

# How Plasma Technology Is Changing Plastics Processing

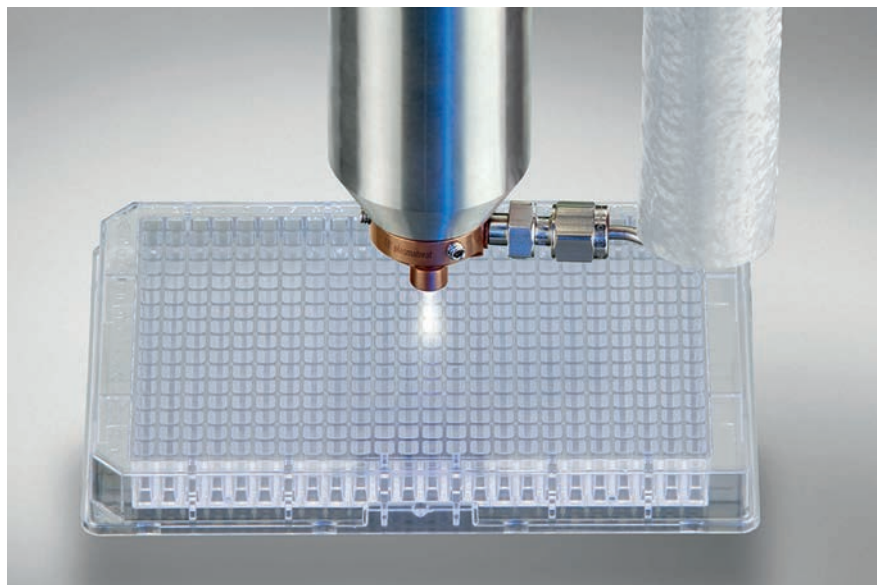
## *Modern Materials, New Adhesive Bonds, Expanded Fields of Application*

Plasma technology is expanding the spectrum of applications for plastics and recyclates through targeted modification of surface properties. Plasmamatreat GmbH covers the whole range of possible applications, as shown by industry examples.

Countless revolutionary developments in all areas of life such as mobility, health, communications or leisure would be inconceivable without plastics. Increasing raw material prices, higher quality specifications and the quest for greater sustainability are constantly requiring new technologies to process this important material. Modern products based on new materials and the economical use of plastics and/or the use of recyclates are increasingly in demand. For example, the consumption of recyclates in 2019 was around 1.9 million t – a rise of 10.2 % over the figure for 2017 [1]. Plastics recycling and the use of recyclates have therefore become established as an important part of the plastics industry and raw material supply.

### *Plasma Treatment Is a Key Technology*

Material selection based on economic and ecological criteria can influence a whole process, e.g. in terms of adhesion, printability, and much more. Plasma technology has established itself as a reliable, efficient and ecofriendly solution for many different plastics. With plasma, the surface of plastics can be specifically modified to improve the bonding of adhesives and coatings in industrial applications and even to join plastics that were previously incompatible. In this way, users benefit from a wider choice of materials. They may, for example, replace costly engineering plastics with less expensive standard plastics.



PMMA, COC or COP: test kits for laboratory analyses are given a superhydrophobic coating that ensures complete utilization of the test medium, so increasing efficiency and cutting costs

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Environmental balance can also be improved by reliable treatment of recycled plastics in downstream processes or the use of solvent-free coatings and adhesives. "Plasma technology provides the ideal basis for this," explains Dr. Alexander Knospe, Head of Innovations at Plasmamatreat GmbH. This family-run company from Steinhagen, North Rhine-Westphalia, Germany, is a leading supplier of atmospheric plasma technology and has developed a wide range of processes for different applications.

Plasma technology depends on a simple physical principle: states of matter can be changed by introducing energy. If

energy is introduced into a gas, it becomes ionized and is transformed into an energy-rich plasma state, which is the fourth state of matter. When plasma with its high energy content comes into contact with materials, their surface properties are changed, e.g. from hydrophobic to hydrophilic. Plasmamatreat exploits this in many applications across a wide range of industries.

