PIV Laser Product Platform

Cutting Edge Optronics
Cutting Edge Optronics manufactures an all diode-pumped scalable family of lasers specifically designed for particle image velocimetry applications. Within the Patara-HP™ laser system platform, CEO offers five laser models that output dual oscillator single coaxial beams ranging from 2mJ – 50mJ energy per pulse (per oscillator) over a repetition rate range of single shot to 30 kHz.

<table>
<thead>
<tr>
<th>Model</th>
<th>Output / Pump</th>
<th>Rep Rate</th>
<th>Gain Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA-100-QMG-PIV</td>
<td>100 W / CW</td>
<td>10 kHz</td>
<td>Nd:YAG</td>
</tr>
<tr>
<td>PA-200-QMG-PIV</td>
<td>200 W / CW</td>
<td>10 kHz</td>
<td>Nd:YAG</td>
</tr>
<tr>
<td>PA-030-QMGF-PIV</td>
<td>30 mJ / CW</td>
<td>1 kHz</td>
<td>Nd:YLF</td>
</tr>
<tr>
<td>PA-040-QMGF-PIV</td>
<td>40 mJ / CW</td>
<td>1 kHz</td>
<td>Nd:YLF</td>
</tr>
<tr>
<td>PA-050-QMGF-PIV</td>
<td>50 mJ / QCW</td>
<td>1 kHz</td>
<td>Nd:YLF</td>
</tr>
</tbody>
</table>
PIV Laser Requirements

- Tracking high speed particles requires short exposure time and sufficient illuminating laser light for the camera.
  - Lasers with short pulse width and high pulse energy are preferred.
  - For high speed PIV applications, high frequency lasers are required.

- PIV measurements rely on precise timing of the illumination laser sources.
  - Low jitter of each laser is required.
  - Matching beam quality and divergence angle between the two lasers creates optimal overlap in space.
PA-050-QMGF-PIV Oscillator Performance Data
50mJ / 527nm @ 1kHz

Long Term Power Stability at 1 KHz, 527 nm

88 Hour Power Stability

Beam Profile @ Output Window
Beam Profile @ Beam Waist (Far Field)

Jitter
< 10ns Specified
< 4ns Measured

Pulse Width
< 150ns Specified
< 120ns Measured

PIV Platform
Pulse Energy (per Oscillator) vs. Repetition Rate

Single Shot to 5 kHz Available

Repetition Rate (kHz)

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PA-100-QMG-PIV Oscillator Performance Data
100W / 532nm @ 10kHz

75 Hour Power Stability

Pulse Width
< 150ns Specified
< 100ns Measured

Jitter
< 10ns Specified
< 4ns Measured

Beam Profile @ Output Window
Beam Profile @ Beam Waist (Far Field)

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PA-200-QMG-PIV Oscillator Performance Data
200W / 532nm @ 10kHz

Long Term Power Stability at 10 kHz, 532 nm

Beam Profile @ Output Window
Beam Profile @ Beam Waist (Far Field)

75 Hour Power Stability

Pulse Width
< 120ns Specified
< 100ns Measured

Jitter
< 10ns Specified
< 4ns Measured

PIV Platform
Average Power (per Oscillator) vs. Repetition Rate

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Patara™ Laser System - Reliability

• All Patara™ laser systems feature NGCEO laser diodes and DPSS gain modules
  – Both are DPSS laser industry standards
  – >10,000 modules installed worldwide
  – Laser diode lifetime in the lasers routinely exceeds 15,000 operating hours
    • Confidently expect a diode lifetime of a minimum 10,000 hours
    • Economical laser diode refurbishment at end of life

• Patara™ laser system
  – Strong industrial history with 100’s of field-proven lasers operating world-wide
  – Installations at universities, US National Labs and international R&D facilities
  – Components are meticulously cleaned prior to assembly
  – Manufactured in a clean, particle controlled environment
  – >100 hr test on every laser prior to shipment

