Superior Reliability & Performance

- Lasers and Laser-based Systems
- Laser Measurement and Control
- Precision Optics
- Related Accessories

A typical Ti:Sapphire terawatt system front-end is an ultra-short cw modelocked Ti:Sapphire oscillator producing <30 fs pulses at 800 nm at a repetition rate of 80 MHz. These pulses are temporally broadened to >150 ps duration in a single-grating stretcher, and then switched into a Ti:Sapphire regenerative amplifier for amplification to ~2 mJ at 1 kHz.

The amplifier is pumped by our Evolution laser, a diode-pumped, intra-cavity doubled, Q-switched Nd:YLF laser.

The output from the regenerative amplifier is directed into a power amplifier, which contains a large aperture Ti:Sapphire crystal, pumped from both ends using frequency-doubled Nd:YAG lasers operating at 10 Hz and spatially optimized for pumping Ti:Sapphire.

In the power amplifier, the pulses are multi-passed through the gain medium in a bow-tie configuration, resulting in amplification to the target energy before recompression.
The Cryo family of diode-pumped, ultrafast Ti:Sapphire amplifiers is a series of flexible, easy-to-use laser systems designed for the varying demands of ultrafast applications in scientific research.

With two models, the 1 kHz or the 5 kHz amplifier, the newly expanded Legend series provides higher energy, superior output stability, and ease of use.

**Superior Output Stability**

At the core of the amplifier’s stability and reliability is our Evolution diode-pumped laser. This 527 nm, Q-switched laser offers stable, high-pulse-energy operation, excellent mode quality and low cost of ownership. Evolution is available in 15-watt, 30-watt, or 90-watt versions. Evolution-30 is used to pump the 1 kHz model. Evolution-90 is used to pump the 5 kHz unit. The Evolution’s stability translates directly into the stability of the amplifier. With <1% RMS noise, the Cryo amplifier is ideal for direct amplifier applications.

**Time-Tested Design**

Legend amplifiers feature a number of innovations for unsurpassed performance and reliability.

In the Cryo amplifier, an advanced vacuum chamber and proprietary thermal management produce the best beam quality available. The use of a single multipass amplifier offers exceptional beam quality and is a more compact, simpler laser than traditional multi-stage amplifiers.

When combined with the Legend-HE, the Cryo amplifier gives you:

- Computerized system control
- Pulse stretcher
- Synchronization electronics
- Regenerative amplifier
- Multipass amplifier
- Closed-loop compressed helium cooling
- Photodiode monitor
- Multiple interlocks for temperature, power, and safety
- Proven compressor with motorized stage
- Single-source vendor

**Complete Ultrafast Laser Systems**

Coherent offers a complete line of ultrafast laser systems, including oscillators, amplifiers, pump lasers, and OPAs.

With more installed systems than any other manufacturer, our kilohertz Ti:Sapphire amplifiers are the industry standard.

---

**LEGEND-HE-Cryo**

**Ti:Sapphire Amplifier**

**FEATURES**

- 50 fs pulses
- 1 or 5 kHz repetition rates
- Stable (<1% RMS noise)
- \(M^2<1.5\)
- Single-shot autocorrelator and other diagnostics available
- Seeded by Vitesse™, Mira™, or Chameleon™ laser

**KEY APPLICATIONS**

- Femtosecond spectroscopy
- High-field physics
- X-ray Generation
- Ultrafast photochemistry
## System Specifications

