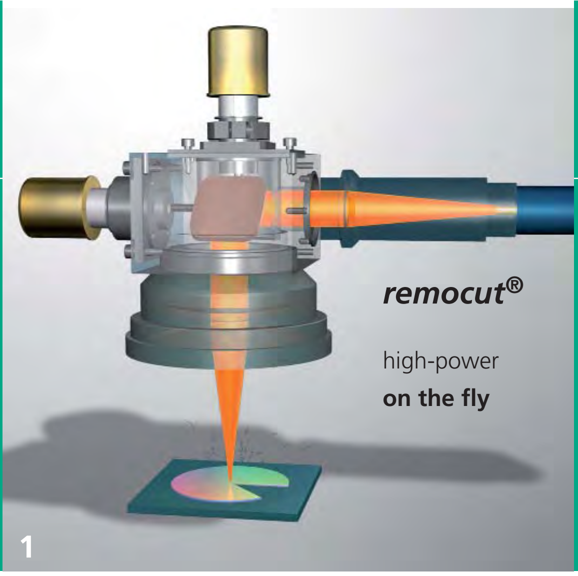


REMOTE PROCESSING OF CARBON FIBER REINFORCED POLYMERS WITH BRILLIANT BEAM SOURCES

THE TASK

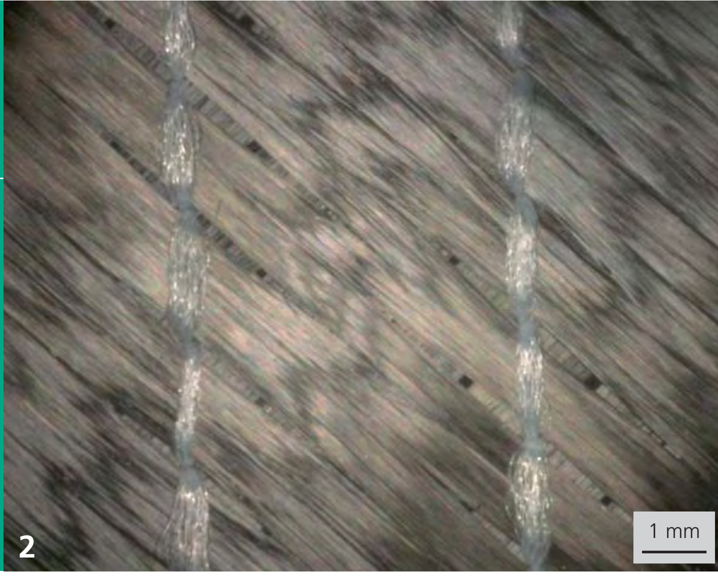
The development of new technologies for energy efficient transportation of people and goods increasingly requires manufacturing solutions for high performance construction materials. Carbon fiber reinforced materials (CFC) combine high specific tensile strengths with low densities, which leads to a great application potential. Since many years these materials have been used in the aerospace and other specialized industries. However, the high volume processing of CFC based parts as required for the automotive industry is barely developed. One of the limiting factors is the currently used forming process, which is based on a duroplastic matrix. This process requires long hardening times and special consolidation strategies to optimize the carbon fiber / matrix bonding. An additional problem is that the individual fibers have strongly anisotropic strength properties. A part that is stressed in multiple directions requires careful construction considering the specific alignment of unidirectional fiber polymer layers.

Besides forming, there are other time consuming manufacturing steps such as cutting and the fabrication of openings or bores. The material properties lead to additional difficulties during mechanical processing. Issues include large material damage in the processing zone and low removal rates with high tool wear. The use of water jet cutting is limited due to layer delamination and accessibility limitations in strongly curved surfaces.

Lasers are already industrially used to structure and ablate CFC materials. However, these processes are insufficient to address the needs of flexible mass production due since they are using pulsed beam sources of medium power levels. Based on these considerations it is evident that new flexible and more process efficient technologies are needed.

