NEW APPLICATION NOTE

Machining Carbon Fiber Reinforced Plastics with Picosecond High-Energy Lasers

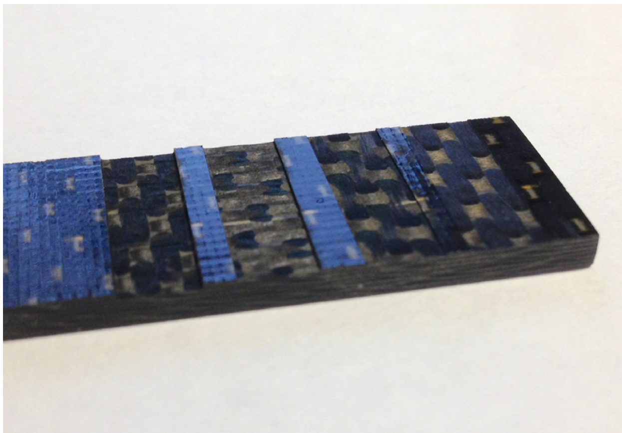
Carbon fiber composites are a growing material of interest for a number of large industrial markets, and they will continue to find more applications in the future. Nearly all implementations of carbon fiber based materials require machining of the bulk materials; from drilling and cutting to milling and joining. Long pulse and CW lasers have demonstrated utility in some bulk processing applications but often suffer from significant and detrimental heat-related side effects. The introduction of ultrafast lasers is instrumental for sensitive processing applications since those side effects can be completely alleviated.

Fianium's high-energy picosecond fiber lasers produce pulse energies up to 125 µJ with incredibly high peak power and high repetition rate that makes them cost-effective tools for high throughput laser processing a variety of composite materials. They provide the capability of inexpensive, maintenance-free, athermal milling, drilling, and general processing of carbon fiber composites. The quality and throughput capabilities make Fianium's picosecond high-energy lasers the ideal tools for the process.

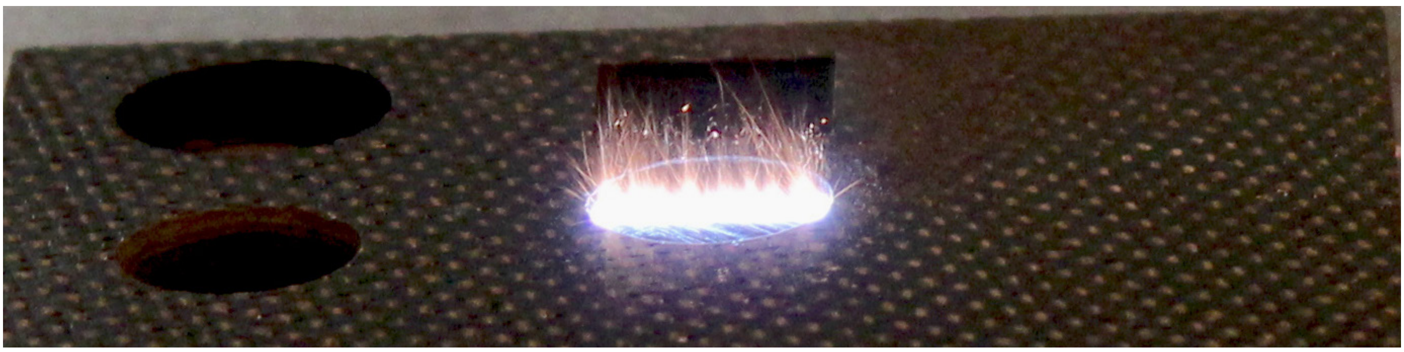
- Up to **125 µJ** pulse energy and **25W** average power
- Picosecond and femtosecond pulse widths
- Single-shot to **40MHz** variable repetition rate
- **1064 nm** or **532 nm** wavelength
- Designed for **24/7** operation and OEM integration
- Maintenance-free

Applications Lab

Fianium's application lab in Portland, Oregon is available for clients to evaluate the effectiveness of Fianium lasers for their custom application. We offer a host of micromachining application capabilities including but not limited to thin film processing, transparent material processing and athermal CFRP machining.