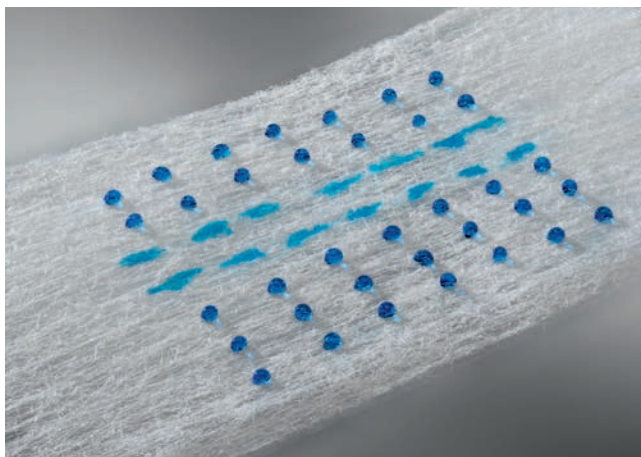
### *Plasma Modifies the Surface Properties of Plastics*

To achieve high-quality end products and a reliable process, the critical param- »

**Fig. 1.** Polypropylene: in fitting the lenses on car headlight housings, Openair-Plasma pretreatment ensures reliable bonding and a tight seal © Plasmatrete



**Fig. 2.** Polypropylene: in an ecofriendly process, plasma treatment modifies the surfaces of textile nonwovens to create the required functionalization (e.g. higher permeation, water repellency, etc.) © Plasmatrete



eters must be continually kept under control. For this reason, the Plasmatrete systems have a variety of control and monitoring functions to ensure consistently high quality and reproducibility of plasma treatment. For example, speed, distance of the jet head from the substrate, and intensity of the plasma beam are adjusted precisely to match the area of the surface being treated. Determination of suitable parameters and specially adapted jet heads are among the core competences of Plasmatrete and ensure reliable pretreatment.

In treatment with so-called Openair-Plasma, oxygen- and nitrogen-containing groups are introduced into (usually) non-polar plastics to increase their surface energy. This activation improves the wettability of the surface, significantly increases adhesive capacity and so permits stable long-term bonding of adhesives, paints and coatings. With PlasmaPlus technology, nanocoatings can be applied to create specifically functionalized surfaces that may, for example, be superhydrophobic or superhydrophilic.

All plasma processes are solvent-free, site-selective and have in-line capability. "Examples of practical applications with various plastics confirm the significant increase in oxygen content that can be measured in the polymer surface after plasma treatment. The long-term stability of the activation after storage at room temperature is also demonstrated. Tests carried out by us also show the improved bonding strength of plastics after plasma treatment, even under extreme conditions," says Knosp.

### **Headlights Are a Good Example**

The way in which industry can make advantageous use of plasma technology in plastics processing is demonstrated by a long-established application of Plasmatrete systems. In fitting the lenses on car headlight housings, which are usually made of polypropylene (PP), it is vital to ensure reliable bonding and a tight seal against moisture ingress. The circumferential adhesive groove around the housing is pretreated with Openair-

Plasma, so uniformly activating the non-polar material in critical areas (**Fig 1**).

Due to the high reactivity of the plasma beam, residual release agent from the injection molding process that is present in the adhesive groove is removed. This full-surface pretreatment of the adhesive joint (both the groove bottom and side walls) ensures a reliable adhesive bond and stable long-term sealing of the headlights. Overall, the process is characterized by high precision at a competitive cost.

The polycarbonate (PC) headlight lenses, which must have very high scratch and impact resistance, also undergo plasma treatment. The sensitive surfaces of these covers are given a scratch-resistant finish, usually acrylic-based, to protect them from mechanical abrasion. Before this curtain coating process, the PC layer is activated with Openair-Plasma. This ensures uniform coating flow and reduces the number of parts rejected as a result of adhering particles.

Finally, a PlasmaPlus coating on the inner surface of the lenses prevents fogging due to condensation inside the headlight. The use of plasma technology has long been standard practice at many leading headlight manufacturers.

