Towards a new era in automotive engineering with plasma

Innovative surface treatment technologies from Plasmatreat – by facilitating new surfaces, composite materials and processes, plasma treatments are key to progress in the automotive industry

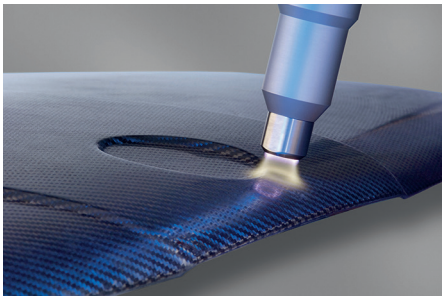
Pioneering plasma technologies from Plasmatreat are the key to progress in the automotive industry. They produce high-quality surfaces with selected characteristics, enable new material combinations and ensure environmentally friendly manufacturing processes. As such, they lay the foundations for high-tech innovative mobility and vehicle concepts such as lightweight engineering, autonomous driving and electromobility. Process-reliable, cost-effective and fully automated.

The automotive industry is undergoing radical change: With electromobility, autonomous driving, intelligent sensor systems and lightweight engineering in the spotlight, innovative materials and complex material combinations are creating new challenges for manufacturers. Surface treatment is particularly important in this context, because careful pretreatment of individual components and assemblies forms the basis for long-time stable adhesive bonds, optimal paint adhesion and reliable corrosion protection. The atmospheric pressure plasma treatment from Plasmatreat is one of the most efficient methods of cleaning, activating and coating surfaces.

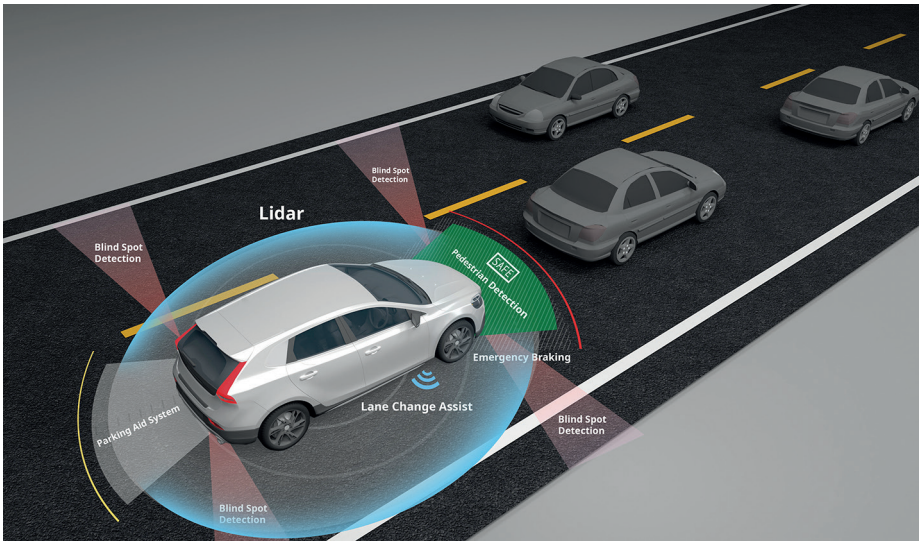
Plasma: The present and future of manufacturing

Plasma is generated by harnessing the energy in gaseous material through the removal of individual electrons from the electron shell surrounding the gas atoms. This produces a highly unstable energy level which modifies the surface characteristics of solid materials. We use this principle to modify surfaces and material characteristics in a targeted manner, explains Joachim Schüßler, Sales Director at Plasmatreat, a world market leader in atmospheric plasma technology. Pretreatment with Openair-Plasma® significantly increases the adhesion capacity and wettability of surfaces in a precisely adjustable manner. This makes it possible to use entirely new (even non-polar) materials and environmentally friendly, solvent-free (VOC-free) paints and adhesives on an industrial scale.

When the plasma comes into contact with the surface of the plastic, a *functionalization* takes place. This is because the excited plasma molecules and ions have sufficient energy to break the bonds between the atoms in the plastic polymer chains. Often these are carbon-carbon or carbon-hydrogen bonds. The radicals released from the broken bonds react with the excited molecules and ions of the plasma or with molecules in the ambient air. This increases both the surface energy and the polarity of the treated surfaces, leading to improved wettability of the plastic.



