Dispensing with chemicals: Atmospheric pressure plasma for the environmentally friendly pretreatment of plastics in the automotive industry

For non-polar plastics, surface activation is essential to ensure the reliable, long-time stable adhesion of adhesive bonds and coatings. For years the automotive industry has been using an atmospheric plasma pretreatment technology from Westphalia in Germany as an environmentally friendly and particularly cost-effective means of satisfying the strict technical and quality requirements.
With the development of its atmospheric plasma jet technology over twenty years ago, the systems engineer Plasmatreat created a solution which the industry had long been seeking: an alternative to wet-chemical pretreatment processes for material surfaces. Growing demands in the nineties for environmentally friendly, safe processes called for new methods which did not require wet chemicals and were at the same time cost-effective and process-reliable. Now used throughout the world, Openair-Plasma technology offered a highly effective, dry pretreatment process based on jet technology that enabled the area-selective pretreatment of mass-produced components in a continuous production process.

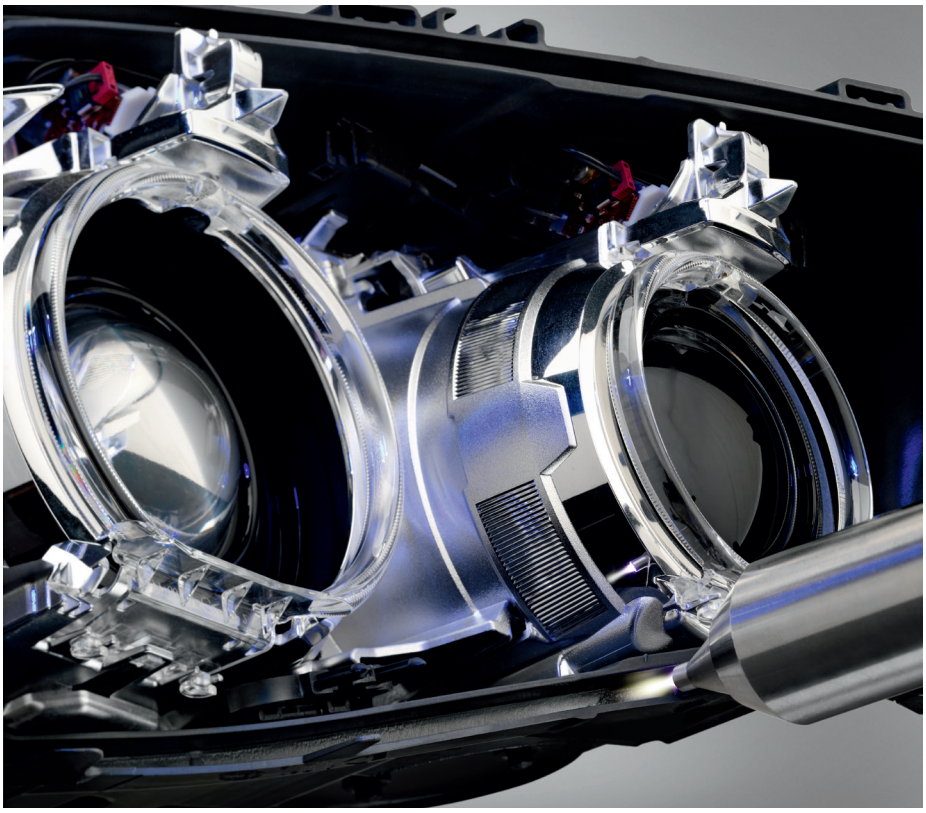

Fig. 1 Photo Plasmatreat: To prevent moisture penetrating the headlamp housing, before bonding the plastic grooves are cleaned and simultaneously activated with plasma at precisely defined locations.

Three functions in a single step

Non-polar plastics require an essential pretreatment before downstream processes such as bonding, painting, printing or foaming. This is because their lack of polarity causes them to have low surface energy. Reliable adhesion is conditional on the surface energy (mJ/m²) of the solid material being higher than the surface tension (mN/m) of the liquid applied (such as adhesive, paint or ink). Plasma has the power to activate a non-polar plastic surface by making it polar and so increasing its surface energy. The result is homogeneous wettability of the substrate and a long-time stable adhesive bond or coating, even under challenging load conditions. The rise in temperature of plastic surfaces during this type of plasma treatment is typically just ΔT< 30 °C. Openair-Plasma is generated without a vacuum chamber, so under normal production conditions, and performs three operations in a single step lasting only a matter of seconds: The plasma emitted from the nozzle at extremely high speed simultaneously brings about the microfine cleaning, electrostatic discharging and activation of the plastic surface – a reactive change at molecular level. Activation is achieved through the chemical and physical interaction of the plasma with the substrate (Fig. 2). When the plasma hits a plastic surface, groups containing oxygen and nitrogen are incorporated into the mainly non-polar polymer matrix.