<table>
<thead>
<tr>
<th></th>
<th>1 kHz</th>
<th>5 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Wavelength</td>
<td>800 nm</td>
<td></td>
</tr>
<tr>
<td>Repetition Rate(^1)</td>
<td>1 - 5 kHz</td>
<td></td>
</tr>
<tr>
<td>Pulse Duration(^2) (FWHM)</td>
<td>50 fs or 130 fs</td>
<td></td>
</tr>
<tr>
<td>Energy-per-Pulse</td>
<td>5 to 10 mJ at 1 kHz</td>
<td>1 to 5 mJ at 5 kHz</td>
</tr>
<tr>
<td>Average Power</td>
<td>5 to 10 Watts</td>
<td>5 to 25 Watts</td>
</tr>
<tr>
<td>Contrast Ratio (ns)(^3)</td>
<td>&gt;1000:1 pre-pulse, &gt;1000:1 post-pulse</td>
<td></td>
</tr>
<tr>
<td>Contrast Ratio (ps)</td>
<td>&gt;1000:1 @ 500 fs</td>
<td></td>
</tr>
<tr>
<td>Power Stability (1000 pulses)</td>
<td>&lt;1% RMS</td>
<td></td>
</tr>
<tr>
<td>Beam Diameter (nominal)</td>
<td>10 mm 1/e(^2)</td>
<td></td>
</tr>
<tr>
<td>Spatial Mode</td>
<td>TEM(_{00}), M(^2) &lt;1.5</td>
<td></td>
</tr>
<tr>
<td>Pointing Stability(^4)</td>
<td>&lt;30 μrad</td>
<td></td>
</tr>
<tr>
<td>Polarization</td>
<td>horizontal (&quot;p&quot;)</td>
<td></td>
</tr>
<tr>
<td>Transform Limit(^5)</td>
<td>15 times</td>
<td></td>
</tr>
<tr>
<td>Pump Laser</td>
<td><strong>Evolution-30</strong></td>
<td><strong>Evolution-90</strong></td>
</tr>
</tbody>
</table>

\(^1\) Repetition rate must be specified when ordered, and must be optimized prior to shipment.

\(^2\) When seeded by Mira or Vitesse. For other seed lasers, the minimum pulse width we will guarantee is 150% of the seed pulse width when not using Coherent oscillators.

\(^3\) Contrast ratio is defined as the ratio between the peak intensity of the output pulse to the peak intensity of any other pulse greater than 1 ns that occurs before or after the output pulse.

\(^4\) Under stable environmental conditions: +2°C, <50% humidity.

\(^5\) Requires transform-limited seed pulses. For more information on transform-limited pulses, see our Technical Note, "Chirped Pulses and the Meaning of Fourier Transform Limited."

### Mechanical Specifications

#### OUTPUT END

- 18.29 cm (7.20 in.)
- 5.61 cm (2.21 in.)

#### RIGHT SIDE

- 243.84 cm (96.00 in.)
- 23.49 cm (9.25 in.)

#### INPUT END

- 12.07 cm (4.75 in.)
- 17.02 cm (6.70 in.)

#### LEFT SIDE

- 243.84 cm (96.00 in.)
- 23.49 cm (9.25 in.)

### Output Stability

Histogram of energy shows <1% RMS.

### Coherent, Inc.

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tech.sales@Coherent.com  
www.Cohereent.com

Coherent follows a policy of continuous product improvement. Specifications are subject to change without notice.

For full details on warranty coverage, please refer to the Service section at www.Coherent.com, or contact your local Sales or Service Representative.
**Long Pulse**

From 20 ns to 100s of microsecs, by Q-switching or a “free-running” laser.

**Superior Reliability & Performance**

- Lasers and Laser-based Systems
- Laser Measurement and Control
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- Related Accessories

We define “Long Pulse” as pulses with durations from 20 ns to hundreds of microseconds.

There are two common ways to produce long pulses from solid-state lasers: by Q-switching with a long resonator, or with a “free-running” laser.

**Q-Switched Nd:YAG**

Nd:YAG exhibits relatively high gain compared to other common solid-state laser materials. This characteristic typically results in short Q-switched pulses, which is one of the reasons it has become such a popular material. However, this property is not beneficial when trying to produce a long-pulse laser, because in a high-gain resonator the photon lifetime is short, and the resultant pulse is short. Another variable that determines the output pulse width from a Q-switched resonator is the resonator length.

It is possible to design a long resonator that will produce longer pulses. The limiting factor is the mechanical stability of the resonator. We have built resonators as long as several meters capable of producing high-energy pulses as long as 75 ns.

**Q-Switched Nd:Glass**

The gain of Nd:Glass is relatively small, which typically results in longer pulses from Q-switched lasers. There are two common types of laser glass: phosphate and silicate. Both phosphate and silicate glasses exhibit somewhat different characteristics that can be utilized, depending on the characteristics required from the laser.