### **Pretreatment of Textile Nonwovens and Wood-Plastic Composites**

The advantages of plasma technology can be utilized for many other plastics. Synthetic nonwovens for hygiene articles such as diapers are high-tech products that can be better wetted with water after pretreatment with Openair-Plasma – an important requirement for using water-based impregnating agents to replace chemical treatment (**Fig.2**). At the same time, this plasma pretreatment can reduce the use of adhesives by up to 40%. With a very fine PlasmaPlus coating it is also possible to create new surface properties, e.g. to provide water, oxygen and CO<sub>2</sub> barriers and soil repellency.

From window profiles to patio decking, plasma treatment opens up new design possibilities for the construction industry. In window manufacture, wood-plastic composites (WPC) can be used. These non-polar, often recycled materials require efficient surface treatment with

Openair-Plasma to achieve a reliable bond, e.g. between the window profile, laminate or edging. This treatment makes WPC suitable for decorative purposes and enables the recycle to be used at a higher value-added stage.

### Application Examples for PA, EPDM, POM and PU

A housing for the latest 5G smartphones produced from polyamide 12 (PA12) had to be coated with a reliable flame retardant. However, this adversely affected the adhesive bonding capacity of the material. Once again, the manufacturer turned to a plasma process that replaces wet cleaning after injection molding and achieves improved properties in the adhesive bonding process.

Vehicle door seals are produced from EPDM compounds. They should be gap-filling, noise-reducing, visually attractive, pleasant to touch, and cost-effective. They should also not freeze to the car body at low temperatures. To meet this requirement, flock or slip coatings are applied. In the past, the seals were pretreated with rotary wire brushes to obtain good coating adhesion. A simpler, cleaner, faster and more reproducible process is offered by Openair-Plasma pretreatment (Fig. 3). The profile sections are given this pretreatment after extrusion to prepare them for subsequent process steps. The dust-free plasma process achieves uniformly high adhesion. With this pretreatment method, the quality of the slip or flock coating is sustainably improved in a way that is both more cost-effective and more ecofriendly.

Thanks to its very low friction coefficient, polyoxymethylene (POM) is an



**Fig. 3.** EPDM: surface treatment activates this non-polar material for vehicle door and window seals and prepares for subsequent coating in a faster and, above all, cleaner process © Plasmamatreat

excellent material for rotary systems, e.g. for products used in medical technology such as adjuster wheels for inhalers. To ensure correct use of the devices, the necessary text or images printed on them must be clear and permanent. However, the material is difficult to print because of its low surface energy and consequent inadequate wettability. Treatment with Openair-Plasma activates the surface and ensures reliable adhesion of the printing ink.

Polyurethane (PU) is a popular material when properties such as low abrasion, high extensibility, and good elasticity are required. In the soccer balls used today, several layers of these PU elastomers are welded together. This makes the ball surface elastic, wear-resistant, and durable. Pretreatment with Openair-Plasma en-

ables very fine cleaning of this difficult-to-print material and activates it for further processing steps (Fig. 4). Applied ink systems therefore wet the surface considerably better. In this way, permanent printed images can be obtained on objects exposed to high mechanical stress, such as soccer balls.

### More Efficient Analytical Test Kits Produced from PMMA, COC or COP

A very relevant subject right now is the treatment of test kits for laboratory analyses, such as those for diagnosing a Covid-19 infection and other diagnostic kits (Title figure). A key requirement is to use as little analytical medium as possible in the tests to increase yield and at the same time minimize the cost of each test. A superhydrophobic plasma coating that meets the highest laboratory standards in terms of seal tightness and transparency is applied specifically to the area of the test kit that comes into contact with the analytical fluid. In this way, the very last drop of test fluid can be used up.

“The examples described impressively demonstrate the effective performance of plasma treatments in plastics processing. Inquiries from customers with unsolved problems in plastics processing mean that we are continually expanding our portfolio. In our webinars on the ‘Activation of plastics’, we show the possibilities of plasma treatment and the expanded fields of application for different plastics,” concludes Alexander Knospe. ■

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### References & Digital Version

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**Fig. 4.** Polyurethane: treatment with Openair-Plasma makes it possible to achieve permanent printed images on objects exposed to high mechanical stress © Plasmamatreat