Processing of Ultrahard Materials at Superior Speed and Quality Using a High Power Femtosecond Laser

Laser machining of ultrahard materials, such as tungsten carbide (WC) and polycrystalline diamond (PCD) is finding wide use in the cutting tools manufacturing industry. In contrast to conventionally used grinding and electro-discharge machining, laser machining offers geometric flexibility, material independency, shorter machining time and a force- and wear-free process. Machining of PCD using nanosecond laser technology leads to formation of graphitic carbon on the surface, which reduces quality and the lifetime of cutting tools. Therefore, the application of femtosecond (fs) pulsed lasers for machining of PCD is very promising due to the non-thermal nature of material removal and the possibility of structuring micron-scale features with clean high surface quality.

The Spirit® 1030-100 SHG laser from Spectra-Physics (Fig. 1) sets new standards for femtosecond lasers in high-precision industrial manufacturing. This laser offers impressive versatility and performance, enabling a variety of applications. High average power (>100 W) and high pulse energy (>100 µJ) combined with high repetition rate (up to 10 MHz) and short pulse duration (<400 fs) push femtosecond micromachining applications to highest levels of throughput at lowest cost-of-ownership. The user-configurable burst mode further enables

Figure 1. Spectra-Physics' Spirit 1030-100 high power industrial femtosecond laser.

processing with increased ablation efficiency, and thus increased throughput and quality for certain materials. Additionally, the integrated second harmonic generation (SHG) offers an output power of >50 W and a typical pulse width of 400 fs at a wavelength of 515 nm.

The Spirit 1030-100 laser system has been used to machine PCD. Two important factors for the cutting tool manufacturing, material removal rate and surface roughness, were studied.

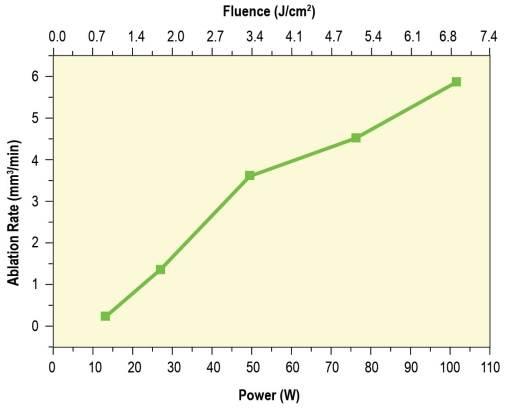

Figure 2. Removal rate for PCD as a function of the applied average power and laser fluence using a Spirit 1030-100 femtosecond laser at wavelength of 1030 nm.

Material removal rate

Throughput is an important factor to consider when comparing results achieved using different laser systems or technologies. The removal rate of PCD as a function of the applied average power and the laser fluence at 1030 nm is shown in Figure 2. The removal rate of up to 6 mm^3/min can be achieved using 100 W average power using the Spirit 1030-100 femtosecond laser at 1030 nm. The demonstrated removal rate is a factor of 10 higher than that for conventional grinding or electro-discharge machining.

Surface Roughness

Surface finish after the laser machining was investigated using a confocal optical microscope. Figure 3 shows the surface topology and 2D roughness profile of the edge perpendicular to the top surface of PCD plate which emulates surface quality of the clearance face of a cutting tool. The resulting surface roughness of R_a <0.05 µm achieved with the Spirit 1030-100 femtosecond laser is significantly lower than the typical surface roughness (of >0.2 µm) achieved using conventional methods of machining PCD.

Our results show that a high power Spirit 1030-100 femtosecond laser is an ideal choice for machining of ultrahard materials for cutting tool manufacturing with higher removal rate and very high quality.

Spectra-Physics®
A Newport Company

Processing of Ultrahard Materials at Superior Speed and Quality Using a High Power Femtosecond Laser

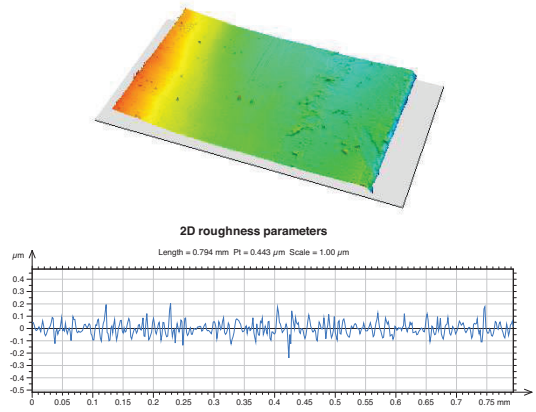

Figure 3. Surface topology and 2D roughness profile of the edge perpendicular to the top surface of a PCD plate after femtosecond laser cutting. The surface roughness of R_a< 0.05 µm is achieved using the Spirit 1030-100 femtosecond laser.

PRODUCTS: ***SPIRIT 1030-100 & SPIRIT 1030-70***

The Spirit 1030-100 and 1030-70 lasers set new standards for femtosecond lasers in high-precision industrial manufacturing. These lasers deliver high average power, high pulse energy, and high repetition rates for increased throughput. Customers benefit from the shortest industrially available pulse duration and superior beam quality that in turn enables machining complex and challenging parts with highest precision and quality with no heat affected zone (HAZ) at the highest throughput. Spirit 1030-100 and 1030-70 are designed for industrial use and offer reliable and robust 24/7 operation with lowest cost of ownership.

	Spirit 1030-100	Spirit 1030-70
Wavelength	1030 nm ±5 nm	
Output Power	>100 W	>70 W
Pulse Energy	>100 µJ	>70 µJ
Repetition Rate	Single shot to 10 MHz	
Pulse Width	<400 fs	
Pulse-to-Pulse Energy Stability	<2% rms	
Power Stability	<1% rms over 100 hours	
Spatial Mode	TEM_{00} (M^2 <1.2)	
Beam Diameter	2.5 ±0.5 mm	
Laser Dimensions (L x W x H)	39.5 x 14.5 x 8.1 in (1003 x 369 x 205 mm)	
Laser Weight	155 lbs (70 kg)	

Spectra-Physics®
A Newport Company

www.spectra-physics.com

3635 Peterson Way, Santa Clara, CA 95054, USA
PHONE: 1-800-775-5273 1-408-980-4300 FAX: 1-408-980-6921 EMAIL: sales@spectra-physics.com

Belgium	+32-(0)0800-11 257	belgium@newport.com	Korea	+82-31-8021-1600	korea@spectra-physics.com
China	+86-10-6267-0065	info@spectra-physics.com.cn	Netherlands	+31-(0)30 6592111	netherlands@newport.com
France	+33-(0)1-60-91-68-68	france@newport.com	Singapore	+65-6664-0040	sales.sg@newport.com
Germany / Austria / Switzerland	+49-(0)6151-708-0	germany@newport.com	Taiwan	+886 -(0)2-2508-4977	sales@newport.com.tw
Japan	+81-3-3794-5511	spectra-physics@splasers.co.jp	United Kingdom	+44-1235-432-710	uk@newport.com

SP-AP-20180520-18