

CFRP Machining Using Pulsed UV Lasers

A strong drive to increase fuel efficiency and reduce carbon emissions in transportation industries is driving the use of Carbon Fiber Reinforced Polymer (CFRP) material in the fabrication of various aircraft and automobile parts. CFRP is a lightweight, strong, durable material with good corrosion and vibration resistance. CFRP is a good candidate to replace many metal parts. An optimally designed CFRP part can be up to 70% lighter than steel and 30% lighter than aluminum. These attributes also make CFRP attractive for use in many non-transportation related industries, such as wind energy production components, sports equipment, oil exploration equipment, and consumer electronics products.

The attributes that make CFRP a very unique and useful material also make it difficult to machine with high quality. Conventional mechanical and waterjet cutting techniques are costly due to high tool wear and operating costs. Also, fiber fracture and delamination of material during machining is very common and results in a high yield loss. The use of lasers for machining provides the advantages of a non-contact process and the ease of automation in manufacturing environments. However, there is a key challenge for laser machining of CFRP, which is to machine it with both high throughput and with minimal heat affected zone (HAZ) formation in the material.

High power continuous wave infrared wavelength lasers with multi-kilowatt power levels can machine CFRP at higher speeds but leave the material with unacceptably large heat affected zone (HAZ). On the other hand, ultrashort pulse lasers can provide low HAZ but usually machine materials at slow speeds. So, the challenge is to find a laser source and process that deliver a good balance of speed and quality.

Pulsed nanosecond lasers thus far have shown moderate processing speeds with reasonable quality, with the wavelength often having a significant impact on results achieved. In particular, the stronger absorption at ultraviolet (UV) wavelength results in good quality machining. The Spectra-Physics® high power UV Quasar® laser with TimeShift™ pulse-shaping technology is uniquely suited to ablate, cut, and drill CFRP material without damaging the fibers and deliver both high speed and quality.

To demonstrate the capability of our Quasar UV laser we machined 250 µm thick PAN-based CFRP plate material. We varied the pulse width, power, repetition rate, and scanning speed. We also tested the burst machining capability provided by Quasar's TimeShift technology. The cutting speed and heat affected zone (HAZ), here defined as the average length of exposed fibers along the cut line, for various conditions were characterized.

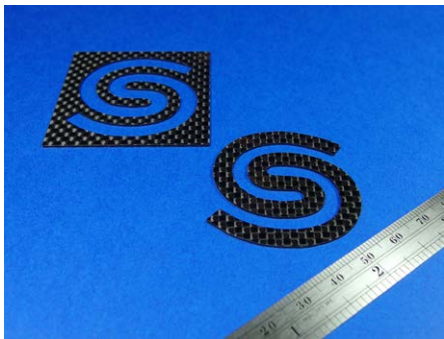


Figure 1: Spectra-Physics logo cutout in ~1 mm thick CFRP plate.

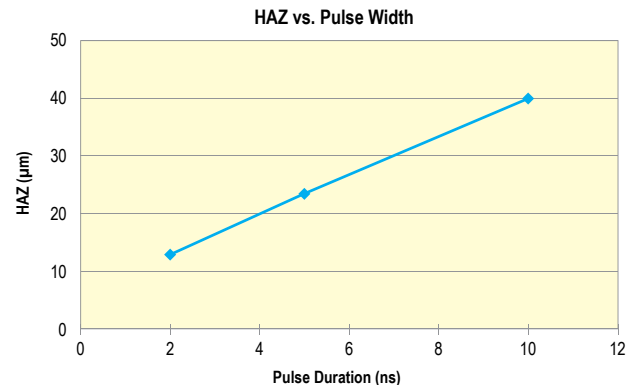


Figure 2: Effect of pulse duration on HAZ.

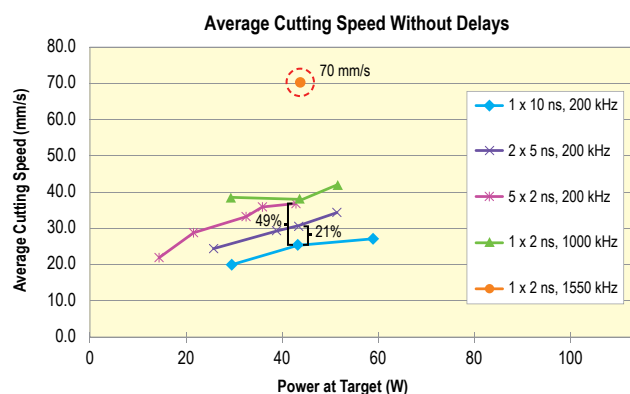


Figure 3: Effect of power, repetition rate, and pulse duration (including burst of pulses) on cutting speed.

