# High Quality Precision Micromachining at 50 m/sec Scanning Speed with Quasar®

As manufacturers continue their persistent demand to increase process quality, yields, and throughput, laser companies and supporting technologies must rise to meet the challenge. The Quasar® platform from Spectra-Physics® is ideally suited to meet this demand. With breakthrough TimeShift™ technology for temporal pulse tailoring, along with high average powers at high pulse repetition frequencies (PRFs), Quasar signals a new potential for high-speed and high-quality industrial-scale laser processing.

For handling high-speed laser micromachining tasks, two-axis scanning galvanometer systems have been an industrial workhouse over the years. The ability to scan a tightly focused beam at speeds of several meters per second has benefited manufacturers in numerous industries, from photovoltaic and medical device manufacturing to printed circuit board (PCB) packaging. However, with recent higher-power products such as Spectra-Physics' Quasar that can operate up to and beyond MHz pulse frequencies, some processes can be realized at higher scanning speeds of several tens of meters per second to achieve the right combination of quality and throughput. (see Figure 1).


*FIGURE 1.*
*Quasar and Next Scan combine for precision high-speed processing.*

One system capable of generating such speeds while at the same time tightly focusing the swept pulses over a large field is Next Scan Technology's Line Scan Engine LSE170. For fast motion, a high-speed rotating 8-sided polygon scans the beam at speeds from 25 m/sec up to 100 m/sec, and a sophisticated optical focusing scheme generates small spot sizes down to 5 µm ($1/e^2$, 355 nm version) over a full telecentric scanning length of 170 mm or 300 mm. Scanners for near-infrared (~1 µm) and green wavelengths are also available, with minimum focus spots of 14 and 7 µm, respectively. The system is designed to replicate the pattern of an arbitrary binary bitmap file onto a work piece. As such, it must be used with a laser capable of receiving pulse trigger signals at essentially random time intervals, such as the Quasar.

With an LSE170 scanner for 532 nm wavelength, the capability of the Quasar laser to operate in a pulse-on-demand mode with minimal pulse temporal jitter and with stable pulse energy was demonstrated. (Actual output results shown in Figure 2.) The laser and scanner system were integrated with a Newport Corporation direct-drive linear motor stage for precise translation in an orthogonal direction, comprising a raster scan patterning system. In this study, the maximum PRF was set to 1 MHz, which represents the densest placement of pulses (50 µm separation) on the wafer and shortest time (1 µsec) between pulses. The longest time between pulses was 8 µsec corresponding to a 125 kHz effective PRF. A relatively large focus spot size of ~40 µm was used to generate larger, more visible marks. The Quasar's $TEM_{00}$ output beam was routed directly to the scanner where focusing occurred.

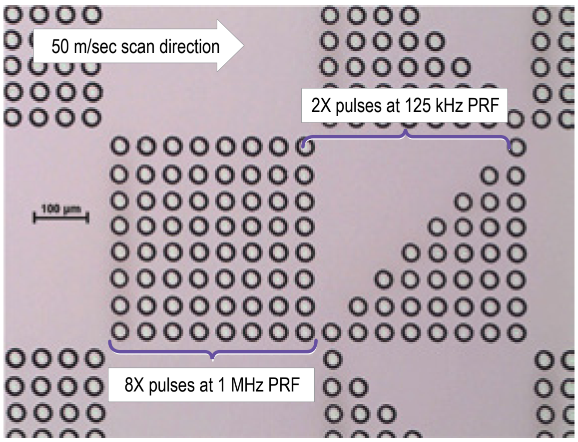


*FIGURE 2.*
*Precise ablation spots in silicon with PRF ranging from 125 kHz to 1 MHz.*

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The results of the work show cleanly patterned ablation spots scanned at 50 m/sec on the silicon forming a precise replica of the binary bitmap file. Even with a fairly large focus size, the Quasar laser produces sufficient pulse energy at 1 MHz and higher PRFs to machine silicon. Upon close inspection, there is a remarkable repeatability in the size and quality of the ablation spot. This is maintained regardless of whether the effective PRF was 1 MHz, 125 kHz, transitioning from one to the other, or somewhere in-between. These stable, clean ablation spots over the 8X range of PRF are enabled by Quasar's TimeShift pulse-shaping technology, which keeps the pulse duration and energy fixed through the wide range of pulse frequencies. With the pulse duration fixed, the interaction dynamics between the energy and material remains remarkably constant during the patterning process, resulting in identical laser-machined "bits" throughout. (see Figure 3).

Besides the question of pulse stability in the pulse-on-demand mode, there is also the question of pulse jitter. With the very high-speed scanning, even a small variability in pulse timing—either from the scanner or laser—can lead to wide variation in pulse placement on the material. In the raster scan action of the polygon scanner, successive rows of ablation spots represent successive revolutions of the spinning polygon along with an incremental motion by the motion stage. To achieve perfect vertical stacking of the spots within a column requires exceptional trigger event control. The result with the Quasar laser coupled with Next Scan trigger output meets this challenge. Measurement reveals there is only about 1.85 µm of total jitter within several successive revolutions of the polygon. The 1.85 µm pulse placement accuracy achieved at 50 m/sec is close to what is theoretically possible with LSE technology. The Quasar's carefully engineered pulse firing electronics allow for such high precision in triggered pulse output. When this is combined with Next Scan Technology's polygon scanning technology, a new regime of precision high-speed micromachining is accessible.

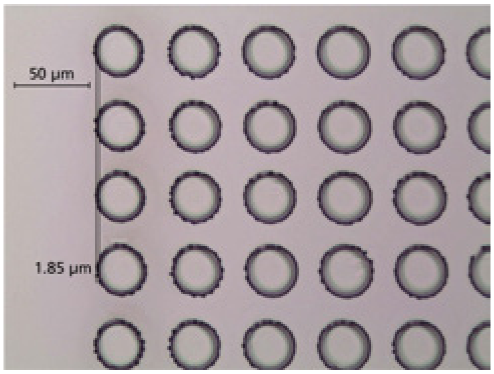


*FIGURE 3.*
*Low pulse jitter between successive polygon revolutions is demonstrated.*

## PRODUCTS: *QUASAR 355-60, QUASAR 355-45, QUASAR 532-75*

The breakthrough performance of the Quasar series leads the industry with unprecedented highest UV average power and energy at high rep rates for fast micromachining. Quasar features novel TimeShift technology for programmable pulse profiles for the ultimate in process speed, flexibility, and control. The newest Quasar laser, the Quasar 355-60, produces >60 W of UV output power at 200 kHz and 300 kHz, and >300 µJ pulse energy, complimenting Spectra-Physics' breakthrough Quasar 355-45 laser. The Quasar 355-60 operates over a wide repetition rate range from 0–3.5 MHz, with pulse widths from <2 ns to >100 ns. The Quasar 532 rounds out the Quasar series with >75 W of green output power. The Quasar family of lasers has excellent beam characteristics and very low noise.

| | Quasar 355-60 | Quasar 355-45 | Quasar 532-75 |
|---|---|---|---|
| Wavelength | 355 nm | 355 nm | 532 nm |
| Power | >60 W @ 200 kHz<br>>60 W @ 1500 kHz<br>~40 W @ 3000 kHz | >45 W @ 200 kHz<br>>45 W @ 250 kHz<br>>41 W @ 300 kHz | 75 W @ 200 kHz |
| Repetition Rate | 0 to >3.5 MHz for Quasar 355-60; 0 to >1.7 MHz for Quasar 355-45 and 532-75 | | |
| Pulse Width | Programmable with TimeShift | | |

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