Interview with Christian Buske, CEO Plasmatreat Group and Dr. Jörg Ihde from the Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM)

# Functional plasma coating under normal pressure - the origin and future of a key technology

**What was previously possible only under vacuum can now be done in-line under normal pressure: Plasma Plus atmospheric plasma coating technology allows a wealth of different functional coatings to be targeted to selected areas of material surfaces – especially to confer corrosion protection or adhesion promotion to a surface, but also to provide an anti-adhesion coating or barrier layer.**

Nanocoating with atmospheric pressure (AP) plasma enables substances tailored specifically to the application to be deposited deep into the nanostructure of the material surface. High-energy excitation within the plasma fragments these substances and deposits them on the surface in the form of an ultra-thin vitreous coating. This technique creates a highly effective functional coating which gives the materials completely new surface characteristics. Apart from its suitability for in-line use, the main advantages of PlasmaPlus jet technology compared with other coating techniques is its area selectivity. But how did this process come about, what are its strengths and what might it be capable of in the future? CEO of the Plasmatreat Group Christian Buske and Dr. Jörg Ihde from the Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) in Bremen answered questions put to them by specialized journalist Inès A. Melamies.

Foto: Plasmatreat

*Adhesion-promoting and anticorrosive: The plasma nozzle applies a functional coating to aluminum*

**APR: Mr. Buske, when and how did the partnership with the Fraunhofer IFAM come about?**

**Christian Buske:** We first started working together in the mid-90s. At that time the Fraunhofer IFAM was already regarded as Germany's leading institute for adhesive bonding research and having recently invented the Openair atmospheric plasma jet technology, we were looking for a reliable partner to develop the process on an industrial scale.

**APR: And what did this further development entail, Dr. Ihde?**

**Jörg Ihde:** Well, it involved significantly extending the capabilities of AP plasma nozzles from cleaning and activation to the deposition of functional coatings. For decades we have been able to apply these coatings successfully on an industrial scale using low-pressure plasmas in a vacuum chamber. With AP plasmas, on the other hand, only basic approaches had been carried out at university level, which – due to their use of expensive noble gases – were not a practical alternative.

**APR: What is the purpose of the new coating technology?**

**Jörg Ihde:** The purpose of this coating technology is to give new value to components or materials. The coatings are designed to create functional surfaces quickly and cost effectively in an environmentally friendly process which makes efficient use of resources. Atmospheric pressure plasma coating lends itself particularly to industrial applications that require thin coatings which are both localized and customized. It provides an alternative to using large wet chemical baths and costly drying processes which are energy-intensive and take up a lot of space. Many environmentally harmful process steps, including the use of solvent-based adhesion promoters and primers, then become entirely redundant without any ensuing loss of quality.

**APR: What has been the challenging aspect of this process from the developer's point of view?**

**Jörg Ihde:** Understanding the complex mechanisms that lie at the heart of these atmospheric pressure plasma processes. This is the key to designing suitable nozzles and processes that enable us to develop high quality coatings tailored specifically to customer needs. The processes must be commercially viable, in other words very high layer deposition rates and process speeds must be achieved using the most cost-effective and environmentally safe coating substances.

**APR: Mr. Buske, can you tell me which users will benefit more from this process than from low-pressure coating? What can the nozzle do that the plasma under vacuum cannot do?**

**Christian Buske:** We developed plasma jet technology specifically for in-line use in automated, continuous production processes. It is fully compatible with robots and can easily be integrated into new or existing production lines. Compared to low-pressure processes investment costs are considerably lower. It is unquestionably of great benefit to manufacturers who produce large numbers of units at high process speeds, since a vacuum chamber is not suited to either of these requirements. The limitations of the vacuum chamber will always restrict the number and size of components that can be coated using the low-pressure process. Furthermore, since the vacuum chamber is normally loaded manually, production processes generally have to be interrupted to carry out this pretreatment.

**APR: And what do you consider to be the greatest ad-vantage?**

**Christian Buske:** Layer deposition is area-selective, i.e. it can be targeted with millimeter accuracy to a precisely defined location, even at very high processing speeds, and there is no doubt in my mind that this is the unique advantage of the process. For example, a 100Nm-thin coating can be deposited in milliseconds. Under vacuum it would take around one to two minutes and area selection would not be an option.