Openair-Plasma® pretreatment of CFRP hood. The plasma ensures complete, homogenous wettability of the treated surface with paints or adhesives (Photo: Plasmatreat)



Automated vehicles navigate using a range of sensors. Anti-fog coatings from Plasmatreat prevent lenses misting up to ensure optimum visibility even under extremely damp conditions (Photo: © Adobe.com/ Akarat Phasura)

Plasma technology for new mobility and vehicle concepts

As a long-standing partner of the automotive industry, Plasmatreat has developed pioneering innovations for more than 100 components which satisfy strict requirements for process reliability, reproducibility, quality and efficiency and support progress in the industry. Openair-Plasma® technology is now firmly established as a key technology in an ever-increasing number of applications; several leading automotive manufacturers have now integrated it permanently into their production lines. This success can be attributed to the ease-of-use, high effectiveness and in-line capabilities of Plasmatreat processes. They enable plasma treatments to be performed under normal pressure, are fully automatable and can be incorporated into existing manufacturing processes with ease. Furthermore, they guarantee perfectly pretreated surfaces, maximum process control (including traceability) and area-selective

applications – with the added benefit of low running costs.

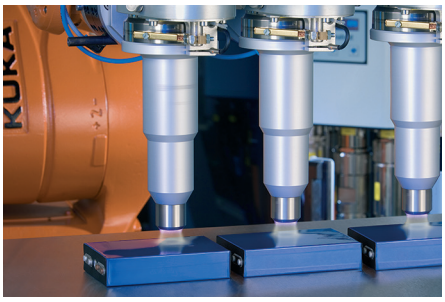
Highly effective plasma cleaning and activation

Whether for vehicle sensors, battery modules/battery packs or electric vehicles, plasma treatments using technologies from Plasmatreat are key to progress in the automotive industry. Possible applications range from pretreating structural bonds with Openair-Plasma®, sealing sensitive electronics and producing flawless paint finishes to using PlasmaPlus® nanocoating to create highly effective functional coatings.

Innovative Plasmatreat processes also come into their own in the production of electric drive and storage systems. The long-time stability of a battery pack is one of the most important factors when it comes to electromobility today. The battery's thermal management system and the insulation of individual battery cells are critical in this respect. To prevent an internal short-circuit, the bonding medium between the individual cells in a cell stack must have an insulating effect. Consequently, polyurethane adhesives are normally used for this purpose. Microfine cleaning and activation of the outer casing of the cell (normally aluminum) is essential to achieve a precise insulating bond with optimum adhesive characteristics, because aluminum and other metals are often contaminated with undefined oxide layers, wafer-thin layers of dust or traces of residue from the production process such as release agents, lubricants, cutting oils and drawing grease. These impurities diminish the effectiveness of the surface energy naturally present in the aluminum which largely determines the strength of an adhesive bond.

Plasma cleaning removes dust deposits, oxide layers, grease and other contaminants. After cleaning, the surface energy of the substrate is restored to optimum levels to ensure complete, homogenous wettability of the treated surface with paints or adhesives. The high energy level of the plasma can fragment the structure of chemical and organic substances on the surface of the material in a targeted manner. Furthermore, the deionizing effect of the plasma beam neutralizes loose particles of dust and removes them from the surface of the material. At the same time, the surface is activated through the incorporation of functional groups containing oxygen and nitrogen into the substrate. Activation binds free radicals to the material surface, preventing air pockets and ensuring optimum heat dissipation to guarantee full nominal performance of the battery cells.