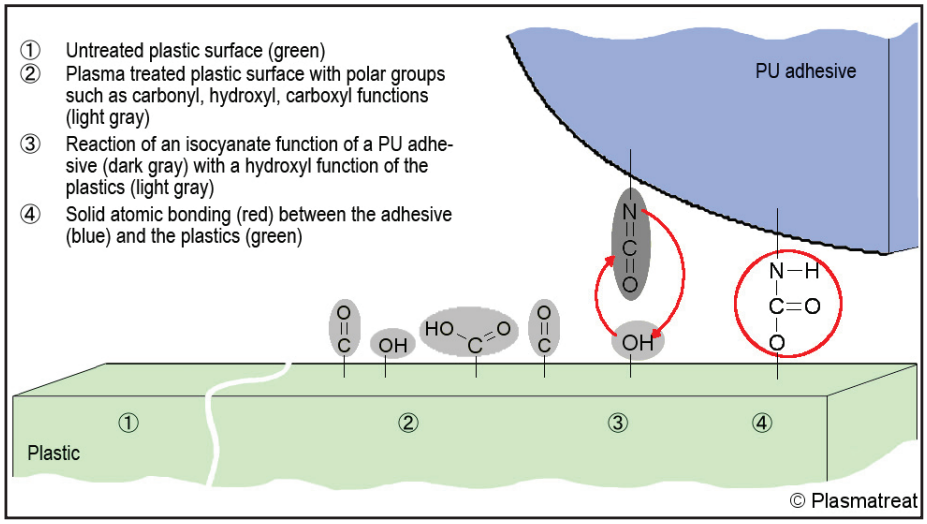

Fig. 2 Diagram Plasmatreat: The surface is activated through the chemical and physical interaction of the plasma with the substrate.

Applications in the automotive industry

Sealing vehicle head lamps
Hella, a leading automotive component

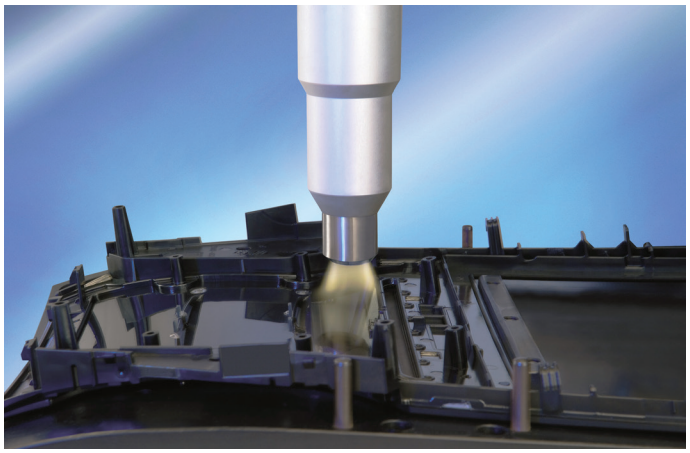

Fig. 3 Photo Plasmatreat: Pretreating a polycarbonate touchscreen panel with atmospheric plasma before laminating the touch foil

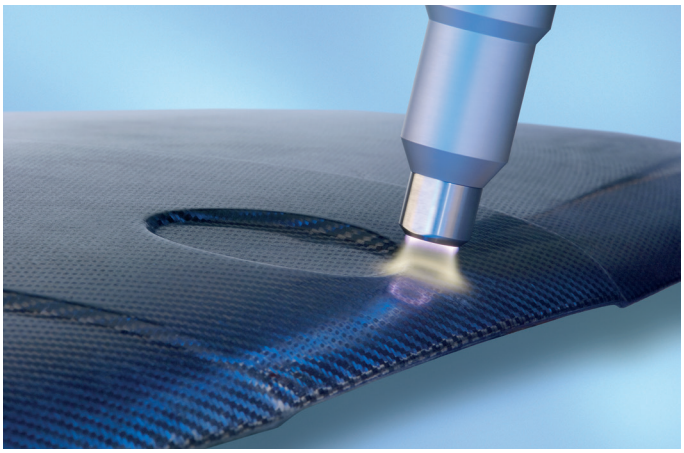

Fig. 4 Photo Plasmatreat: Plasma cleaning eliminates in seconds any release agents remaining on the surface after demolding a CFRP component.

