E-Track™: Active Pulse Energy Control for Explorer® One™ Lasers

Achieving higher precision and improved throughput in industries such as microelectronics is the key to a competitive advantage. Striving for higher precision increases the need for laser based tools used in these manufacturing processes. Precise deposition of energy, short response times, and stabilized laser pulse energy control over short or long process periods are key enablers for precision manufacturing capabilities now possible with the new E-Track feature for the Explorer One lasers.

E-Track is a closed-loop control algorithm that, for the first time, is commercially available on actively Q-switched DPSS lasers. Highly advanced electronics circuitry of the Explorer One laser enables single pulse energy measurement across the full repetition range and delivers feedback into the laser control algorithm. The desired pulse energy level can be set via software, or by simply supplying an analog signal linearly proportional to the desired pulse energy to the analog port. This analog signal control enables very fast energy/power modulation. E-Track enables almost instant pulse energy response of the Explorer One lasers.

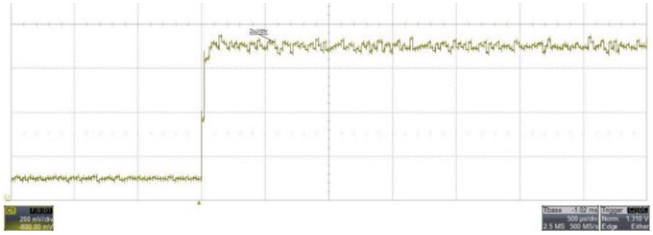

Figure 1: Pulse energy change controlled by E-Track, monitored on an oscilloscope. Each single step of the signal represents the energy of one pulse

Figure 1 shows the output energy changing from 1 µJ to 7 µJ for an Explorer One 355-300 at 50 kHz. This demonstrates that the E-track capability results in changes between energy levels within as few as 2–3 pulses. Furthermore, the output power after the step in pulse energy stays very constant.

E-Track is capable of compensating unwanted over- or undershooting when gating Q-switched lasers, as shown in Figure 2. Unwanted overshooting while gating the laser (orange line) can be automatically compensated by using E-track (green line).

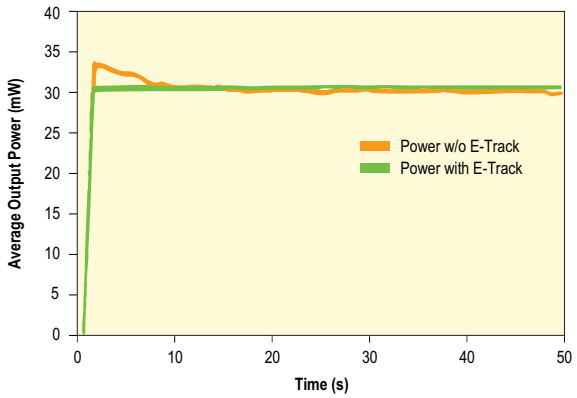

Figure 2: Overshoot compensation controlled by E-Track while gating the laser

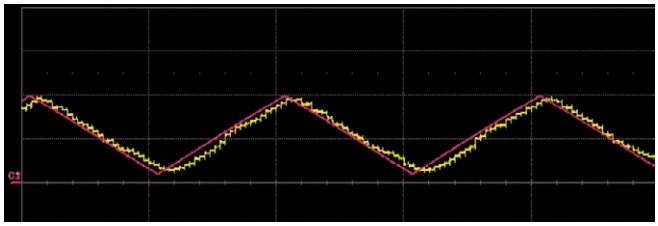

Figure 3: Modulated pulse energy levels controlled by E-Track monitored on an oscilloscope

Figure 3 shows how the Explorer One lasers can be controlled by applying an analog signal (magenta) to the analog port of the Laser. The laser output pulse energy closely follows the analog signal. In this example the energy is modulated with a 1 kHz triangular signal.

