PLASMA AS AN ENABLER FOR SUPPLY CHAIN TRACEABILITY

In recent years, plasma pre-treatment has established itself as one of the most reliable and suitable methods for printing on challenging surfaces. Isabelle Doelfs and Dr. Eva Brandes explain how the process is becoming an increasingly popular choice for traceability in the medical sector

Isabelle Doelfs is a Project and Application Engineer at relyon plasma

Traceability is essential for the serialisation of supply chains. It ensures the visibility of the chain itself and reduces risks, which increases the overall quality of the supply chain. To achieve traceability, label printing is one of the most important means. In recent years, plasma pre-treatment has established itself as one of the most reliable and suitable methods for this purpose, as it significantly improves the adhesion of inks to materials that are usually difficult to print on due to their surface properties.

Atmospheric pressure plasmas are generated by electrical discharges in air or other gases, building very reactive but short-lived chemical species. While conventional plasma systems are based on an electric arc most of the time, the novel piezobrush PZ3-i from relyon plasma works with a piezoelectric direct discharge (PDD). As the high voltage is generated directly at the tip of the module via a piezoelectric element, the device is very compact. This opens the application field of plasma to a wide range of applications. Plasma can be used for cleaning and disinfection, but also for modification and functionalisation of many surfaces, like metals, plastics, or inorganic materials, to prepare them for subsequent bonding, varnishing and printing steps.

Dr. Eva Brandes is an Application Engineer at relyon plasma

PLASMA MECHANISM

The mechanism of plasma processing is based on a combination of ultrafine cleansing from organic contaminants and incorporation of functional chemical groups. The increase in surface energy results in a higher hydrophilicity and therefore better wettability. To determine the wettability, contact angle measurements are a common method. It is a quantitative measure of wetting of a solid by a liquid. The boundary of the intersection of the solid, gas and liquid phase forms the contact angle θ, which strongly corresponds with the polarity of the surface. By using at least two different liquids, the polar and dispers contribution can be determined.

In **Figure 1**, the interaction between plasma treatment, surface energy and printing ink is illustrated. On the left side, the surface has a contact angle of more than 90°. The ink contracts on the surface, leading to an uneven printing result with very bad coverage. The two contact angles in the middle depict an increasingly better printing result the lower the contact angle gets. The contact angle of the drop on the right side stands for a high wettability and therefore excellent print quality.

LABELLING ON CHALLENGING MATERIALS

In the medical sector, traceability gains further importance due to its greater safety impact. This is very difficult to achieve on widely used materials such as silicone or polytetrafluoroethylene (PTFE). Silicone materials have unique chemical and physical properties such as excellent biocompatibility and bio durability. Silicone elastomers can also withstand conditions from cold storage to autoclaving while maintaining their flexibility. Their high permeability to gases and many drugs leads to silicones being preferred for use in wound healing and transdermal drug delivery. Their low surface tension and high chemical stability also allows their use in implant applications but decreases their ability for ink adhesion.

PTFE is often used for coating on catheters due to its bacteria and infection inhibiting abilities, but also as a graft material in surgery and for implants. PTFE coatings are highly inert, non-stick, low-friction, non-wetting, heat-resistant and high chemical stability, making it ideal for medical tools and machinery. PFTE is difficult to wet and almost impossible to glue without any prior surface treatment.

"With plasma treatment, both the coverage and the abrasion-resistance of the ink improves"

To achieve the required print quality of the labelling on these materials, plasma pre-treatment is a frequently used solution. It ensures high manufacturing quality and replaces the use of environmentally harmful chemical primers. **Figure 2** shows the efficiency

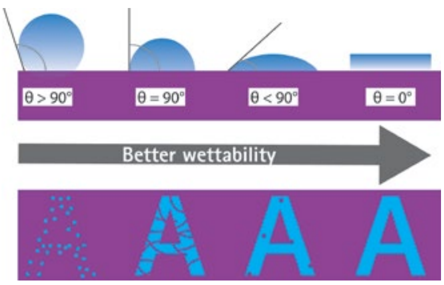

Figure 1: Contact angles and their corresponding wetting behaviour and ink adhesion properties

Figure 2: Adhesion test showing results of inkjet printing on untreated and plasma-treated PTFE with the piezobrush PZ3

of plasma pre-treatment on PTFE using the piezobrush PZ3, with the left side untreated and the right side showing the plasma-treated area. With plasma treatment, both the coverage and the abrasion-resistance of the ink improves.

PLASMA DEVICES FOR LABELLING

For automated plasma processes, use of high-performance systems is very popular. These are particularly suitable for high process speeds, which are associated with relatively stringent demands for process safety and control. However, with temperature-sensitive substrates like many plastics and particularly films, overheating of the sample must be avoided. With conventional pre-treatment methods, such as conventional atmospheric plasma devices or flame treatment, the starting and stopping process of the production line is critical, due to the low process speed and thus high heat impact.

