PLASMA PRE-TREATMENT FOR IMPROVED PRINT QUALITY

These days, high demands on print quality requires a surface pre-treatment. Markus Mayer, of relyon plasma, sets out the benefits of the use of plasma in this process

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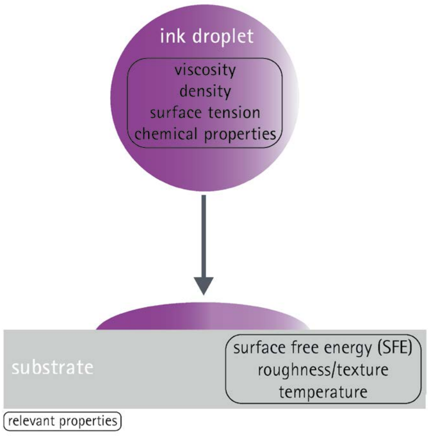
The use of plasma – especially cold atmospheric plasma – has become a beneficial way to improve print quality. One of the ways that this can be achieved is based on piezoelectric direct discharge (PDD) technology. Employing this technology, the piezobrush PZ3-i and modular-designed piezobrush PZ3-c, from relyon plasma, can be utilised for high and precise surface activation.

PRINT INDUSTRY CHALLENGES

With the ever-increasing variety of printable materials today, comes growing possibilities in development and commercial production. Three main criteria are key to enable a high-quality result – the material itself, the ink used and the method of printing. Specialising on one of these factors will lead to more specific solutions for niche applications since many relevant properties must be considered. For example, viscosity and density in inks, the surface-free energy and texture for the materials. With only a few applications, the challenge lies in finding the right balance between high-quality results and economic viability.



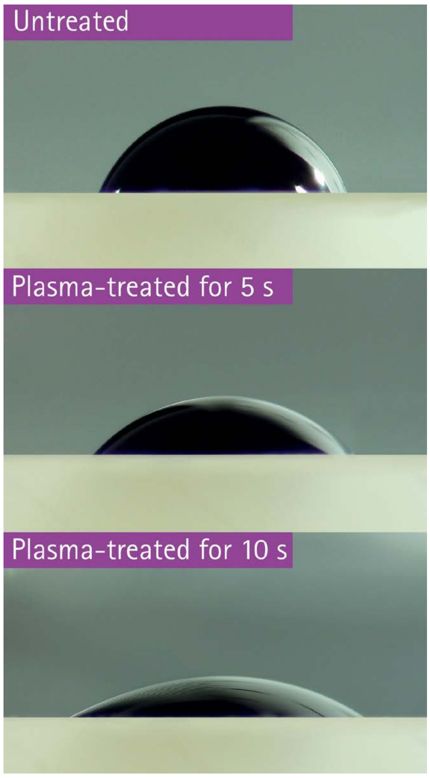
The wetting behaviour of ink droplets on a substrate depends on different relevant properties

NECESSITY OF SURFACE PRE-TREATMENT

In many processes, various pre-treatment steps are used to enable a broader compatibility of printing inks and materials. Typically, binders, primers or other wet chemicals, with a strong oxidative effect, are applied before the printing process. This guarantees sufficient activation on the substrate and thus leads to satisfactory wetting behaviour of the printing ink. However, these chemicals are often only matched to a few materials and must be selected accordingly. Otherwise, mismatches in adhesion strength may occur.

"The challenge lies in finding the right balance between high-quality results and economic viability"

In contrast to these chemicals, plasma processing – immediately before printing – is a more universal and consistent pre-treatment method. Meanwhile, plasma is a well-established technology in many printing applications and, while already being optimised, the limits of this methodology are still far from being exhausted.

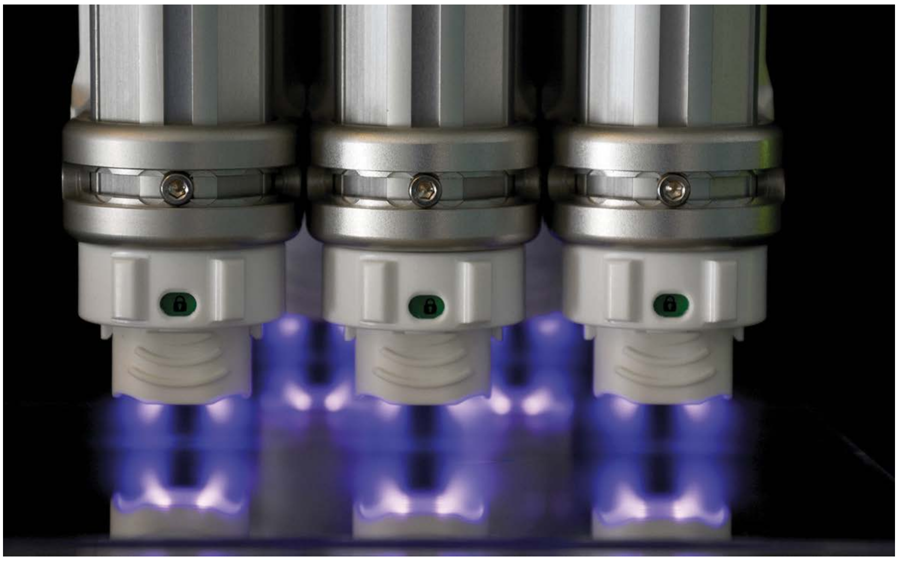


Different treatment times with an otherwise identical parameter setting show the wetting capability of ink droplets on a substrate

