Ceramic Scribing Using Talon® Pulsed UV and Green Lasers

Ceramic materials are used extensively in the microelectronics, semiconductor, and LED lighting industries because of their electrically insulating and thermally conductive properties, as well as for their high-temperature-service capabilities. Their brittleness makes laser processing attractive when compared with conventional machining, particularly for producing the increasingly small and intricate features required for advanced microelectronics packaging.

Scribing is one of the commonly performed ceramic machining operations. In this Application Focus, we consider two cases of laser scribing using Spectra-Physics' Talon® family of pulsed nanosecond ultraviolet (UV) and green lasers: (1) shallow scribing (for scribe-and-break process) and (2) deep scribing (for full-cut process). We studied both processes in two widely used ceramic materials: alumina and aluminum nitride. For high processing speeds, we tested high power green and UV Talon product offerings: the green (40 W) model Talon 532-40 and the UV (30 W) model Talon 355-30.

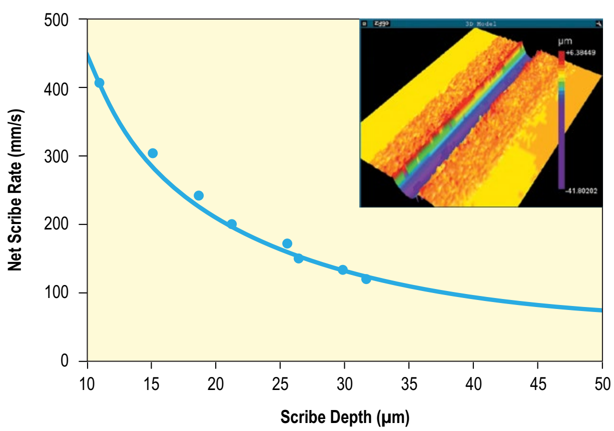

Figure 1: Shallow scribing in alumina using a Talon 355-30 laser. Inset graphic shows good scribe quality with average burr height ~4 µm.

Figure 1 shows the scribe rate as a function of scribe depth in alumina for shallow scribes using a Talon 355-30 UV laser. The Talon 355-30 provides the best balance of speed and quality, producing a fast scribe (50 µm deep at approximately 75 mm/s) with good quality (4 µm average burr height). The Talon 532-40 laser was comparable in speed, but with lower quality scribes (6 µm average burr height).

Figure 2 shows the scribe rate as a function of scribe depth in alumina for deep scribes using a Talon 532-40 laser. For the deep scribes, the Talon 532-40 provided the best balance of speed and quality, producing

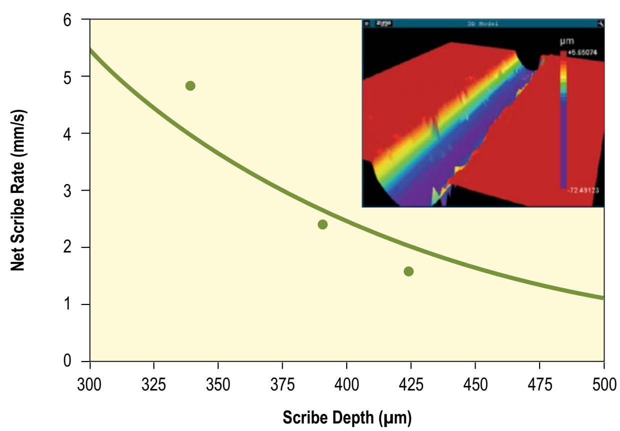

Figure 2: Deep scribing in alumina using a Talon 532-40 laser. Inset shows good scribe quality with burr height <1 µm.

a 300 µm deep scribe at approximately 5.5 mm/s with excellent quality (<1 µm burr height). The scribe quality was generally better for deep scribes compared with shallow ones. Likely this can be ascribed to the removal of accumulated dross by the large number of passes required for deep scribes. For the same 300 µm deep scribe, the speed for the 30 W UV Talon was 1.8 mm/s. Although the green wavelength produces a faster deep scribe in alumina, UV could potentially be preferable for some applications requiring small features because it allows for a tighter focus and therefore a smaller kerf width.