**APR: What makes the process so fast, Dr. Ihde?**

**Jörg Ihde:** With the plasma nozzles we use, we can achieve deposition rates with these processes which are in some cases 10 to 100 times higher than for other AP plasma sources. Deposition processes at speeds of even 100m/min or more are achievable, which results in extremely high throughput rates. Then there is the added benefit that the processes have been designed to work with inexpensive compressed air in the majority of cases, whereas other sources often require nitrogen or even noble gases.

**APR: Now let's talk about the coatings themselves. What are their particular qualities and characteristics?**

**Jörg Ihde:** As well as adhesion-promoting and anti-corrosion coatings, permanent anti-adhesion coatings containing simple organosilicon compounds can be deposited. By refining the nozzle systems and the plasma chemistry, it has become possible to apply an enormous variety of functional coatings at extremely high deposition rates - up to 1 micrometer per second - using just one single, low-cost precursor - and that's what makes this system so special. Apart from organosilicon layers, pure organic coatings which confer new functions can also be developed thanks to the variety of organic precursors available.

**APR: Can the composition of the precursor be individually controlled or modified according to the requirements of the user?**

**Jörg Ihde:** The choice of precursor is just one way to influence coating functionality. The coating chemistry can also be modified and controlled in a targeted manner by adjusting the plasma parameters and nozzle geometry. What makes the AP plasma process so attractive is that by carefully selecting coating thickness and plasma chemistry, we can decide whether to deposit a hydrophobic or hydrophilic coating.

**APR: What kinds of functional coatings can already be achieved with this technology?**

**Christian Buske:** This technology can give specially aluminium alloys a greater degree of corrosion protection. Scratch-resistant layers can be generated or even release coatings. It can also be applied to plastics, glass and ceramics where it confers a variety of functions. In each case this coating technology provides an alternative to environmentally harmful chemical primers.

**APR: The first industrial application of this coating process was already carried out at automotive component supplier TRW Automotive in 2007. How have developments progressed since then?**

**Jörg Ihde:** We have successfully increased the deposition rate by improving the nozzle design, which has greatly increased layer deposition efficiency. In addition we have been able to develop anti-ageing processes for electronic components which provide the same degree of protection as solvent-based paints but have a much more efficient cooling effect due to the very thin coating. This makes it possible to create new, compact construction methods. Furthermore, we can now deposit composite layers containing corrosion inhibitors which act at nano-level. This means that coatings continue to provide corrosion protection even after they have been damaged, for example by scratching.

The quality of the layers has advanced to such an extent that we can now apply AP plasma processes to protective coatings for the solar energy sector which are designed to increase lifespan and efficiency.

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*Dipl.-Ing. Christian Buske: Managing Partner Plasmatreat GmbH and CEO Plasmatreat Group*

**APR: What potential uses do both of you envisage for PlasmaPlus technology in the future?**

**Christian Buske:** The ability to manufacture products with selectively functionalized surfaces opens up a completely new dimension in innovation capability, the scope of which we can only begin to imagine at this stage. With PlasmaPlus it has only very recently become possible to create a strong, stable, media-tight bond between metal and plastic components in hybrid injection molding. Looking ahead, I see very promising areas in new forms of energy, medical, engineering, electronics and lightweight vehicle manufacturing.

In terms of automotive construction, I see the trend for bodywork components made from lightweight metals and lightweight composite materials as a great opportunity because, as well as offering functions such as high corrosion protection, PlasmaPlus coating achieves reliable and long-time stable adhesive bonds without the use of chemical substances that are harmful to the environment.

**Jörg Ihde:** I agree. We too believe that this technology is only in the very earliest stages of industrial use. In the automotive sector I envisage new applications particularly in electric mobility, but also, as Mr. Buske has already mentioned, in efficient, lightweight structures made from aluminium and CFRP, where the combination of long-time stable adhesion and avoidance of contact corrosion is essential. We are also working jointly with Plasmatreat to develop medical and biocompatible coatings which will shortly be market ready. Particle modification also enables us to create completely new products with the aid of AP plasma coating. AP plasma coating technology will find countless future applications which at present we can only guess at in areas where there is a need to use resources efficiently, save energy, reduce costs, be environmentally responsible or create a healthy working environment.

**APR: Mr. Buske, Dr. Ihde, thank you very much for this interview.**