Processing Flexible Printed Circuit and Microelectronics Materials with High Power UV Nanosecond Lasers

Ultraviolet nanosecond pulsed lasers continue to see increased use for manufacturing flexible printed circuit (FPC) and microelectronics components, primarily due to the high quality processing results and smaller feature capabilities of the short wavelength and the steadily improving cost and reliability. Compared to longer wavelengths, UV light couples energy more efficiently to a wider variety of materials, and the shorter pulse width reduces heat effects. In addition, FPC processing generally requires smaller features, and the UV wavelength is more easily focused to small spot sizes thereby adding an additional benefit. Materials commonly found in FPC manufacturing include copper, polyimide, and various laminates thereof.

These same properties of ns UV lasers are also beneficial to processing materials used in microelectronics manufacturing. Scribing, drilling, etc., are typical processes for materials such as silicon and ceramics in applications related to high density chip packaging, high temperature electronics substrates, and LED manufacturing.

For high power UV ns material processing, the Spectra-Physics Talon® 355-45 laser delivers 45 Watts average power and >300 µJ pulse energy at 150 kHz pulse repetition frequency (PRF). Like all Talon family products, the laser offers sustained high average power and high pulse energy stability at higher PRFs, up to 500 kHz. Recently, this laser was tested for various processes associated with FPC and microelectronics processing.

One common material processed in FPC manufacturing is a laminate of copper, polyimide, and copper (Cu-PI-Cu), typically with individual layer thicknesses of ~12–25 µm. In this material, blind vias are drilled through the top copper and middle polyimide layers, exposing the bottom copper layer pad. Subsequent copper plating of the vias forms a conducting pathway between the two copper layers, and therefore it is important to avoid damaging the bottom copper layer pad during the laser drilling process.

Using the Talon 355-45 laser, blind vias were drilled in 12/25/12 µm Cu/PI/Cu laminate using a percussion drilling process (the beam was stationary on the material without any optical deflection). With a small focus spot size of ~25 µm, the entry diameter of the vias was ~24 µm, and the bottom diameter of the via was ~10 µm. Figure 1 below shows the drilled via, imaged at the top (left) and bottom (right) of the feature.

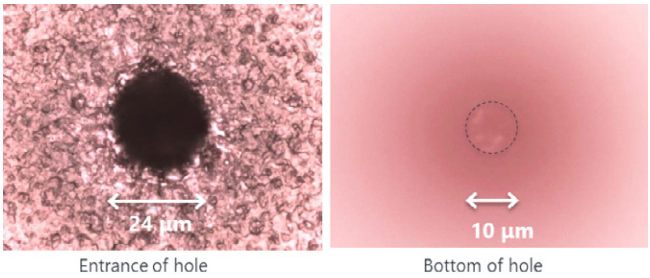

Figure 1
FPC blind via drilled with a Talon 355-45 laser through 12 µm thick copper and 25 µm thick polyimide, exposing the underlying copper layer for subsequent copper plating.

Due to the small spot size and thin material layers, the optimal process was achieved at a high PRF of 350 kHz and only 17 pulses were required. The high PRF and low number of pulses equates to a theoretical throughput of 20,000 vias per second. (Note, this throughput estimation reflects the laser capability only and does not consider the time required to deflect the beam from one via location to another.)

Silicon and alumina ceramic are two materials widely used in microelectronics/PCB/LED manufacturing for substrates, cooling media, etc. Common processes include cutting, scribing, and drilling. Using the Talon 355-45 laser, scribing speeds were characterized and compared to that of a Talon 355-30 laser with lower power and lower PRF. In the first case, silicon scribing and full-cutting was explored. Figure 2 shows the scribe depth vs. net processing speed for the two lasers.

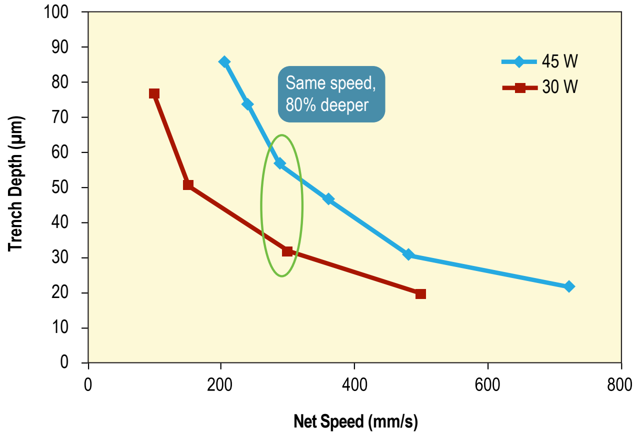

Figure 2
Scribe depth vs. net processing speed for 30 W and 45 W Talon UV lasers.

