Application Focus

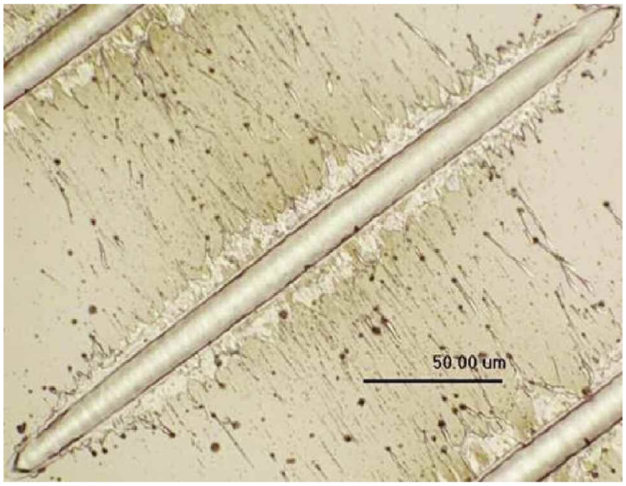
Industrial Laser Applications Lab

No. 5

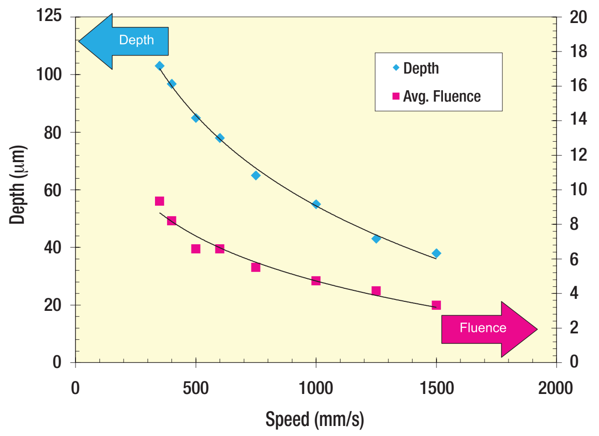
High Speed Laser-Dicing of Thin Silicon Wafers Using Line-Focus

Laser dicing of silicon wafers has been in use for several years—and it is a growing application. As wafers become thinner, and as lasers become more powerful, the advantage of laser dicing increases dramatically. And naturally, this leads to the question: what is the best laser for the job?

The answer is not simple. For pulsed lasers with the same average power and repetition rate, the speed and quality of a dicing process can vary widely due to the strong influence of other laser characteristics such as pulse duration and wavelength. For example, while longer pulse widths and longer wavelengths will generally cut faster, they are also more likely to cause excessive melting and cracking. Alternatively, shorter pulse widths (ps, fs) and shorter wavelengths (UV, DUV) will offer the best quality result with minimal HAZ (heat affected zone) and higher die strength, but at a much higher cost and with lower system throughput. With these considerations, many in the industry have found short ns-pulse 355 nm Q-switched laser systems to be ideal for wafer scribing and dicing applications.



Single-pulse ablation spot in silicon using Pulseo laser with high-aspect ratio elliptical line focus beam spot



Ablation depth (blue, left scale) and optimal processing fluence (pink, right scale) vs. cutting speed

Today's laser products offer ever-higher power levels—and this holds true even for short-ns pulse widths and 355 nm wavelength. With this trend, the challenge increasingly becomes utilizing this higher power and pulse energy as efficiently as possible. In Spectra-Physics' Industrial Laser Applications Lab, we have examined experimentally the efficiency advantage of line-focus fluence optimization for thin silicon dicing. We have shown that even with the high-quality of short pulse and short-wavelength processing, exceptionally high cutting speeds are still possible, as highlighted in the table below.