CFRP Machining Using Pulsed UV Lasers

The results show that both speed and quality are achieved with Quasar. The smallest HAZ of ~15 μm was achieved using 2 ns pulses. This is an average over a number of process conditions, and in some cases the HAZ was effectively zero. Burst machining proved to be advantageous, achieving 20 to 50% higher cutting speeds for the same average power. Through additional process development and optimization efforts we have shown that the Quasar can cut 250 μm thick CFRP plates at 70 mm/sec with HAZ of < 15 μm.

Besides cutting and drilling, bonding and joining of CFRP parts are very important processes since traditional riveting and other types of fastening techniques require hole drilling in the material,

which can be detrimental to the strength of the part due to fiber damage during the drilling process. Thus, adhesive bonding is desirable and a commonly used technique for joining of CFRP parts. However, parts need to be cleaned of the various residues and debris imparted to the surface by the molding process. A thorough cleaning and surface texturing of the part without damaging the fibers is crucial to achieve higher joint strength. Research shows that parts textured with a UV laser have higher strength compared to those textured with an IR laser. We have demonstrated an area cleaning and surface texturing rate of 80 mm²/min using the Quasar UV laser without any visible damage to the fibers.

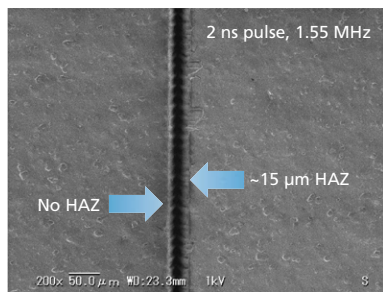


Figure 4: SEM image of CFRP sample showing excellent laser cut quality.

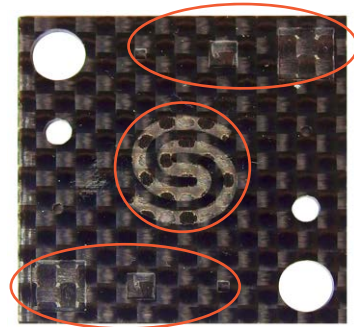


Figure 5: Surface textured CFRP without any visible fiber damage.

PRODUCTS: **QUASAR 355-60, QUASAR 355-45, QUASAR 532-75**

The breakthrough performance of the Quasar lasers leads the industry with unprecedented highest UV average power and energy at high repetition rates for fast micromachining. Quasar features novel TimeShift™ programmable pulse technology for the ultimate in process speed, flexibility, and control.

The newest Quasar laser, Quasar 355-60, produces >60 W of UV output power at 200 kHz and 300 kHz, and >300 μJ pulse energy. The Quasar 355-60 operates over a wide repetition rate range from 0-3.5 MHz, with pulse widths from <2 ns to >100 ns.

	Quasar 355-60	Quasar 355-45	Quasar 532-75
Wavelength	355 nm	355 nm	532 nm
Power	>60 W @ 200 kHz, 10 ns >60W @ 300 kHz, 10 ns	>45 W @ 200kHz, 10 ns >45 W @ 250kHz, 10 ns >41 W @ 300kHz, 10 ns	>75 W @ 200kHz, 10 ns
Repetition Rate	0 to >3.5 MHz	0 to >1.7 MHz	
Pulse Width	<2 to >100 ns	<5 to >100 ns	



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	+82-31-8069-2401	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

© 2015 Newport Corporation. All Rights Reserved. Spectra-Physics, the Spectra-Physics logo and the Newport logo are Registered Trademarks of Newport Corporation. Quasar is a Registered Trademark and TimeShift is a Trademark of Newport Corporation. Spectra-Physics Santa Clara, California, Stahnsdorf, Germany, Rankweil, Austria and Tel Aviv, Israel have all been certified compliant with ISO 9001.

SP-AP-20150820-23

nonstop... volume production | nonstop... cost-performance | nonstop... industrial lasers