A typical long-pulsed laser would utilize a dual-head Nd:Silicate glass oscillator. This oscillator produces pulses of duration 100–200 ns, depending on pump energy. The spatial mode is $TEM_{00}$ and the energy is about 30 mJ. Because of the thermal lensing and birefringence associated with Nd:Glass, the maximum repetition rate of this laser is 5 Hz. If higher energy is required, then it is beneficial to add Nd:YAG amplifiers. The high gain of the Nd:YAG results in a simpler overall design, and the pulse length is maintained through amplification.

If a shorter pulse is required, then Nd:Phosphate glass can be used. In this case, pulse lengths of 50–100 ns are generated. Because Nd:Phosphate glass lases at 1053 nm, Nd:YLF is the material of choice for further amplifiers.

Of course, there is no problem with amplifying either phosphate or silicate glass oscillators further, using glass amplifiers when the repetition rate is not an issue. In this case, energies to 100 joules are obtainable.
Free-Running Laser

In order to produce microsecond duration pulses we use a simple “free-running” oscillator, which can feature etalons and a KDP crystal to produce narrow linewidths and smooth temporal characteristics. A free-running Nd:YAG oscillator will produce an output pulse of approximately 150 µs duration and energy 30 mJ. This pulse can be further amplified, if necessary. If required, the pulse can be shortened to 1 µs or 5 µs by a Pockels cell pulse slicer.

In a “free-running” laser, during the lamp emission, the gain of the laser will increase and quickly overcome the losses. The lasing then becomes pseudo-cw, following the current discharge of the lamp. Because there is very low loss in this resonator design, the laser discharge is very close, in temporal profile, to the lamp current. The lamp current is close to Gaussian, with a FWHM of about 200 microseconds.

It must be noted, however, that in this design the initial lasing is characterized by a large spike, of about 1 microsecond duration, that is due to gain switching. Following this spike, and after some further small modulation, the temporal profile becomes smooth in a microsecond time-scale. When viewed with a fast photodiode, there will be some temporal modulation, with a period of about 6 ns, due to mode beating.

Pulse Slicer

The output pulse from the oscillator will be of approximately 150 µs duration. In order to produce a shorter pulse width of 5 – 50 µs, it is necessary to temporally slice a portion from the pulse. This is achieved with a Pockels cell pulse slicer. The pulse slicer consists of a Pockels cell, two polarizers, high-voltage electronics, and a digital pulse-shaping circuit.

The slicer will be activated towards the middle of the 150-µs pulse, thus insuring that any relaxation oscillations have subsided and the pulse is temporally smooth at this point. Because only a portion of the pulse is selected by the pulse slicer, the energy will be significantly reduced at this point. This necessitates adding linear amplifiers to produce higher output energy.

Frequency Doubling

Following amplification, the beam can be softly focused through an LBO doubling crystal. The LBO will be non-critically phase-matched. This has a significant advantage, in that the large angular acceptance will ensure optimum conversion efficiency for the focusing laser beam.

<table>
<thead>
<tr>
<th>Types of Long-Pulse Custom Lasers</th>
<th>Pulse Width</th>
<th>Rep. Rate</th>
<th>Typical Maximum Energies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nd:YAG Q-switched</td>
<td>Up to 75 ns</td>
<td>Up to 50 Hz</td>
<td>1J</td>
</tr>
<tr>
<td>Nd:Glass Q-switched</td>
<td>Up to 250 ns</td>
<td>Up to 5 Hz</td>
<td>5J</td>
</tr>
<tr>
<td>Nd:YAG “free-running”</td>
<td>Up to 500 ns</td>
<td>Up to 50 Hz</td>
<td>3.5J</td>
</tr>
</tbody>
</table>

* Depends on pulse duration
Macro/Micro-Pulse

Several available systems operate in a pulse-burst or macro/micro-pulse mode.

**Superior Reliability & Performance**

- Lasers and Laser-based Systems
- Laser Measurement and Control
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- Related Accessories

Various applications require the generation of a pulse train of uv pulses. Coherent engineers have built several systems that operate in a pulse-burst or macro/micro-pulse mode.