The highly effective, process-reliable and fully automated plasma treatments from Plasmatreat are key technologies in the production of electric drive and storage systems for the electromobility sector
(Photo: © Adobe.com/ 2dmolier)



Openair-Plasma® pretreatment of prismatic cells. Cleaning and activation lay the foundations for a precise adhesive bond with optimum adhesive characteristics
(Photo: Plasmatreat)

Effective, long-time stable corrosion protection

From individual cells to battery modules and packs, effective Plasmatreat processes play an important part in ensuring that strict re-

Innovative plasma processes for long-time stable battery modules

- **Optimal adhesion.** To prevent an internal short-circuit, the bonding medium between the individual cells in a cell stack must have an insulating effect. Plasma microfine cleaning and activation ensures a precise insulating bond with optimal adhesive characteristics (1).
- **Completely seal-tight.** Plasma microfine cleaning significantly increases the seal's effectiveness and so prevents moisture and other corrosive media gaining entry between the housing cover and the battery module. A corrosion-inhibiting PlasmaPlus® coating can be applied if the component requires a higher level of protection. This completely eliminates the problem of subsurface migration (2).
- **Selective contact surface cleaning.** The interfaces for peripheral electronic components must be completely free from contamination. Selective cleaning of the contact surfaces with Openair-Plasma® ensures a better bond for subsequent contacting (3).
- **Long-time stable corrosion protection.** Regardless of the type of sealing system, aluminum and plastic composites are highly susceptible to subsurface migration on account of their different affinity to water. PlasmaPlus® plasma-polymer nanocoating provides highly effective protection (4).
- **Improved adhesive bond for temperature control.** High-performance batteries need temperature control with active cooling. One method of achieving this is to bond a thermal strip/cooling system made of aluminum to the underside of the battery using a heat-conductive adhesive. Plasma surface cleaning and activation improves the adhesive bond (5).

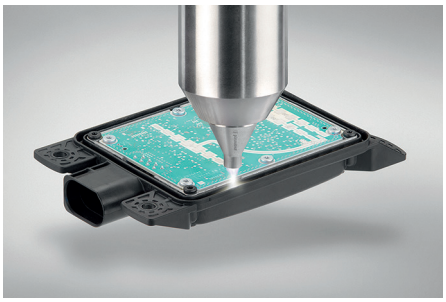
Plasma treatments can be used in cleaning, activation and coating steps to optimize cell efficiency, process stability and cost effectiveness in battery production processes
(Photo: Plasmatreat)

quirements for cell efficiency, process stability and cost-effectiveness are met in a range of process steps. For instance, plasma treatments ensure a strong adhesive bond between the metal and the plastic when bonding cell stacks to insulating polypropylene strips, eliminate impurities on electrical contact surfaces and ensure that die-cast aluminum battery housings are fully sealed. The housing cover that seals the battery module must be completely sealed to prevent the penetration of moisture or other corrosive media. The key to achieving this level of seal-tightness is to define and test the surface condition before applying the seals.

Regardless of the type of sealing system (sprayed, bonded or FIPG), aluminum and plastic composites are highly susceptible to subsurface migration on account of their different affinity to water. PlasmaPlus® plasma-polymer nanocoating from Plasmatreat provides highly effective protection. After cleaning and activation with Openair-Plasma®, the nanocoating is applied to the metal component to ensure a media-tight bond in the downstream injection molding process. It provides exceptional, long-time stable corrosion protection by forming a highly effective barrier against corrosive electrolytes.

Specific additives can be added to the plasma via a special nozzle head. Plasma excitation greatly enhances the reactivity of these additives, thereby ensuring optimal deposition and secure bonding to the material surface during plasma coating. The resulting coating provides the greatest possible protection from moisture ingress. According to Joachim Schüßler, apart from its suitability for in-line use and high process reliability,

The insulating, adhesion-promoting PlasmaPlus® coatings from Plasmatreat ensure reliable adhesion and a completely tight seal to protect sensors, cameras and electronics from harmful environmental influences
(Photo: © Adobe.com/ Ilya)



The treatment of electronic control units and sensors with Openair-Plasma® guarantees long-time-stable adhesive bonds and reliable corrosion protection (Photo: Plasmatreat)

the main advantage of this technology compared with wet-chemical and diverse other pretreatment methods is the area selectivity of the plasma beam. Furthermore, it is a dry, environmentally friendly process with no associated disposal costs and the components can be further processed immediately after pretreatment.

Selective modification of material characteristics

Corrosion protection is not the only application for PlasmaPlus®. By incorporating different coating materials (precursors), surfaces can be selectively functionalized and given new characteristics in order to satisfy specific product requirements. The automotive industry is also harnessing other beneficial effects. For example, nanocoatings with active adhesion are used in hybrid injection molding to produce long-time stable rubber-to-metal or plastic-to-metal bonds, while anti-adhesion coatings create water- and dirt-repellent surfaces.

