High Power, High Repetition Rate UV Lasers for Fast Flex-PCB Processing

In recent years, UV wavelength lasers have become the workhorse in many industries for precision micromachining applications. Moving to UV results in an ability to process a wider variety of materials with improved quality and higher precision compared to longer wavelengths.

For industrial OEM manufacturing, Spectra-Physics introduced Talon®, a disruptive cost-performance line of UV lasers. One large and growing market for laser processing is PCB manufacturing, which has traditionally used CO_2 and excimer lasers but is increasingly moving towards UV DPSS lasers. The migration to UV DPSS laser technology is driven by several factors, including the need to machine smaller features with higher precision and density, the ability of UV wavelengths to process many types of materials with good quality and the improving cost-performance of UV DPSS products available on the marketplace.

The Talon UV product family is highly versatile and allows for product offerings with widely variable configurations in terms of power, energy and pulse repetition frequency. For example, the 15 W UV Talon offers a high 300 µJ of pulse energy at 50kHz for larger feature machining in thicker materials such as FR4-based rigid PCBs. On the other hand, the more recently introduced 20 W UV Talon has lower maximum pulse energy but maintains an elevated power output level at very high PRFs, which is ideal for processing thinner materials with a tight beam focus and fast beam scanning equipment for high-speed, high-resolution fine-feature machining. Figure 1 below shows how the power output varies between the 15 and 20 W Talon versions through a range of pulse repetition frequencies (PRFs).

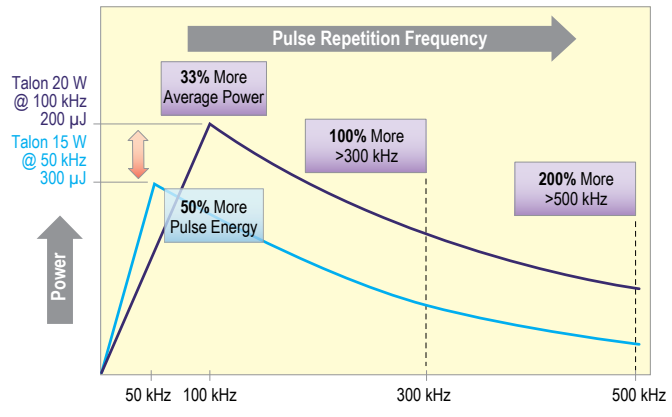

Figure 1: The Talon 20 W and 15 W UV power curves out to 500 kHz.

As electronic devices shrink and improve in performance, the need for compact and thin flex-PCBs is growing rapidly. Flex-PCBs are typically comprised of layers of materials on the order of 10's of micrometers in thickness. Materials include copper foils, polyimide sheets, and adhesives to create various laminates. A typical flex-PCB material is comprised of 12 µm thick polyimide laminated in between two copper foils of the same or similar thickness (Figure 2). In flex-PCB fabrication, laser processes may include blind- and thru-via drilling, straight-line and contoured cutting, as well as 2-dimensional patterning. Given the high power at high PRFs that is available from the new Talon 355-20 laser, we have optimized various high-speed processes with this material.

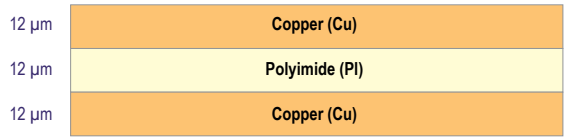

Figure 2: Schematic of a typical flex PCB laminate comprised of 12 µm of polyimide sandwiched between 12 µm copper layers.

By optimizing scanning speed and pulse frequency to achieve the proper spot overlap in the material, the result is high-quality cutting at high speeds. Due to the Talon's high average power at high PRFs, there is still sufficient pulse energy to ablate the copper material up to several hundred kHz. The Cu/PI/Cu material in Figure 2 can be cut through with the Talon 355-20 laser at over 450 mm/sec, operating at 500 kHz. The optical micrograph in Figure 3 shows the exceptional cutting quality that is achieved, exhibiting minimal burring and small heat-affected zone (HAZ).

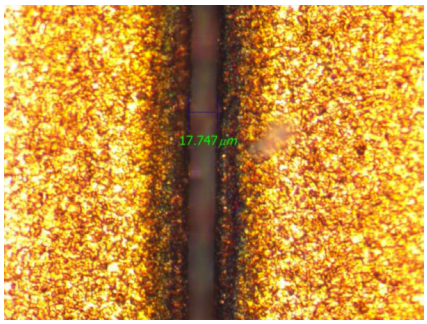

Figure 3: Optical micrograph showing quality of Cu/PI/Cu flex-PCB laminate processed with the Talon UV laser.