The most common application of this technology is photocathode illumination in electron accelerators. Typical requirements are uniform energy, 10-100 ps, UV pulses at a rep. rate of 50-350 MHz with a macro-pulse period of 1-100 microseconds.

A system of this type typically begins with a modelocked oscillator, often with a rep. rate that can be locked to the RF of the accelerator. We then use our digitally controlled optical pulse slicer to shape the macro-pulse out of the modelocked pulse train.

This macro-pulse is then amplified to the required energy, typically in flashlamp-pumped Nd:YAG, Nd:YLF or Nd:Glass. This amplified macro-pulse can then be non-linearly converted to second, third, fourth or fifth harmonic as required by the specific photocathode material.

Because gain saturation can distort the overall macro-pulse shape, we use a specially designed pulse slicer that allows the customer to select virtually any desired macro-pulse shape at the output of the laser.

<table>
<thead>
<tr>
<th>Product</th>
<th>Macro-Pulsewidth</th>
<th>Micro-Pulsewidth</th>
<th>Typical Macro-Pulse Energies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Typical Macro-Pulse Energies</strong></td>
</tr>
<tr>
<td>Nd:YAG</td>
<td>1-100 µs</td>
<td>20-100 ps</td>
<td>500 mJ</td>
</tr>
<tr>
<td>Nd:YLF</td>
<td>1-100 µs</td>
<td>10-100 ps</td>
<td>500 mJ</td>
</tr>
</tbody>
</table>
Nd:Glass Terawatt Laser Systems

High-energy, low rep-rate Nd:Glass terawatt laser systems.

Superior Reliability & Performance

- Lasers and Laser-based Systems
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In applications that require very high energy and pulse widths from 500 fs to 10 ps, we recommend amplification in Nd:Glass with preamplification in Ti:Sapphire.

With advancements in DPSS pump sources, extremely stable performance is now obtainable in Ti:Sapphire amplification at 1 micron. This makes Ti:Sapphire the ideal preamplifier for a glass amplifier chain.

Coherent uses the Evolution-15 DPSS Nd:YLF laser to pump a Ti:Sapphire amplifier optimized for 1 micron operation. 200 fs pulses from a diode-pumped, mode-locked Nd:Glass oscillator are propagated into our single-grating stretcher, then amplified to 500 µJ in the Ti:Sapphire regenerative amplifier.

These pulses are then relay imaged into a chain of flashlamp-pumped Nd:Glass amplifiers where energies >20J per pulse (pre-compression), and as high as 15J per pulse at 1 ps are easily produced in a single beam line. Output pulse-to-pulse stability of <4% RMS is easily achieved from these systems.
Nd:YAG
High-Energy, Frequency-Doubled
Hi-energy, frequency-doubled lasers for pumping large-diameter Ti:S crystals.

Superior Reliability & Performance

- Lasers and Laser-based Systems
- Laser Measurement and Control
- Precision Optics
- Related Accessories

Coherent offers several high-energy, frequency-doubled Nd:YAG lasers for pumping large-diameter Ti:Sapphire crystals (such as those used in our terawatt lasers). A typical pump laser produces >5 joules at 532 nm and >10 joules at 1064 nm with an exceptional flat-top relay-imaged beam. These lasers are also used in material processing and launching flyers (shockwave physics experiments) where beam spatial quality is critical.

Superior beam quality begins with a TEM$_{00}$ oscillator. Other designs use a high-energy Gaussian resonator design, producing a beam profile with spatial modulation that results in diffraction rings and a "dip" in the energy at the center of the beam. This "dip" is exacerbated in the frequency doubler, resulting in a poor amplified beam spatial profile and potentially dangerous modulations in intensity across the beam profile.

A Gaussian-shaped TEM$_{00}$ beam has the ideal spatial profile for relay imaging. Proper imaging and amplification of this beam will result in a near-perfect flat-top profile at the image, which can then be re-imaged to a target, such as a Ti:Sapphire crystal. Minimal modulation means reduced peak intensity across the beam profile and less susceptibility of the laser to optical damage.