Wafer Thickness	Approximate Cutting Speed
25 µm	2000 mm/sec
50 µm	1000 mm/sec
75 µm	600 mm/sec
100 µm	375 mm/sec

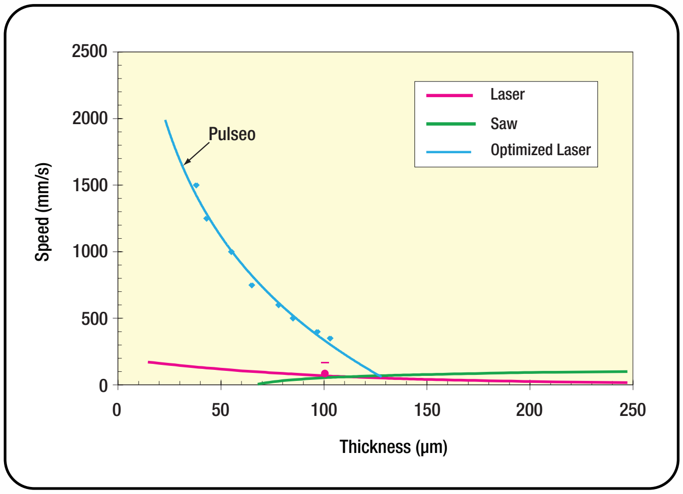
The low ablation threshold – which is a result of the short pulse width – coupled with line-focus fluence optimization offers the best of both worlds: high-quality of short pulse/short wavelength machining with industrial-scale process speeds.

Spectra-Physics®

A Newport Corporation Brand

High Speed Laser-Dicing of Thin Silicon Wafers Using Line-Focus

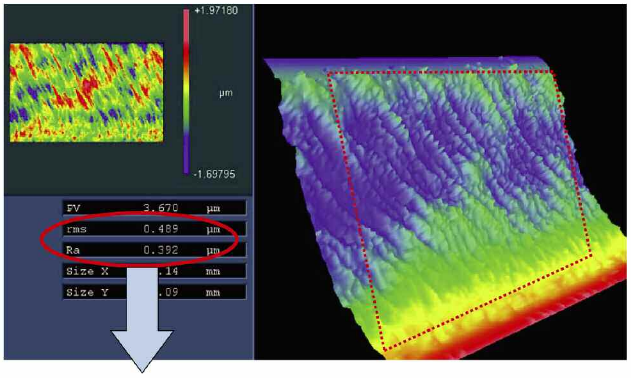
There is a long list of publications on laser processing of silicon wafers. From very long to very short pulse widths – and likewise for wavelength – quality and efficiency has been well characterized. In particular, thin wafer dicing speeds using ns-pulse 355 nm Q-switched lasers as compared to traditional diamond saw dicing has been published relatively recently*. Compared to these results, Pulseo 355-20 laser data using line focus fluence-optimization technique shows significant improvement—changing the processing speeds from barely 100's of mm/s into the meters-per-second regime.



Product: Pulseo Laser

The Spectra-Physics Pulseo 355-20 laser has the highest-power offering in our UV Q-switched laser product portfolio. With 200 µJ pulses delivered 100,000 times a second, high-throughput performance is achieved; and at <23 ns pulse width, quality does not suffer. This is the high-peak power benefit.

Model	Wavelength	Peak Power	Average Power	Pulse Width	Repetition Rate (nominal)
Pulseo 355-20	355 nm	~10 kW	>20 W	<23 ns at 100 kHz	100 kHz
Pulseo 355-10	355 nm	~5 kW	>10 W	<23 ns at 90 kHz	90 kHz



Sidewall roughness: RMS <0.5 µm, Ra <0.4 µm

Beyond high cutting speeds, the line-focus processing technique coupled with the Pulseo laser's short-pulse and 355 nm wavelength results in exceptional quality and low HAZ, both of which are essential for a successful wafer-dicing process. The longer beam spot produces a very high pulse-overlap on the material and therefore a heavy averaging effect, resulting in the formation of smooth, laser precision-cut sidewalls. Measurement data from an optical profiler has shown <0.5-µm RMS roughness and <0.4 µm Ra measurement for a 97-µm deep cut at 400 mm/s scan speed.

---

* Proc. SPIE 6458, P1-9 (2007)