

Excimer Laser Based Solutions for Carbon Composites Cleaning

Carbon fiber–reinforced plastics (CFRP) as high-strength lightweight materials enable leaps in efficiency both in the aerospace and in the automotive sector. When producing carbon fiber-reinforced composite structures, the removal of the parts from their molds leads to residual organic release agents remaining on the surface. Surface contaminations in the form of mold release agents are largely responsible for impeding subsequent bonding or painting tasks. With high-performance UV excimer lasers, it is possible to clean CFRP surfaces fast, thoroughly, and gently at the same time. The cleanCELL production cell from Clean-Lasersysteme GmbH represents a turn-key solution combining technical competence in CFRP pre-treatment with excimer laser precision.

After curing and de-molding, carbon composite parts need to be joined in a non-destructive manner. To this end, aerospace and automotive industries employ adhesive bonding, often based on epoxy resin and polyurethane, wherever possible. In order to join two composite parts reliably and permanently, as a first step, any remnants of release agent used for mold release of the part, must be thoroughly removed from the surface. To accomplish this step, it is necessary to apply a precise and sufficiently fast pre-treatment method to clean the CFRP surface without weakening the composite structure e.g. by damaging the carbon fibers.

Laser technology offers crucial advantages in comparison with the relatively coarse mechanical erosion procedures. Lasers emitting in the infrared or visible spectral range are unsuitable as these laser wavelengths accumulate significant amounts of heat relatively deep into the composite material. As a consequence, thermally induced stress usually reveals itself in the form of cohesive material failure. Excimer lasers, on the other hand, emit at short UV wavelengths and ablate the release agent while remaining unnoticed by the carbon fibers.

Coherent Inc. and Clean-Lasersysteme GmbH in Herzogenrath near Aachen join forces to provide economical system solutions for surface activation and

surface adhesion performance of CFRP structures. “The powerful excimer lasers from Coherent extend the product range of Clean-Lasersysteme GmbH in view of the increasing demand for efficient system solutions capable of a fast and precise surface pre-treatment of CFRP parts”, explains Edwin Büchter, President at cleanLASER. “Excimer lasers at 308 nm deliver excellent results while enabling the highest cycle rates”.



Figure 1: Coherent COMPexPro laser for 308 nm treatment

Excimer lasers at 308 nm emit photons with high energy of 4 eV which are capable of breaking the molecular bonds of the organic release agent and of the CFRP matrix material. For a moderate laser energy density of 600 mJ/cm² at the CFRP surface, the thickness of the ablated layer can be carefully adjusted via the number of applied laser pulses. Based on the need, only the release agent layer or also the adjacent matrix material can be removed. Applying an increasing number of pulses, this can be continued until a fiber layer is completely exposed.

“Our excimer lasers with their several centimeters wide beam profiles cover the surface to be cleaned like a photonic brush”, illustrates Dr. Ralph Delmdahl. “Solid-state lasers are available with an appropriate wavelength but their beam has a 150,000 times smaller area. It’s as time-killing as scrubbing the deck of a ship with a toothbrush”.

The excimer laser beam can be adapted to the particular geometry of the surface. Based on a typical processing beam area of 30 x 2 mm² and a pulse overlap of 50 %, processing rates of 5 to 50 m²/h are achieved depending on the excimer laser model used.



Figure 2: Plasma clouds during 308 nm cleaning of CFRP part

According to Delmdahl, the current trend in release agent removal from CFRP surfaces for adhesive joining and painting clearly goes to the 308 nm excimer laser. Flexible system solutions making use of a broad spectrum of available laser power levels allow their cost-optimized application in CFRP surface activation and pre-treatment.

Most importantly for cleanLASER, Coherent extends the product portfolio of the Herzogenrath-based company towards pre-treating plastics and carbon fiber composites. “The combination of proven cleanLASER system technology with modern excimer laser technology opens up completely new applications for us”, explains Edwin Büchter, CEO and President of cleanLASER. Laser processing can successfully replace sandblasting or grinding as well as surface treatment using atmospheric-pressure plasma. Uniquely, the excimer laser achieves both the residue-free removal of the contamination layer plus a surface activation.

In the case of plastics, usually very thin contamination films in the form of release agent residues, meaning only a small amount of laser energy need be applied. The ideal material interaction of the short wavelength excimer photons ensures an extremely effective pre-treatment. This leads to astonishingly fast processing cycles with reproducible quality even at moderate output power levels. In order to fully leverage these excimer laser capabilities, accurate, dependable and highly dynamic automation systems are needed. cleanLASER has substantial in-house knowledge in operating and designing production cells for laser systems and employs state-of-the-art beam management as well as application specific motion control. Such a complete solution is rounded off by an appropriate exhaust and filter technology.

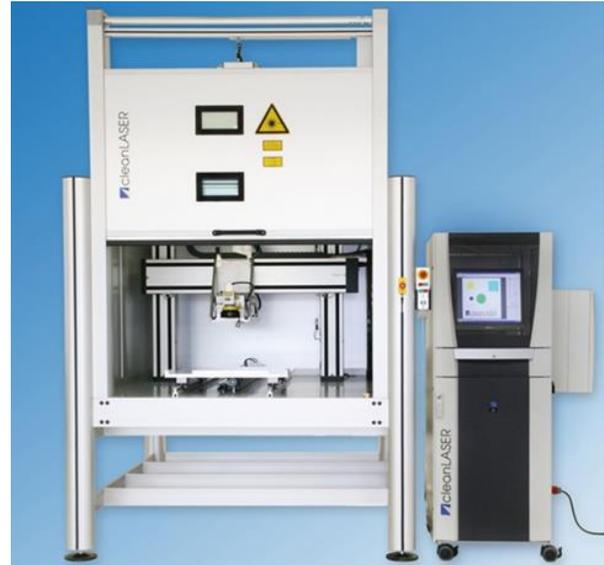


Figure 3: System solution cleanCELL for excimer laser treatment

The cleanCELL production cell represents a turn-key solution combining the technical competence in adhesive bonding pre-treatment with the optimal laser system. This compact and cost-effective production cell supports manual insertion but can also be operated directly inline. The intuitively operated software controls both the laser system and the automation technology.

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