Reliability is further enhanced by use of larger diameter final amplifier rods. We uses 5/8" diameter final amplifier rods, delivering a 30% decrease in the average fluence compared to other commercially available designs.
Regenerative Amplifiers

High-energy Lasers

Macro-Micro Pulse Lasers

Terawatt-class Lasers

Advanced Solid-State Laser Systems
Designed to Your Specifications

Positive Light

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Experience you can trust
When you have a challenging application or need a non-standard laser, turn to Positive Light. We’ve been delivering custom designed laser systems for over 12 years. Our technological advancements include the first commercial terawatt laser, the first commercial vacuum pulse compressor, and the first relay-imaged amplifier system. Let our dedicated custom engineers manufacture an advanced laser system, designed to your specifications.

Positive Light offers:
• The most experienced custom laser team in the industry
• Technical expertise in chirped pulse amplification, relay imaging, and temporal pulse shaping
• Fast and reliable switching and synchronization electronics
• The highest peak power lasers available
• A wide range of pulse forming networks and control electronics
• Custom components, controls, and software to your specifications

Standard Products-Custom Fit
We use a variety of solid-state materials, including Nd:YLF, Nd:YAG, Nd:Glass, and Ti:sapphire. Wavelength, energy, pulsewidth, repetition rate, and linewidth are tailored to your requirements.

Many components used in our custom designs are adopted from our standard products, giving you the benefit of time tested designs and field-proven reliability.

Overview

<table>
<thead>
<tr>
<th>Laser Type</th>
<th>Wavelength (nm)</th>
<th>Energy</th>
<th>Pulse Width</th>
<th>Rep Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nd:YLF</td>
<td>1047, 1064, 527, 523</td>
<td>mJ to J</td>
<td>ps to ms</td>
<td>1 Hz to 50 kHz</td>
</tr>
<tr>
<td>Nd:YAG</td>
<td>1064, 1053, 532, 531</td>
<td>mJ to J</td>
<td>ps to ms</td>
<td>1 Hz to 50 kHz</td>
</tr>
<tr>
<td>Nd:Glass (phosphate)</td>
<td>1064, 528, 526, 525</td>
<td>mJ to J</td>
<td>ps to ms</td>
<td>1 Hz to 1 MHz</td>
</tr>
<tr>
<td>Nd:Glass (induced)</td>
<td>1064, 528, 526, 525</td>
<td>mJ to J</td>
<td>ps to ms</td>
<td>1 Hz to 1 MHz</td>
</tr>
<tr>
<td>Ti:sapphire</td>
<td>750 to 1064</td>
<td>mJ to J</td>
<td>ps to ms</td>
<td>1 Hz to 50 kHz</td>
</tr>
</tbody>
</table>

Terawatt Lasers
- Tunable ultrafast Ti:sapphire systems with peak power over 20 TW at 10 Hz
- 20 TW Nd:Glass CPA system producing 20 J, <1 ps pulses at 1.05 µm
- 2 TW Nd:Glass CPA system producing 2 J, <1 ps pulses at 1.05 µm

High Energy Lasers
- 5 Joule, 10 Hz, high energy Ti:sapphire pump laser
- Multi-Joule lasers for material processing
- 10-20 Joule “Flyer Launchers” for shock physics experiments
- High energy, 1.3 micron Nd:YAG system

Macro/Micro Pulse Lasers
- Long pulse (15 µJ) Nd:YAG with sub-15 MHz linewidth
- Long pulse (1 mJ) laser producing 15 µJ at 1 kHz
- Multiple pulse ultraviolet Nd:YLF system for photocathode illumination
- Nd:YAG and Nd:YLF lasers with outputs from 30 µJ at 50 kHz to 5 J at 20 Hz
- Relay-imaged Nd:Glass lasers with near diffraction limited outputs exceeding 50 J

Regenerative Amplifiers
- Regenerative amplifier systems with pulsewidths from 20 fs to 2 ns
- Dual beam Nd:YAG regenerative amplifier with output of 600 µJ at 200 ps
- 4 GW Nd:YLF regenerative amplifier with relay-imaged beam
**Largest Ti:sapphire pump source commercially available**

