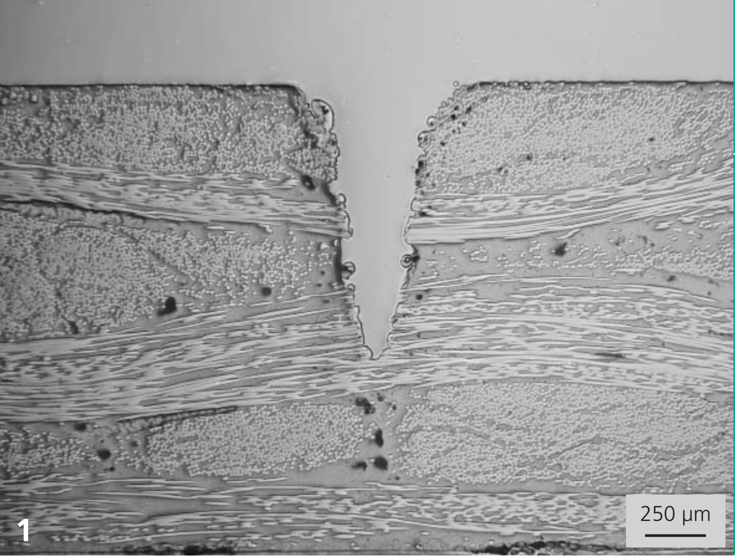

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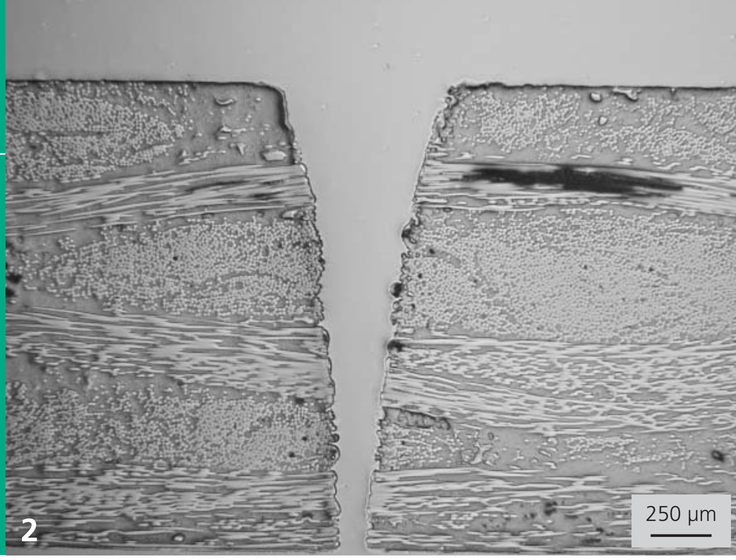

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FAST ABLATION AND CUTTING OF FIBER REINFORCED COMPOSITE MATERIALS WITH HIGH POWER LASERS

THE TASK

Originating from the aerospace industry, high performance fiber reinforced composite materials are now being established in many application areas. Optimally designed structures of these high performance composites combine an extreme mechanical loading capability with a minimal use of the material. These characteristics are mainly due to the mechanical properties, which include strength, stiffness and low density. These materials also offer excellent corrosion resistance and good damping performance, which are exploited in many applications.