SURFACE FUNCTIONALITY

To achieve a greater compatibility between surface and ink, it is common practice to pre-treat the material before printing. Whether using wet chemical agents, such as oil or latex-based primers, or plasma technology, a preliminary processing will lead to increased adhesion of the ink. The main target is to achieve a cleaned and activated surface. In the case of wet chemical treatment, this activation takes place through the direct application of a dispersion. To ensure the desired properties, a kind of undercoat of functional chemical groups remains after the solvent has evaporated. In plasma pre-treatment, the mechanism of action is based

Modular-designed piezobrush PZ3-c and versatile exchange modules for different applications



Five active piezobrush PZ3-i units connected in parallel

on the interaction of ionised molecules and radicals, as well as other physical particles, with the uppermost molecular layers of the material. Regardless of the choice of plasma solution, the result – along with fine cleaning – is the accumulation of polar and disperse chemical groups on the surface through a variety of reactions. This already shows the advantage of functionality of plasma, as pre-treatment takes place, purely by means of electricity as a consumable. As a result, it can make the use of environmentally harmful chemicals superfluous.

INFLUENCE OF SURFACE-FREE ENERGY ON WETTABILITY

The functional groups attached to the surface, by the pre-treatment process, act as a kind of microscopic velcro between the material and the printer ink. In particular, the polarity of the nitrogen and oxygen atoms, incorporated by the plasma process, leads to stronger interactions between material and liquid, and results in an increase in surface-free energy.

"PDD technology is extremely versatile due to its gentle treatment of the material"

This energy is measured in mN/m and provides information about the wetting behaviour of different printing inks. This is essential for a good and homogeneous print image. Every liquid has a surface tension at the interface with air, which is also given in mN/m. If this value exceeds the surface energy of the solid, the ink does not wet the area. Many materials to be printed, have a naturally low surface energy, especially with Teflon (<20mN/m) or other polymer-based materials. Subsequently, the beading effect of liquids is the norm. Water, for example, has a high surface tension of about 72mN/m. This can be observed by its droplet formation on most untreated surfaces. However, if the surface energy after pre-treatment is greater than the tension of the applied ink, the liquid cannot maintain its 'elastic skin' and wetting of the surface occurs. Although from a practical point of view, an excessively activated surface can also be the reason for a poorer quality print image. The applied ink may run and lead to undesirable artefacts, such as in the colour gradient. Precise surface activation is therefore very important.

EFFICIENT PLASMA SOLUTIONS

In addition to the already established pre-treatment methods of a corona plasma or flame treatment, the technology of atmospheric pressure plasma can be used for industrial surface functionality. The piezobrush PZ3-i and PZ3-c, are excellent examples in this process. Corona and flame treatment often lead to a less precise, insufficient activation and can, because of this, only be used for printing materials where a low level of surface activation is already adequate. In addition, the physics of the corona process sometimes leads to high electrostatic fields and charges on the surfaces. These can become dust traps and influence the print quality. However, a very high material throughput can often be achieved via the pure size of the system.

In contrast, plasma generation by PDD technology, as used by the piezobrush PZ3-i and PZ3-c, involves a low input voltage being transformed upwards by a factor of about 1,000 to several kilovolts by the CeraPlas – the plasma-generating piezo transformer. This piezo transformer is used to generate cold atmospheric pressure plasma by an ionisation process. The resulting micro-discharges ensure constant ignition of the plasma and uniform power distribution on the surface. Strong electrostatic charges are only possible to a limited extent, due to the high voltage generated locally at the CeraPlas. At the same time, the plasma does not exceed temperatures of 50°C on the material surface, meaning thermal over-treating is almost impossible when compared to high performance, atmospheric plasma-jet solutions. Although the underlying mechanisms of plasma activation are similar in the different processes, PDD technology is extremely versatile due to its gentle treatment of the material.

PRECISE ADJUSTMENT OF SURFACE ACTIVATION

As a plasma pre-treatment method, PDD technology offers comprehensive process control for the end user in terms of the suitable setting of surface energy. For this purpose, the distance and angle of the plasma-generating unit to the surface, treatment speed, process gas and applied power, can be used to fine tune the activation process. The challenge for a controlled wetting behaviour of inks on the surface, can therefore be effectively counteracted.

Treatment width and speed can be varied, to a certain degree, by working in parallel or stringing together several units. Additionally, the plasma can be started and stopped with a latency in the range of milliseconds, via analogue-switching signals. Depending on the conductivity of the surface, there are different requirements for the plasma discharge. For this reason, the piezobrush PZ3-i and PZ3-c units make use of different insertable modules in which the CeraPlas is integrated.

With the piezobrush PZ3-i, already highly energy efficient and cost effective – based on the same technology – it strips down costs even further. This is possible due to its modular design that comes without housing. This just leaves the control board and plasma-generating module for integration into machines, printers or process systems, that offer little space with other components, ensuring the best-quality results.

CONCLUSION

To achieve a high-quality print image, and ensure compatibility between printer ink and material, pre-treatment of materials is often required. Among the various possibilities, plasma is proving to be particularly forward-looking, enabling precise treatment of many different materials, especially through the innovative PDD technology. Running costs and the climatic impact incurred using chemicals is cushioned. At the same time, the low energy consumption compared to other established plasma solutions, offers further economic advantages. ■

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