Positive Light offers several high-energy, frequency-doubled Nd:YAG lasers for pumping Ti:sapphire crystals (such as those used in terawatt lasers). A typical pump laser produces >5 Joules at 532 nm and >10 Joules at 1064 nm with an exceptional flat-top relay-imaged beam. These lasers are also used in material processing and launching flyers (shockwave physics experiments) where beam spatial quality is critical. Superior beam quality begins with a TEM\(_{00}\) oscillator. Other designs use a high-energy Gaussian resonator design, producing a beam profile with spatial modulation that results in diffraction rings and a “dip” in the energy at the center of the beam. This “dip” is exacerbated in the frequency doubler, resulting in a poor amplified beam spatial profile and potentially dangerous modulations in intensity across the beam profile.

A Gaussian shaped TEM\(_{00}\) beam has the ideal spatial profile for relay imaging. Proper imaging and amplification of this beam will result in a near perfect flat-top profile at the image, which can then be re-imaged to a target, such as a Ti:sapphire crystal. Minimal modulation means reduced peak intensity across the beam profile and less susceptibility of the laser to optical damage.

Reliability is further enhanced by use of larger diameter final amplifier rods. Positive Light uses 5/8” diameter final amplifier rods, delivering a 30% decrease in the average fluence compared to other commercially available designs. Better beam quality and better reliability mean better performance and better results.

---

**Examples of Applications**

- Pumping Ti:sapphire for Terawatt Lasers
- Flyer Launcher for Shock Physics
- Material Processing

**Typical spatial profile of a high-energy relay-imaged amplifier system.**
**Highest power laser commercially available**

Positive Light offers Terawatt laser systems that provide unique solutions in applications such as High Field Physics, X-ray Generation, Thompson Scattering, Plasma Physics and others. An established leader in diode-pumped ultra-short pulse, multi-kiloherzt Ti:sapphire amplifiers, Positive Light has shipped hundreds of chirped-pulse-amplification (CPA) systems around the world. There are two well established materials for Terawatt CPA laser systems:

**Ti:sapphire**
- Broad gain bandwidth (10’s of nm)
- Good saturation fluence (~1 J/cm²)
- Readily available material
- Good thermal conductivity (high repetition rate)

**Nd:Glass**
- Good gain bandwidth (3-4 nm)
- High saturation fluence (4-6 J/cm²)
- Good energy storage and extraction
- Poor thermal characteristics (low repetition rate)

**Ti:sapphire Terawatt Systems**

A typical Terawatt system front-end is an ultra-short cw modelocked Ti:sapphire oscillator producing <30 fs pulses at 800 nm at a repetition rate of 80 MHz. These pulses are temporally broadened to >150 ps duration in a single-grating stretcher, and then switched into a Ti:sapphire regenerative amplifier for amplification to ~2 mJ at 1 kHz. The amplifier is pumped by our Evolution laser, a diode-pumped, intra-cavity doubled, Q-switched Nd:YLF laser.

The regen output is directed into the power amplifier which contains a large aperture Ti:sapphire crystal, pumped from both ends using frequency-doubled Nd:YAG lasers operating at 10 Hz and spatially optimized for pumping Ti:sapphire. In the power amplifier, the pulses are multi-passed through the gain medium in a bow-tie configuration resulting in amplification to the target energy before recompression.

**Nd:Glass Terawatt Systems**

In applications that require very high energy and pulsewidths from 500 fs to 10 ps, we recommend amplification in Nd:Glass with preamplification in Ti:sapphire. With advancements in DPSS pump sources, extremely stable performance is now obtainable in Ti:sapphire amplification at 1 micron. This makes Ti:sapphire the ideal preamplifier for a glass amplifier chain.

Positive Light uses the Evolution-15 DPSS Nd:YLF laser to pump a Ti:sapphire amplifier optimized for 1 micron operation. 200 fs pulses from a diode-pumped, mode-locked Nd:Glass oscillator are propagated into our single grating stretcher, then amplified to 500 µJ in the Ti:sapphire regenerative amplifier.

