stability:** 0.34% RMS

**532-nm**

- **Pulse Energy:** 1.7 mJ
- **Repetition Rate:** 1 kHz
- **Long-Term Stability:** 0.29% RMS
Low-Rep. Rate Post Amp: *Spitlight PICO*

- **1000 Hz** (residual)
- **1000 Hz**
- **1-10 Hz**

1-10 Hz to INNOLAS Post Amplifier

- **3 mJ @ 1–10 Hz**

- **1 J @ 1–10 Hz**

- Innolas Spitlight PICO Post Amplifier
Low-Rep. Rate Post Amp: *Spitlight PICO*

Repetition Rates: 1-10 Hz
Flash-Lamp pumped

- 2 Pump Chambers:
  - First chamber consists of 3 Nd:YAG laser rods pumped by 1 flash lamp
  - Second chamber consists of 1 large Nd:YAG laser rod pumped by 2 flash lamps

Total Amplification:
Low-Rep. Rate Post Amp: *Spitlight PICO*

### Flash Lamp Pumped Version

**Specifications**

- RepRate up to 20Hz
- Energy up to 1J

**Measured Data at 1J 10 Hz 1064nm 500ps**

- Beam Quality: $M^2 = 1.8$
- Pointing stability: $D = 12.5 \, \mu \text{rad}$
- Energy Stability: RMS = 0.9%
Flash Lamp Pumped Version

Profile 160mJ Nearfield  Profile 1J Nearfield  Profile 1J Beam Waist 1m Lens
**picoREGEN™ / Spotlight PICO: Results II**

**Diagram of Energy Stability**

- **Repetition Rate:** 10 Hz
- **Pulse Energy:** 1000 mJ
- **Energy Stability:** 0.9% RMS

15 minutes
### Specification Summary: Low-Rep Rate

**Repetition Rates: 1-10 Hz**  
Flash-Lamp pumped

<table>
<thead>
<tr>
<th>#Nd:YAG Laser Rods</th>
<th>Pulse Duration [ps]</th>
<th>Pulse Energy @ 1064-nm [mJ]</th>
<th>Pulse Energy @ 532-nm [mJ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>&gt;250 ps</td>
<td>90</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>&gt;250 ps</td>
<td>250</td>
<td>125</td>
</tr>
<tr>
<td>5</td>
<td>&gt;250 ps</td>
<td>1000</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>~10 ps</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>~10 ps</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>~10 ps</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>
2 Pump Chambers:
- Each with 1 single Nd:YAG laser rod
- Each pumped by 3 laser diodes
High-Rep. Rate Post Amp: *Spitlight PICO*

**Diode Pumped Version**

**Specification example 100Hz, 250ps**

Energy up to 30mJ @ 1064nm
               15mJ @ 532nm

**Specification example 100Hz, 8ps**

Energy up to 25mJ @ 1064nm
               13mJ @ 532nm

**Specification example 1kHz, 8ps**

Energy up to 12mJ @ 1064nm
               6mJ @ 532nm
Summary

- >3 mJ @ 1064-nm, 1-1000 Hz, ~10 ps
- >1.5 mJ @ 532-nm, 1-1000 Hz, ~10 ps
- >1.5 mJ @ 1064-nm, up to 2 kHz, ~10 ps
- >0.75 mJ @ 532-nm, up to 2 kHz, ~10 ps
- up to 1 Joule @ 1064-nm and 10 Hz available
- up to 12 mJ @ 1064-nm and 100-1000 Hz available
- Green conversion efficiency: >50%
For Questions…

…please do not hesitate to contact our sales team:

**Alex Lang**  
E sales@highQ-us.com  
T +1 (617) 924 1441

**US subsidiary**  
High Q Laser (US), Inc.  
118 Waltham Street  
Watertown, MA 02472 / USA

**Heinz Huber**  
E sales@highQlaser.at  
T +43 5522 82 646 148

**Headquarters**  
High Q Laser Innovation GmbH  
Feldgut 9  
A-6830 Rankweil / Austria

High Q Laser & InnoLas – your partners for high-energy ps laser ranging systems