Sensors, headlights and camera systems also benefit from PlasmaPlus® polymerization. Hydrophobic anti-fog coatings prevent lenses misting up with water or condensation to ensure optimum visibility even under extremely damp conditions. This process will become particularly important as attention increasingly turns to driver assistance systems and autonomous vehicles, since sensors are the eyes and ears of the cars of the future. LiDAR sensors (light detection and ranging) scan their environment with lasers to obtain detailed information about distances, speeds and objects. This creates an exact 3D image of the surroundings – the basis for the vehicle navigation system. Clear visibility is absolutely essential to ensure maximum reliability and safety.

Using plasma to join previously incompatible materials

Whether for electronics, battery, chassis, drivetrain, body or interior – plasma treatments have long been an intrinsic part of automotive manufacturing. They create stable bonds, protect surfaces, facilitate new, environmentally friendly production processes and make a major contribution to reducing costs. In fact, they are often the only technical solution available for bonding the new materials and complex material blends increasingly used in modern lightweight construction, to give one example. Nowadays, for instance, vehicle exterior parts are mainly made from composite materials such as glass fiber-reinforced plastic (GFRP) or plastic-metal composites. These materials reduce the weight and increase the range of electric vehicles as well as reducing the fuel consumption of conventional drive systems. However, since the base materials often have very different surface qualities, they cannot be bonded effectively, or indeed at all, without pretreatment.

Thanks to Openair-Plasma®, reliable adhesive bonds can be obtained even with hard-to-bond plastics like polycarbonate (PC) and liquid silicone rubber (LSR), for example in the production of rain/light sensors
(Photo: Plasmatreat)

A range of components are pretreated with Openair-Plasma® to prepare them for bonding, including vehicle roofs (fixing the plastic parts of the sunroof to the coated stainless steel or anodized aluminum frame with 1-component polyurethane adhesive), trunk lids (bonding two polypropylene plastics with a 2-component polyurethane adhesive) or windscreens (bonding glass ceramic surfaces to the metal body). Environmentally friendly, VOC-free and fully automatable plasma treatments offer distinct advantages over

The plastic components of the sunroof are cleaned and activated with Openair-Plasma® before being bonded to the coated stainless steel or anodized aluminum frame to ensure high adhesive strength and long-time stable bonding (Photo: Plasmatreat)

conventional methods such as solvent-based adhesion promoters (primers) or flame treatments on account of their reliable adhesion, high process availability and easy in-line integration.

Maximum process reliability

The high level of process control is another plus point. Spectral monitoring of the plasma beam ensures that the plasma quality is consistently high: A sensor in the plasma nozzle measures the light emitted by the plasma using a single-channel optical detection system. The amplitude of the emitted light in the relevant spectral range is continually analyzed. If deviations occur, the intensity of the plasma beam can be correspondingly adjusted. A motion control system also monitors the forward and rotational speed of the plasma nozzle. To ensure that process-specific plasma characteristics (temperature, intensity) can be reproduced, Plasmatreat offers monitoring units to suit all requirements. All process data are provided in real time, while the HMI ensures a high level of data accessibility. Furthermore, process data are logged to make them available for subsequent analysis and evaluation.

With Industry 4.0 in mind, the interoperable system components (plasma control unit and generator) have been designed for use in intelligent process lines. Connection is via EtherCAT / CANopen gateways. This means that interfaces are defined in a way that allows them to be used for automation systems. They can also be integrated into existing production lines and network infrastructures.

Openair-Plasma® – a driver for change in the automotive industry

There is no question that mobility is changing, and with it the demands made on the automotive industry. With Openair-Plasma® technology, Plasmatreat provides a process-reliable, effective and environmentally friendly solution which raises surface pretreatments to a new level. At the same time, the innovative technology satisfies current process requirements for mass production in full, including reproducible process flows, high system reliability, low manufacturing tolerances, consistent quality levels and data-assisted automation.

The Plasmatreat process offers extensive scope for precise process management and control to ensure the highest possible level of process reliability (Photo: Plasmatreat)

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