To overcome this issue, relyon plasma GmbH, a subsidiary of TDK Electronics based in Regensburg, Germany, developed the cold atmospheric plasma device piezobrush PZ3-i with Piezoelectric Direct Discharge (PDD) technology. The piezobrush PZ3-i can generate cold plasma highly efficiently, and thus is able to pre-treat temperature-sensitive substrates without sacrificing treatment quality. Because its plasma temperature is below 50°C, it does not face the problem of overheating the sample.

Figure 3 shows the treatment of a foil

> *"In the medical sector, traceability gains further importance due to its safety impact"*

with the high-performance system plasmabrush PB3 (200mm/s) and with a piezobrush PZ3-i (20mm/s). The sample does not withstand the high process temperature of the plasmabrush PB3 and contracts, whereas the treatment with the piezobrush PZ3-i does not show any shrinkage of the film. As the sample is damaged, this is unacceptable for most [print] processes. Prior to the treatment, the surface energy was below 50mN/m, which means that there is a bad wetting. After treatment from

> *"The piezobrush PZ3-i can prepare difficult materials such silicones and PTFE for the subsequent labelling process"*

both methods the surface energy could be raised to a value well above 50mN/m, which is well suited for subsequent processes, such as labelling. Other tests have shown that there are comparable results in the printing quality at higher speeds for both plasma systems.

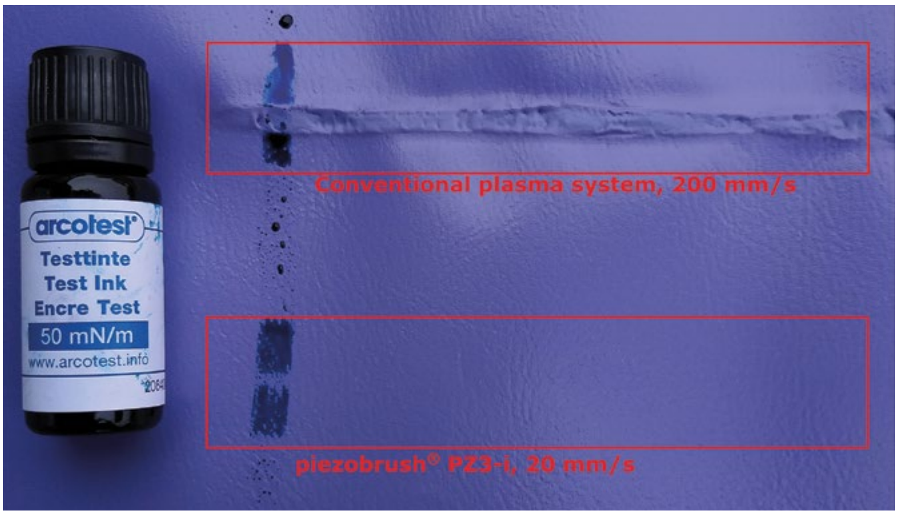

Figure 3: Comparison of plasmabrush PB3 and piezobrush PZ3-i on a temperature-sensitive film

SAFETY AND FLEXIBILITY

Temperature-damaged material inhibits proper traceability, but a missing plasma treatment is also equally critical. Therefore, control of the plasma system is important. Typically, there will be an error signal if the plasma ignited; however, this signal does not contain information on whether a plasma treatment actually took place. Due to the special type of discharge, the piezobrush PZ3-i not only reports an error if no plasma ignites, for conductive samples it gives feedback if there was a substrate present. If a non-conductive substrate gets treated, an error message appears as soon as anything conductive occurs, which might be an unwanted treating area or a worker touching the system while it is running. Owing to the low temperature and the very low current, touching the plasma system is only uncomfortable, not dangerous.

This makes it possible to use this plasma system in typically more cost-effective semi-automated systems, which are easier to implement and have lower requirements on the safety features. The high flexibility of the piezobrush PZ3-i is not only based on the safety features and the compact design for integration into even the smallest production lines, but also in the variety of applications. In addition to its highly efficient preparation of difficult materials (such as the aforementioned silicones and PTFE) for the subsequent labelling process, the device can also handle difficult geometric conditions like complex cavities through the appropriate choice of module. Currently, two modules for conductive and non-conductive materials are available; others are set to launch over the next few months – for example the multigas module, allowing the selection of the most suitable process gas to guarantee best results for your labelling application. ■

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Isabelle Doelfs is a Project and Application Engineer and Dr. Eva Brandes is an Application Engineer at relyon plasma

Further information:
relyon plasma GmbH., Regensburg, Germany
tel: +49 941 60098 180
email: i.doelfs@relyon-plasma.com; info@relyon-plasma.com
web: www.relyon-plasma.com