These pulses are then relay imaged into a chain of flashlamp pumped Nd:Glass amplifiers where energies >20 J per pulse (pre-compression), and as high as 15 J per pulse at 1 ps are produced in a single beam line.

The regen output is directed into the power amplifier which contains a large aperture Ti:sapphire crystal, pumped from both ends using frequency-doubled Nd:YAG lasers operating at 10 Hz and spatially optimized for pumping Ti:sapphire. In the power amplifier, the pulses are multi-passed through the gain medium in a bow-tie configuration resulting in amplification to the target energy before recompression.

**The Positive Light Advantage**

Our Evolution pump laser and Ti:sapphire regenerative amplifier - both in their third generation - form the backbone of our Terawatt class amplifier systems. The exceptional stability that is obtained through cw diode-pumping offers the distinct advantage of having the best amplified stability in the industry. Relay imaging techniques utilized in the Positive Light amplifier systems add to the performance and reliability of our Terawatt class amplifier products. Relay imaging is a powerful technique for producing excellent beam quality, while insuring maximum energy extraction from solid-state rod amplifiers.
The Ti:sapphire amplifier uses exceptionally reliable switching electronics, including our SDG (Synchronization and Delay Generator) and our HSD (High Speed Driver) on which we proudly offer a full 5 year warranty.

We also offer a complete line of ultrafast diagnostics to measure the intensity, phase, and pulsewidth of ultrafast pulses. CCD camera systems, power and energy meters, fast photo-detectors, and a host of other diagnostic equipment are available for easy maintenance.

Positive Light offers TW class pulse compressors that operate in air, as well as complete vacuum chambers, vacuum prepped mounts and vacuum pump systems for vacuum-based pulse compressors. Full remote control of pulse compressors is available whether in vacuum or in air.

Examples of Applications
- X-ray Generation
- Thompson Scattering
- Plasma Physics
- Advanced Accelerator Physics
- High Energy Physics

Examples of Common High Energy Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Wavelength</th>
<th>Energy</th>
<th>Rep Rate</th>
<th>Pulse Width</th>
<th>Vacuum Compress</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSA-2TW</td>
<td>800 nm</td>
<td>35 – 100 mJ</td>
<td>10 Hz</td>
<td>35 – 100 fs</td>
<td>Optional</td>
</tr>
<tr>
<td>TSA-10TW</td>
<td>800 nm</td>
<td>350 – 600 mJ</td>
<td>10 Hz</td>
<td>35 – 100 fs</td>
<td>Recommended</td>
</tr>
<tr>
<td>TSA-20TW</td>
<td>800 nm</td>
<td>0.7 – 1 J</td>
<td>10 Hz</td>
<td>35 – 100 fs</td>
<td>Recommended</td>
</tr>
<tr>
<td>TSA-100TW</td>
<td>800 nm</td>
<td>3.5 – 5 J</td>
<td>Single shot - 1 Hz</td>
<td>35 – 100 fs</td>
<td>Recommended</td>
</tr>
<tr>
<td>Glass CPA</td>
<td>1063 nm</td>
<td>1 – 10 J</td>
<td>Single shot - 1.0 ppm</td>
<td>35 – 100 fs</td>
<td>Recommended</td>
</tr>
</tbody>
</table>

Optional
Recommended
More Energy-Less Hardware

Various applications require lasers to produce energetic pulses at a high repetition rate. Fortunately, many of these applications will work with a system that provides these energetic, high rep-rate pulses with a relatively low duty cycle. In this case, Positive Light can provide a more economical laser system that operates in a pulse-burst, or macro/micro pulse mode. A common application of this technology is driving photocathodes at the front end of electron accelerators. Typical requirements are uniform-energy, 10-100 ps, UV pulses at a rep-rate of 50-350 MHz with a macro pulse period of 1-100 microseconds.