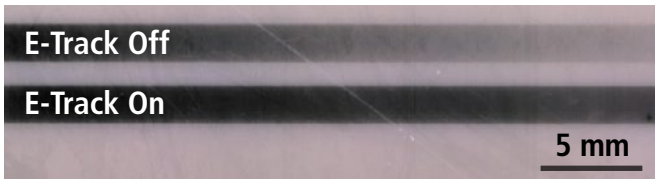

Figure 4: E-Track can compensate effects due to uneven surfaces

Figure 4 demonstrates that the effect of an uneven surface on laser marking can be compensated by using E-Track. The sample in this example is mounted at a 4° inclining plane. When marking the upper bar, the E-Track feature was off. Using E-Track (lower bar), the pulse energy set point was modulated by applying a linear signal ramp to the analog port, resulting in uniform marking of the sample.

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Such closed-loop pulse energy control allows customers to further optimize application processes. With E-Track it is possible to compensate external influences such as physical changes in material thickness that needs to be processed, uneven substrates, or strong changing temperatures.

Figure 5: E-Track provide stable pulse energy and power even under changing conditions and external perturbations

A further application study shows the potential of pulse energy compensation to offset the effects of unwanted changes in ambient operating conditions. The example in Figure 5 shows marking a white square onto black POM (Polyoxymethylene), while intentionally detuning THG temperature to simulate a change in output power. With E-Track off the marking quality changes (left) due to a power change without control; with E-Track turned on, excellent marking quality is achieved by actively controlling and maintaining the pulse energy (right).

These examples demonstrate how changing conditions are compensated by the E-Track closed-loop control with highly accurate and on-the-fly laser parameter adjustments to achieve quality products in demanding production processes.

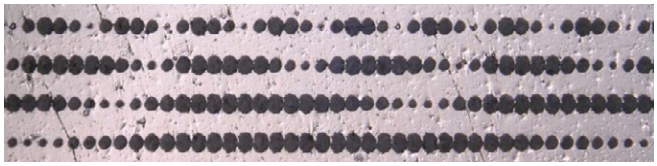

Figure 6: Precise pulse energy deposition on an aluminum foil using E-Track

Figure 6 clearly demonstrates how precise and fast process results can be modified using the E-Track analog control feature marking an aluminum foil. The pulse energy is modulated by applying analog control signals to the E-Track input port at four different modulation frequencies. The first modulation frequency is 10 kHz (top) and is divided down by a factor of two for each following line to 5 kHz, 2.5 kHz, and 1.25 kHz, respectively). A very accurate and highly repeatable pattern can be achieved.

In summary, any application or process that relies heavily on precise pulse energy control or average power can benefit from E-Track. As the first commercially available closed-loop pulse energy control, E-Track enables reliable manufacturing processes and improved process quality in customers' applications not previously possible.

PRODUCTS: *EXPLORER ONE – 355 nm, 532 nm*

Explorer One is the most compact active Q-switched laser series in the power range up to 1W UV and 2W of 532nm. High performance standards such as the extra-ordinary mode quality with a M2 of typical 1.1, the short pulses, and high peak power, as well as the capability for fast power modulation and quick rise times guarantees best process quality in critical applications. High quality standards including tight system-to-system specifications, longevity, and the rugged and durable design ensures lowest cost of ownership. Software features and the compact size result in fast and cost efficient integration and ensure our customers a fast time–to-market with their own products.

	Explorer One 349	Explorer One 355	Explorer One HE 355	Explorer One 532	Explorer One HE 532	Explorer One HP 355
Wavelength	349 nm	355 nm	355 nm	532 nm	532 nm	355 nm
Power	120 µJ / 60 µJ @ 1 kHz	800 mW / 300 mW @ 50 kHz	80 µJ @ 10 kHz	2 W @ 50 kHz	200 µJ @ 10 kHz	4 W @ 80 kHz
Repetition Rate	Single shot to 5 kHz	Single shot to 200 kHz	Single shot to 50 kHz	Single shot to 200 kHz	Single shot to 50 kHz	Single shot to 500 kHz
Pulse Width	<5 ns	<10 ns	<15 ns	<15 ns	<15 ns	<15 ns

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