Surprisingly, the 45W Talon UV laser demonstrated a greater than anticipated throughput increase compared to the 30W version. For the same net speed of ~300 mm/s, the scribe depth was 80% deeper whereas a 50% improvement should be expected based purely on average power scaling.

Similar results were found when machining alumina ceramic plate. Figure 3 below shows depth vs. cutting speed for the two lasers for scribing 20–100 µm deep grooves.

Even more than in silicon, the scribe speed for a given depth, or the scribe depth for a given speed, is much improved when using the 45 W vs. the 30 W Talon UV laser. In alumina, we observed a

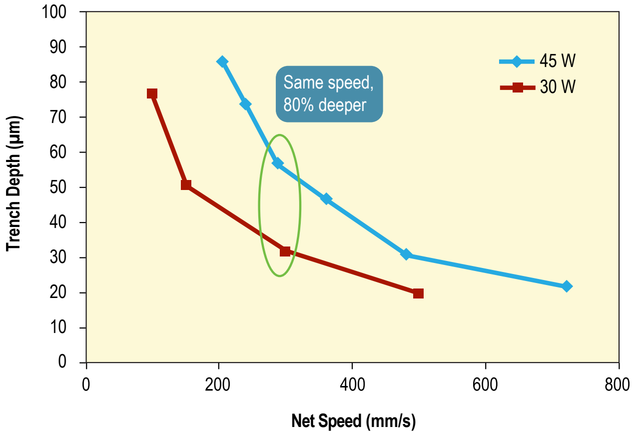

Figure 3
Talon 355-45 laser demonstrate higher processing speeds when scribing alumina ceramics.

100% (2x) enhancement, far above the expected 50% gain solely from power scaling. The Talon 355-45 was operated at its optimal 150 kHz PRF for these tests and the Talon 355-30 was operated at its optimal 100 kHz PRF. Based on previous experiments, both silicon and alumina are known to benefit from increased heating during the processing. With the higher PRF of the 45 W Talon, perhaps there was additional heat accumulation resulting in improved ablation efficiency. However, with too much heating, there is the risk of detrimental heat effects that can damage the material and decrease product yield in a manufacturing environment. In short, material heating (achieved by way of low scanning speed, high PRF, or high pulse duration) can sometimes be beneficial for material processing throughput but can also decrease quality. With the Talon laser platform, however, a variety of pulse widths can be applied to the workpiece at a variety of energies and PRFs, which makes it a flexible tool for addressing material processing challenges in a variety of industries.

PRODUCT: *TALON 355-45*

The Talon laser platform is a family of UV and green diode-pumped solid state (DPSS) Q-switched lasers that deliver an unprecedented combination of performance, reliability, and cost. Talon is based on Spectra-Physics' It's in the Box™ design, with the laser and controller combined in a single, compact package. Talon exhibits high pulse-to-pulse stability and excellent TEM_{00} mode quality for tens of thousands of operating hours. The Talon laser is designed specifically for micromachining applications in a 24/7 manufacturing environment where system uptime is critical. As presented in this Application Focus, there is a strong advantage to having available a broad range of powers and wavelengths, which is provided with the complete Talon portfolio. The Talon provides disruptive cost-performance: lowest cost-of-ownership in the industry with no compromise in features, performance, or reliability.

	Talon 355-45
Wavelength	355 nm
Power[*]	>30 W @ 100 kHz
	>45 W @ 150 kHz
	>35 W @ 200 kHz
	>23 W @ 300 kHz
Repetition Rate	0–500 kHz
Pulse Width	<40 ns @ 150 kHz
Pulse-to-Pulse Energy Stability	<2% rms @ 150 kHz
	<3% rms up to 300 kHz
	<5% rms above 300 kHz
Beam Quality (M^2)	<1.2

[*] Power specification and warranty applies to **Boldface power** specs only. Other values are typical.

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