A system of this type typically begins with a mode-locked oscillator, often with a rep-rate that can be locked to the RF of the accelerator. A Positive Light digitally controlled optical pulse slicer is used to shape the macro pulse out of the mode-locked pulse train. This macro-pulse is amplified to the required energy, typically in flashlamp pumped Nd:YAG, Nd:YLF or Nd:Glass. This amplified macro-pulse can be non-linearly converted to second, third, fourth or fifth harmonic as required by the specific photocathode material. Gain saturation and harmonic conversion will impact the shape of the macro pulse envelope, but real-time digital control of the input pulse shape allows the customer to dial in virtually any desired macro-pulse shape at the output of the laser.
Overview

Experience you can trust
When you have a challenging application or need a non-standard laser, turn to Positive Light. We've been delivering custom designed laser systems for over 12 years. Our technological advancements include the first commercial terawatt laser, the first commercial vacuum pulse compressor, and the first relay-imaged amplifier system. Let our dedicated custom engineers manufacture an advanced laser system, designed to your specifications.

Positive Light offers:
- The most experienced custom laser team in the industry
- Technical expertise in chirped pulse amplification, relay imaging, and temporal pulse shaping
- Fast and reliable switching and synchronization electronics
- The highest peak power lasers available
- A wide range of pulse forming networks and control electronics
- Custom components, controls, and software to your specifications

Standard Products—Custom Fit
We use a variety of solid-state materials, including Nd:YLF, Nd:YAG, Nd:Glass, and Ti:sapphire. Wavelength, energy, pulsewidth, repetition rate, and linewidth are tailored to your requirements.

Many components used in our custom designs are adopted from our standard products, giving you the benefit of time tested designs and field-proven reliability.

Custom Laser Examples

Terawatt Lasers
- Tunable ultrafast Ti:sapphire systems with peak power over 20 TW at 10 Hz
- 20 TW Nd:Glass CPA system producing 20 J, <1 ps pulses at 1.05 µm
- 2 TW Nd:Glass CPA system producing 2 J, <1 ps pulses at 1.05 µm

High Energy Lasers
- 5 Joule, 10 Hz, high energy Ti:sapphire pump laser
- Multi-Joule lasers for material processing
- 10-20 Joule “Flyer Launchers” for shock physics experiments
- High energy, 1.3 micron Nd:YAG system

Macro/Micro Pulse Lasers
- Long pulse (5 µJ) Nd:YAG with sub-15 MHz linewidth
- Long pulse (1 µs) laser producing 15 mJ at 1 kHz
- Multiple pulse ultraviolet Nd:YLF system for photocathode illumination
- Nd:YAG and Nd:YLF lasers with outputs from 350 µJ at 50 kHz to 5 J at 20 Hz
- Relay-imaged Nd:Glass lasers with near-diffraction limited outputs exceeding 50 J

Regenerative Amplifiers
- Regenerative amplifier systems with pulsewidths from 20 to 2 ns
- Dual beam Nd:YAG regenerative amplifier with output of 600 mJ at 200 ps
- 4 GW Nd:YLF regenerative amplifier with relay-imaged beam

We continue to be pleased with the design and performance of Positive Light products. Our ultrafast spectroscopy experiments require reliability and stability of the laser source. On both counts, the Positive Light Evolution and regenerative amplifier in our system pass with flying colors. Both are clearly of high quality and are critical components of our research.”

J. Gary Eden
Professor of Electrical and Computer Engineering and Associate Vice-Chancellor for Research
University of Illinois

“We have a long standing and productive relationship with Positive Light, and have come to expect ingenuity, quality and good service, all while providing a state of the art laser product. We regard the Positive Light team as our scientific partners in laser development.”

Dr. A. J. Taylor
Director, Laboratory for Ultrafast Materials and Optical Science
Los Alamos National Laboratory

“We perform experiments that depend crucially on low signal-to-noise ratios as the emitted radiation we detect is extremely small. The Evolution has been wonderful in this regard, as it serves as the optical pump source for our Ti:sapphire amplifiers (regen & two-pass) which generate the signals. Even at 83% max. output (22.5 W) over periods longer than 48 hours, the Evolution is rock-solid, with negligible shot-to-shot noise. The solid state design allows for system turn-ons that come back right where they were at turn-off, which is a real time-saver! Kudos to Positive Light!”

Richard Haight
IBM TJ Watson Research Center

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