• eDrive laser system controller
  – Designed and manufactured at CEO
  – Extensive system protection interlocks and on board diagnostics
  – Robust, reliable and easy to use
High Reliability Laser Diodes

• All diode bars for laser gain modules are fabricated at CEO
  – Wafer processing, device fabrication, packaging & testing are all performed in Class 100 - 10,000 clean rooms
  – Every wafer is lot tested for long term degradation
    • At higher than nominal operating current
    • 1000-2000+ hours
  – Every laser diode bar and array is tested prior to installation in a gain module
  – 100% bar traceability from wafer to arrays, gain module and laser system

Laser Diode Bars
 Array Submodules
 Laser Diode Arrays
 DPSS Gain Modules
High Quality DPSS Gain Modules

• The DPSS gain module is *the* critical component in a DPSS laser
  – Key contributor to all of the important DPSS laser parameters
    • Mode quality
    • Beam roundness
    • Beam pointing
    • Pulse to pulse stability
    • Average power output

Cutting Edge Optronics has manufactured >15,000 Gain Modules
**Patara™ Laser System Background**

<table>
<thead>
<tr>
<th><strong>Patara - Introduced 2006</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
</tr>
<tr>
<td>16W-20W</td>
</tr>
</tbody>
</table>

**Notes:** Turn key TEMoo DPSS laser system with superior beam pointing, pulse-to-pulse stability and high conversion efficiency. With 100’s of worldwide installations, the system became a workhorse for micromachining, diamond processing and medical applications.

<table>
<thead>
<tr>
<th><strong>Patara-HP - Introduced 2010</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
</tr>
<tr>
<td>50W-400W</td>
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</tbody>
</table>

**Notes:** Developed, as a higher power version, with similar architecture to service more industrial and scientific applications. The flexibility of this system has allowed its utilization in a wide range of applications from paint stripping to Ti:Sapphire pumping.

<table>
<thead>
<tr>
<th><strong>IKLWA - Introduced 2012</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
</tr>
<tr>
<td>16W-20W</td>
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</tbody>
</table>

**Notes:** Developed as a more economical solution with virtually the same form, fit and function as the Patara™ laser system. Innovative manufacturing techniques were developed to drive costs down while preserving critical functions to serve the micromachining and diamond processing markets.

<table>
<thead>
<tr>
<th><strong>Patara-PIV - Introduced 2016</strong></th>
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<tbody>
<tr>
<td>Power (per oscillator)</td>
</tr>
<tr>
<td>30W-200W</td>
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</tbody>
</table>

**Notes:** Developed specifically for the scientific field of particle image velocimetry with a decade of knowledge in manufacturing industrial and scientific lasers. The combination of technology and innovative manufacturing techniques makes this an affordable yet progressive product line.
Why Cutting Edge Optronics?
CEO designs & manufactures OEM laser components for commercial, industrial, scientific, & military/aerospace applications.

Products are delivered at every stage and each product feeds into the next product level.
## 25 Years DPSS Laser Manufacturing Experience
CEO is Experienced in a Variety of Markets

<table>
<thead>
<tr>
<th>Product</th>
<th>Annual Volume</th>
<th>Typical Markets</th>
</tr>
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<tbody>
<tr>
<td>Raw Diode Bars</td>
<td>100,000+</td>
<td>Hair Removal, Material Processing Systems, Medical Systems, etc.</td>
</tr>
<tr>
<td>Diode Arrays</td>
<td>10,000+</td>
<td>Direct Energy Weapons, LIDAR, Diamond Processing Machines, Hair Removal, Material Processing Machines, etc.</td>
</tr>
<tr>
<td>Gain Modules</td>
<td>1,000+</td>
<td>Diamond Processing, Marking Machines, Material Processing, High Energy Laser Systems, Scientific Lasers, etc.</td>
</tr>
</tbody>
</table>