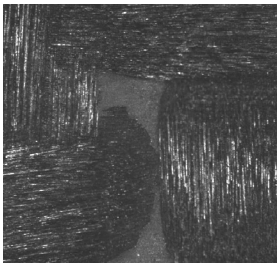
Carbon fiber composite sample cleanly milled to depths of 100-500 µm



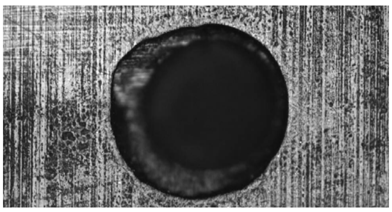
High-Energy Picosecond Lasers for Microprocessing Carbon Fiber Reinforced Plastics

Carbon fiber composites are being applied to more and more manufacturing environments every year. What was once a niche material used in the fabrication of only a handful of applications is being increasingly used within larger conventional industrial spaces such as aerospace and automotive. The benefit of these composite materials is, of course, the incredibly high strength to weight ratio that far surpasses that of any metals. The downside however, is the difficulty of processing them without causing detrimental collateral damage. Virtually all integrated parts require processing to create holes for fasteners, milling to create surfaces for joining, and simply cutting shapes for parts, but processed area edge quality can be a significant cause of part failure in the case of heat-related or mechanical processing.

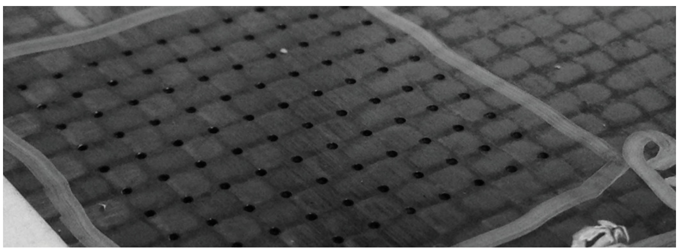
Problematic issues with conventional mechanical cutting and drilling of carbon fiber reinforced plastics (CFRP) can be cracking and delamination of the epoxy-carbon layers that can undermine the strength of the part, particularly at the edges. For conventional long pulse and CW laser processing of CFRP, heating, melting, delamination, and carbonization of the surrounding material can be problematic and can extend millimeters into the matrix. Ultrafast high-energy lasers, however, offer the short pulse widths that enable truly athermal ablation of the polymer matrix and the carbon fibers. The result of using such short pulsewidths can be extremely clean cuts, drill holes, and milling surfaces. The microscope image center left of this page demonstrates the quality of the process for milling down into a carbon fiber material. The fibers that remain behind are intact and the polymer material between the fiber weave remains uncharred or otherwise damaged.



Microscope image of the surface of CFRP milled down 300 µm using Fianium's picosecond high-energy fiber lasers



Microscope image of a 400 um diameter hole drilled through 1 mm thick CFRP (left) and a macroscopic photo of an array of holes in a 1 mm thick coupon (bottom).



Holes can also be drilled through CFRP materials with Fianium's picosecond fiber lasers and one example of an array of 400 µm holes drilled through a 1 mm thick coupon is demonstrated at the bottom-left of the page. The microscope image demonstrates that there are no discernable heating affects in the sidewalls, and the macroscopic photo shows the overall quality of the remaining CFRP material. No detrimental side effects are apparent.

Photo of rings milled into the surface of a CFRP coupon, 250 µm deep per ring (top). Microscope image of the concentric rings (left).

High-energy picosecond fiber lasers can also be used to machine arbitrary 3D profiles into the surface of carbon fiber composites. The image above shows an example where a series of concentric rings were machined into the surface 250 µm deeper at each step. The material left behind is a clean surface of fiber and polymer, as shown in the microscope image. There is no cracking, delamination, or charring visible.

Summary

Fianium's picosecond fiber lasers provide the short pulses necessary for athermal processing of materials like carbon fiber composites. These materials can be drilled, milled, and generally processed with none of the detrimental side effects inherent to CW and long pulse machining. No cracking, delamination, charring, or melting is observed when CFRPs are processed with short picosecond pulses. The high energy available, up to 125 µJ, coupled with the short pulsewidth and high repetition rate makes Fianium's ultrafast high-energy fiber lasers ideal tools for high quality and high throughput laser machining of CFRP.

This work done in conjunction with Liverpool John Moores University