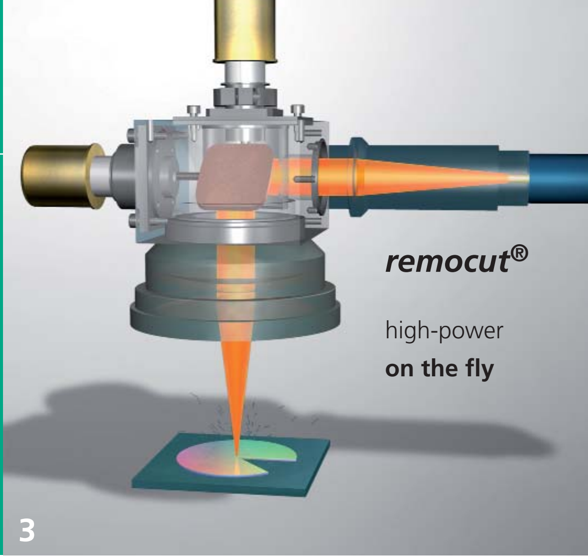
These composite materials consist of a polymeric matrix filled with high strength and stiff fibers, which makes them hard to cut since the individual material components have very different physical and substantial properties. This is true not only for the mechanical processing and water jet cutting, but also for thermal cutting processes. Key issues for the mechanical processing are tool wear and the general force impact on the component. The application of water jet cutting processes is limited with respect to accessing curved surfaces. The process also tends to delaminate the lowest fiber layers.

A conventional gas assisted laser beam cutting process leads to a shift of the geometrical boundaries of both components of the composite material. The drastically different melting temperatures of fibers and the matrix material cause this problem. Depending on the type of material a completely cut fiber layer may lead to more or less damage of the matrix. The matrix material is mostly evaporated or burnt in the region affected by the heat. The adhesion reduces between the laminated layers, which deteriorates the tensile shear strength of the material. These considerations require the development of new flexible and process efficient technologies.

OUR SOLUTION

Fraunhofer IWS engineers demonstrated a clear quality improvement when laser processing polymer-based high performance fiber reinforced composites using a highly dynamic beam deflection technique. This technique rapidly projects the laser beam onto the material via quickly adjustable mirrors. Since the weight of the mirrors is very low they can be actuated with galvanometer scanners and maintain high precision even at high path velocities. Accelerations of several 10 g are possible.

The very high processing speed leads to a very short interaction time between laser beam and material. This results in a drastically reduced damaging of the matrix material compared to classic gas assisted laser cutting processes.



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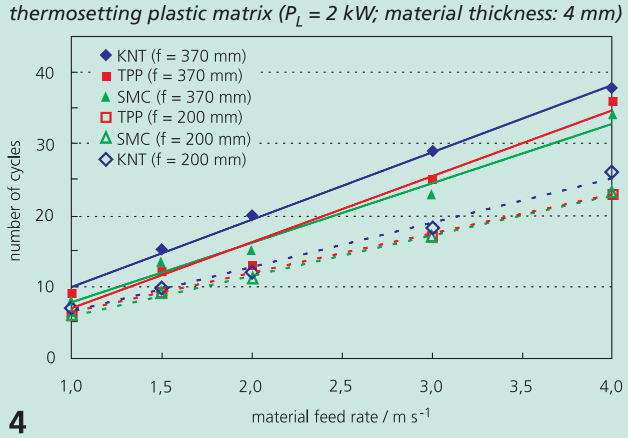
RESULTS

The shortened interaction time between laser beam and composite reduces the evaporation and carbonization of the matrix material, which leads to better ablation and cutting results. When using kW range lasers the ablation rates can be as high as several 100 µm depending on the material thickness and composition. Subsequently there is cyclical material ablation necessary when the material is several millimeters thick. The number of cycles to fully cut the material depends primarily on the beam focus intensity and the ablation rate.

Number of cycles as a function of material feed rate and aperture for various glass fiber reinforced polymers

KNT, TPP: long glass fiber + PP matrix; SMC: short glass fiber + thermosetting plastic matrix (P_L = 2 kW; material thickness: 4 mm)



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The fast beam scanning technique also allows cutting small structures or bores into the fiber reinforced composite materials at high speed and quality. It is also possible to actively couple the motions of the processing optics and other handling systems such as industrial robots. This approach is used to efficiently process complex 3D parts.

1/2 Cutting joints of a glass fiber PP composite after cutting with highly dynamic beam scanning

3 Principle of a high speed beam scanning

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