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The Talon UV laser was also tested for high-speed percussion drilling of blind vias in a similar Cu/PI/Cu laminate material. In this case, the middle polyimide layer was twice as thick, at 25 µm. High-quality vias (Figure 4) with sub-30 µm diameter opening size were processed at very high pulse frequencies to minimize the drilling time. With the Talon operating at 300 kHz, just twenty pulses were required for drilling each hole, which equates to a throughput of 15,000 holes per second.

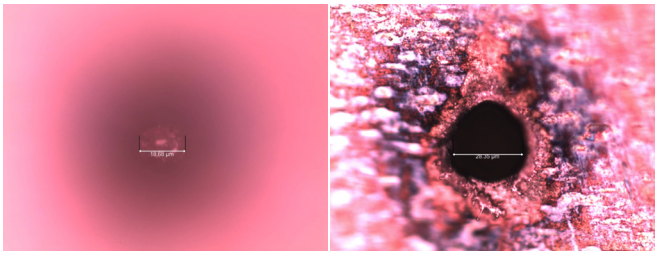

Figure 4: Bottom surface (left) and top surface (right) of blind via drilled with Talon UV laser.

Thin polyimide film is also used extensively in flex-PCB manufacturing as a coverlay material to protect circuitry from harsh environments, similar to solder masks in thick PCB manufacturing. UV wavelengths are very effective for processing polyimide with high quality and precision, due to the strong optical absorption by the material and subsequent photo-ablation. With thicknesses around 12-25 µm commonly used, cutting of these materials is ideally achieved with a high PRF, lower energy laser source. Talon is ideal for such requirements and a wide range of cutting speeds are possible with the various product offerings, as shown in Figure 5.

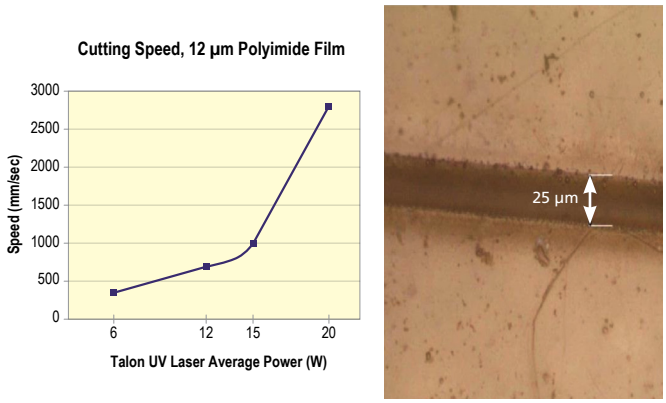

Figure 5: Talon product cutting speeds for ~12-µm thick polyimide.

PRODUCTS: *TALON 355-20*

Talon is a new family of UV and green DPSS Q-switched lasers that deliver an unprecedented combination of performance, reliability and cost. Based on Spectra-Physics' *It's in the Box*™ design, with the laser and controller combined in a single, compact package, Talon 355-20 uses field-proven technology to output >20 W and >200 µJ per pulse of UV, plus a wide repetition rate range of 0 to 500 kHz, 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. UV nanosecond lasers are becoming the workhorse in many industries for precision micromachining applications, for example in high speed and high quality PCB processing applications. Talon provides disruptive cost-performance: the lowest cost-of-ownership UV in the industry with no compromise in features, performance or reliability.

	Talon 355-20	Talon 355-15	Talon 355-12	Talon 355-6	Talon HE 355-500	Talon HE 355-275
Wavelength	355 nm					
Power	20 W @ 100 kHz 11 W @ 300 kHz >7 W @ 450 kHz	15 W @ 50 kHz 13 W @ 100 kHz 3 W @ 300 kHz	12 W @ 50 kHz 10 W @ 100 kHz 3 W @ 300 kHz	6 W @ 50 kHz 4 W @ 100 kHz 1 W @ 300 kHz	10 W @ 20 kHz 7.7 W @ 40 kHz 4.2 W @ 100 kHz	5.7 W @ 20 kHz 11 W @ 40 kHz 5.9 W @ 100 kHz
Repetition Rate	0 to 500 kHz				0 to 200 kHz	
Pulse Width	<25 ns @ 100 kHz				50 to 90 ns @ 40 kHz	

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