Figure 3 shows the scribe rate as a function of scribe depth in aluminum nitride for shallow scribes using a Talon 355-30 laser. The Talon 355-30 yielded the best balance of speed and quality, producing a fast scribe (50 µm deep at approximately 45 mm/s) with excellent quality with little or no burr. The green Talon 532-40 was more than two times faster at ~100 mm/s, but the quality was inferior (4 µm burr height). However, if burr height is of lesser concern, then the green Talon would be the preferred option for its high cutting speed.

Figure 4 shows the scribe rate as a function of scribe depth in aluminum nitride for deep scribes using a Talon 355-30 laser. For the deep scribes, the Talon 355-30 resulted in the best balance of speed and quality, producing a 300 µm deep scribe at approximately 1.5 mm/s with excellent quality (negligible burr). As was the case for the shallow scribes, the green Talon 532-40 was faster than UV (~2.8 mm/s), but lower quality (2 µm average burr height).

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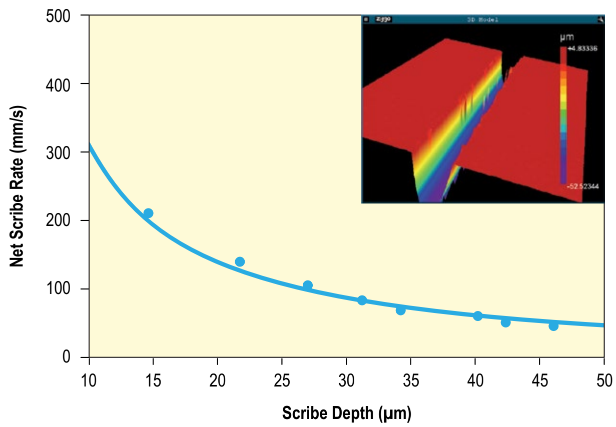

Figure 3: Shallow scribing in aluminum nitride using a Talon 355-30 laser. Inset shows excellent scribe quality with negligible burr.

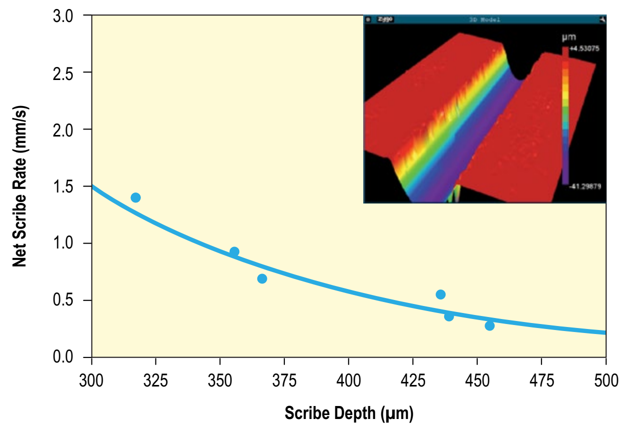

Figure 4: Deep scribing in aluminum nitride using a Talon 355-30 laser. Inset shows excellent scribe quality with negligible burr.

Note also that the advantage of the green Talon relative to UV for deep scribing aluminum nitride was significantly less than was the case for deep scribing of alumina (2× vs. 3× advantage). We speculate that two factors may be at play: (1) cumulative heating in alumina, which has lower thermal conductivity than aluminum nitride, and (2) greater self-limiting behavior for deep scribing with green compared with UV because of the higher divergence combined with higher transparency of green light in alumina ceramic compared with UV.

Laser machining of ceramics is enabling applications that are not well-suited for conventional ceramic machining processes because of the requirement for smaller and more intricate features. Both UV and green wavelengths offer advantages in different regions of the ceramics machining application space. Selection of the right laser in terms of wavelength, power, and other characteristics is necessary to optimize the process.

PRODUCTS: *TALON 355-30 & TALON 532-40*

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 355-30	Talon 532-40
Wavelength	355 nm	532 nm
Average Power	>30 W @ 100 kHz	>40 W @ 100 kHz
Maximum Pulse Energy	>300 µJ	>400 µJ
Repetition Rate	0–500 kHz	0–500 kHz
Pulse Width	<25 ns @ 100 kHz	<25 ns @ 100 kHz
Pulse-to-Pulse Energy Stability	<2% RMS @ 100 kHz	<2% RMS @ 100 kHz
Beam Quality (M^2):	<1.2	<1.2

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