Picosecond Laser and PSO Motion Capability for Fast, Variable Speed Trajectory Processing

With the constant push for higher throughput processing in electronics, PCB, and consumer electronics manufacturing, it is necessary to eliminate bottlenecks wherever possible. With lasers offering increasingly high pulse repetition frequencies (PRFs), a large and growing segment of laser processing applications utilize scanning galvanometers due to their ability to quickly accelerate the beam to very high speeds. A key limitation of galvo scanners, however, is their limited processing field of view, especially for small focus spots. For processing large areas with high precision and tightly focused beams, the workpiece must be moved under the focused beam on an XY stage system, which will have significantly lower acceleration/deceleration compared to a galvo scanner. Thus, the proper combination of high speed XY stages with galvos can result in fast processing over large areas.

However, in order to produce high quality machining results, it is necessary to be able to fire the laser at a constant spatial, not temporal, separation at all stages of a motion trajectory, including acceleration, deceleration, and constant velocity segments. For a typical q-switched laser, if pulses are triggered at different frequencies to match the variable speed during acceleration/deceleration along the trajectory, both the energy and the temporal width of the pulses will be variable, resulting in an inconsistent process. If, on the other hand, the laser pulses are fired at a fixed frequency (thus ensuring constant pulse energy and pulse width), the process will be highly variable due to the different speeds along the trajectory, with undesirable “burn-in” occurring due to higher pulse overlaps at lower motion speeds.

A common motion trajectory in display manufacturing is that of a rounded-corner rectangle with dimensions similar to those of a mobile device such as a smartphone or tablet. For such a trajectory, XY stage systems typically move slower going around a corner and can move much faster on the straight-away segments. The absolute numbers depend on a range of factors included the mass of the payload and the electrical drive capabilities of the motion system. If a laser must only be fired at a fixed pulse frequency to ensure fixed pulse energy, width, etc., then the trajectory velocity must be fixed as well in order to maintain a fixed overlap and stable process. The speed will be limited by what can be achieved while maneuvering around a rounded 90-degree corner; and smaller corner radii require lower speeds to maintain trajectory accuracy. Hence, although a motion system may be capable of achieving very high speeds on a straight segment, the speed along the entire trajectory is limited to that of the rounded corners. If a motion system could send laser pulse trigger signals at a fixed distance along a trajectory regardless of overall speed, a capability known as position synchronized output or PSO, and if the laser technology could generate stable pulse energies over a range of frequencies, then processing throughput could be maximized by unleashing the full capability of a motions system, vis-à-vis moving at very high speeds on the straight segments while slowing down for the rounded corners, all the while generating a constant processing result in the material. The throughput advantage can be quite large, especially for smaller corner radii. Figure 1 shows the overall speed advantage of PSO vs. non-PSO for the case of a motion trajectory typical of a modern smartphone and with motion capabilities of a typical industrial stage system.

As Figure 1 shows, the overall speed advantage with PSO capability is significant. Even for a larger corner radius of 10 mm, the overall speed of the trajectory is twice as fast as the non-PSO case. As the corner radius decreases to 2 mm and below, the advantage becomes more than fivefold.

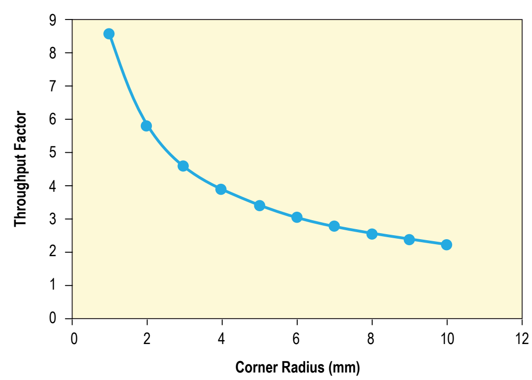

Figure 1: PSO throughput advantage vs. corner radius for typical smart-phone trajectory and XY motion equipment (60x120mm rounded corner rectangle; 5,000 mm/s² straight acceleration, 1,000 mm/s² cornering acceleration).

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Spectra-Physics hybrid fiber lasers feature TimeShift™ technology, that allows a constant pulse energy and pulse width to be generated regardless of the frequency at which the pulses are being triggered. TimeShift technology is incorporated in both the Quasar® high power UV/green pulsed nanosecond and IceFyre® picosecond lasers. In conjunction with Newport's latest PSO motion control technology, laser processing throughput can be maximized. Recently, Spectra-Physics' and Newport's application engineers demonstrated the benefits of laser-based TimeShift technology combined with motion-based PSO capability. Figure 2 shows the processing result in SnO_2-coated glass of a variable speed trajectory without (left) and with (center, right) TimeShift+PSO.

Using the PSO capability, the laser-fired spots are evenly spaced around the entire trajectory, with speeds ranging from below 10 mm/s at the corners to 350 mm/s on the straight segments. This factor of 35 in trajectory speed corresponds to a factor of 35 in the effective laser PRF. The uniformity of the ablation dots over the wide range of speeds demonstrates the IceFyre's ability to generate constant pulse energy over a wide range of PRFs. Such a capability is critical to maximizing processing throughput in high-volume manufacturing processes such as display cover glass cutting and OLED display cutting, both for mobile device manufacturing.

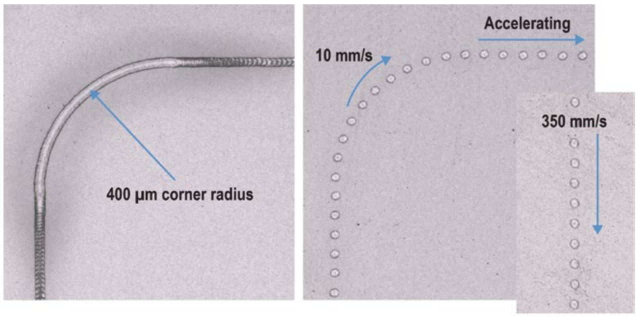

Figure 2: Processing SnO_2-coated glass with a fixed PRF and variable trajectory speed (left) shows excessive burn-in compared to variable to variable PRF/variable speed (center, right).

PRODUCT: *ICEFYRE 1064-50*

IceFyre redefines picosecond micromachining lasers with a patent-pending design to achieve exceptional performance and unprecedented versatility at industry leading cost-performance. Based on Spectra-Physics' It's in the Box™ design, IceFyre integrates laser and controller into the industry's smallest package. IceFyre's unique design exploits fiber laser flexibility and Spectra-Physics' exclusive power amplifier capability to enable TimeShift ps programmable burst-mode technology and wide adjustability of repetition rates. A standard set of waveforms is provided with each laser; an optional TimeShift ps GUI is available for creating custom waveforms. The laser provides pulse-on-demand triggering with the lowest jitter in its class for high quality processing at high scan speeds, e.g. when using a polygon scanner.

	IceFyre 1064-50
Wavelength	1064 nm
Power	>50 W
Maximum Pulse Energy, typical	>200 μJ single pulse at 200 kHz
Repetition Rate Range	Single Shot to 10 MHz
Pulse Width, FWHM	<20 ps
Pulse-to-Pulse Energy Stability	<1.5% rms
Power Stability (after warm-up)	<1%, 1 σ over 8 hours
Spatial Mode (TEM_{00})	<1.3
Beam Asymmetry	1.0 ±10%
Beam Pointing Stability	< ±25 μrad/°C

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