OUR SOLUTION

Fraunhofer IWS engineers developed a highly dynamic beam deflection system to significantly improve the efficiency of laser processes to treat high performance polymer based fiber reinforced composite materials. A fast mirror system based on galvanometer scanners is used to rapidly project the laser beam onto the material. The mirrors operate very precisely even at very high path velocities. Accelerations of several 10 g are achievable. The high processing speeds reduce the interaction time between laser beam and material. Compared to the classic gas supported cutting, the new method significantly reduces thermal damage of the matrix material. In addition to beam motion it is also necessary to carefully select the processing wavelength to minimize absorption in matrix and fiber materials.



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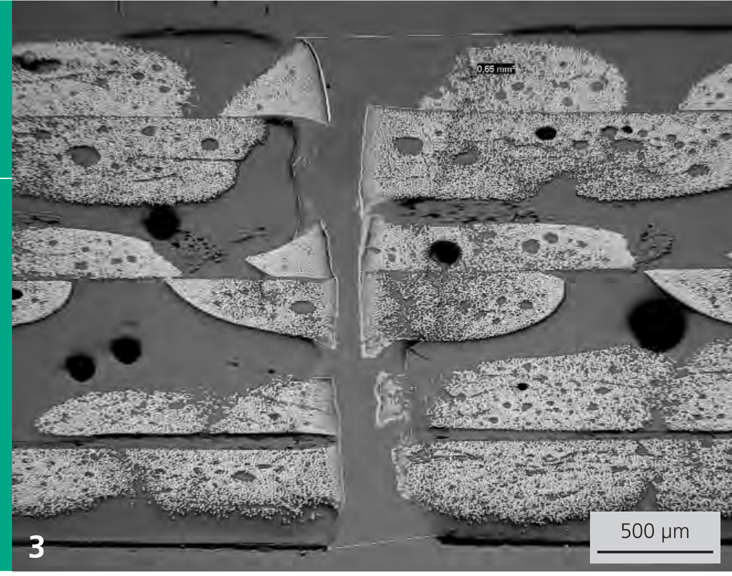

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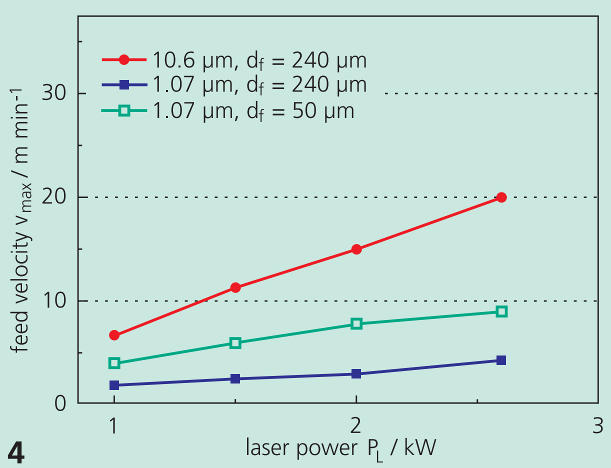
RESULTS

The shortened laser interaction with the composite material reduces the thermal decomposition of the matrix material leading to better ablation and cutting results. High power CO_2 and brilliant solid state lasers such as fiber and disk lasers are used depending on the matrix type. CO_2 laser radiation is sufficiently absorbed by almost all polymer materials. On the other hand solid-state lasers can be better focused and thus may offer efficiency improvements.

Correlation of feed velocity and laser power for various processing wavelengths and power densities
material: bidiagonal carbon netting + VE resin, 2.4 mm thick, fiber fraction 50 wt%



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Despite the availability of lasers with continuous wave powers in the kW range it is necessary for the typical thicknesses to ablate the material in cycles. Typically a cycle ablates 100 µm. The number of required cycles to cut through the material depends on:

- material composition,
- laser radiation absorption in matrix and fiber material,
- power density in the processing spot,
- ablation velocity.

The diagram shows possible processing speeds on a carbon fiber duromer composite. The galvanometer scanners have almost no inertia, which allows the achievement of these velocities also for nonlinear cutting contours or small holes and structures. Subsequently the cutting quality remains constant. On the fly processing is possible by actively coupling the handling systems motion with the processing optics.

1 *Principle of high speed beam deflection*

2 *Bi-diagonal carbon netting (topview)*

3 *Cutting kerf of a carbon fiber reinforced duromer (cross section)*

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