supplier for lighting technology and electronic products, decided back in 1995, i.e. the year the technology was first placed on the market, to purchase a plasma jet system for pretreating their vehicle headlamps. With these components, the adhesive bond between the polycarbonate lenses and their polypropylene housings must satisfy extremely strict sealing requirements. Even the slightest leak would result in moisture penetration leading to impairment of the lens, which in turn would adversely affect the beam angle of the light. Hella uses the plasma to clean the grooves in the polypropylene (PP) housing before applying a 2-component silicone adhesive and to activate the non-polar material at precisely defined locations (Fig. 1). As a result, the surface energy of the PP increases from 35 mJ/m² to over 72 mJ/m². This has the effect of improving the adhesive characteristics of the subsequent bond to ensure seal tightness.

Bubble-free touchscreen bonding

Touchscreens provide the driver with information about the vehicle, navigation system, GSM data and much more besides. The potting between the glass cover and the TFT screen must be bubble-free and have good adhesive characteristics. This calls for a very clean surface with extremely high surface energy. Bavarian automotive component supplier Preh from Bad Neustadt an der Saale found that patented plasma rotary nozzles satisfied these requirements in the production of their central console control systems (Fig. 3). A laminator is used to bond the PET touch foil complete with adhesive backing to the back of the injection-molded polycarbonate panel of the center stack. The foil is supplied with multiple layers of screen-printed electronic circuitry. Bubbles forming between the foil and the carrier during the climatic test were successfully removed by pretreating the PC panel with Openair-Plasma.

Pretreatment of plastic body assemblies

In order to save weight in vehicle body construction, individual assemblies are now made from high-performance plastics which are glued together. The plasma treatment not only replaces conventional methods of pretreating the SMC (Sheet Molding Compound) – such as sanding or cleaning with acetone – it also produces superior bonding results. After assembly, the plasma-treated high-performance thermoplastic and thermoset components meet all the requirements in terms of lightweight construction, passive safety, mechanical properties and a “Class A finish”.

The plasma process is also particularly effective on fiber composite materials such as carbon fiber-reinforced plastic (CFRP) or glass fiber-reinforced plastic (GFRP). Nowadays automotive parts such as vehicle roofs, trunk lids or hoods are molded from CFRP. Release agents are required to remove the complex individual parts safely from the molds after production. After demolding, components from these release agents remaining on the surface must be laboriously removed. With plasma cleaning, on the other hand, any residual release agents are completely broken down and eliminated in seconds before bonding (Fig. 4).

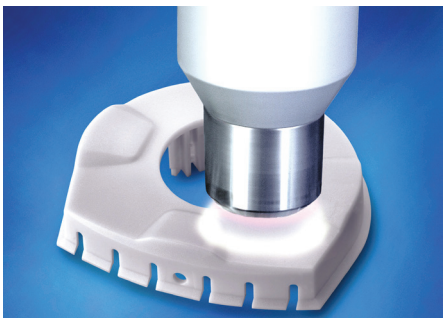

Fig. 5 Photo Plasmatreat
TRW Automotive pretreats millions of switches with Openair-Plasma® each year. The high activation power of the plasma enables the use of water-based, solvent-free paint systems.

Dispensing with adhesive primers before painting

TRW Automotive Electronics & Components in Radolfzell, Germany, pretreats millions of switches for car interiors a year with atmospheric pressure plasma before applying solvent-free paint (Fig. 5). A high degree of process reliability is top priority, and this is achieved through the computer-controlled and screen-monitored system provided by the Westphalian systems engineer. Throughput has tripled since the company started using a new painting line with integrated plasma system and stopped using primers completely. Furthermore, not only has a complete run incorporating six operations been dropped, according to TRW, they have also been able to save a great deal of time and 90% of the energy costs compared with the previous cleaning systems and a primer activation.

Conclusion

Apart from its effectiveness, other factors which have persuaded users to switch to plasma technology include high process speed, high process reliability, robot compatibility and accurate process reproducibility. The technology provides other desirable features such as easy integration into process operations and signal chaining to higher and lower-ranking control units, as well as satisfying requirements for total environmental compatibility.

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