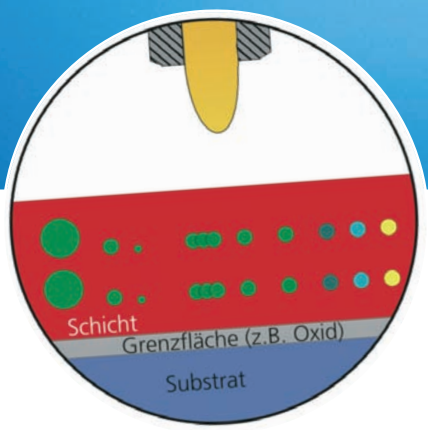
<< Figure 1: Photo courtesy of Plasmatreat. At the heart of the process is a plasma nozzle, which conceals a complex coating system allowing the deposition of locally selective nano-coatings. >>



<< Figure 2: Graph courtesy of Fraunhofer IFAM. Structure of an antimicrobial plasma coating from the APASI project. >>

English:
red=coating
grey=boundary layer
blue=substrate

Functional Nanocoating with Millimeter Precision

Atmospheric Plasma Polymerisation in Medical Engineering

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A special atmospheric plasma coating process can bring about micro fine cleaning, disinfection and sterilisation, and apply functional coatings. Diffusion barriers and anti-frictional coatings can be produced, or antimicrobial layers deposited.

Manufacturing processes in medical engineering demand extremely high standards. Surfaces must be absolutely clean, or even sterile, before they can be further processed or used. Furthermore, pre-treatment processes in medical technology must be very reliable and precisely reproducible.

A special plasma process meets these requirements. PlasmaPlus is a plasma process that for the first time enables functional nanocoating to be applied to material surfaces under normal air conditions in a fully automated and continuous inline process. Until recently, plasma polymerisation could only be carried out under low pressure in a vacuum chamber. Together with the Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) in Bremen, market leader Plasmatreat GmbH in Steinhagen, Germany has spent the last few years developing and patenting a much simpler, quicker and more cost-effective process using atmospheric pressure plasma. The nanofine functional coatings allow a variety of new applications in medical engineering, such as self-cleaning or antimicrobial surfaces. In 2012 the process was awarded with the German Industry Award 2012 in the category "Production and Mechanical Engineering".

Atmospheric plasma coating

At the heart of the process is a plasma nozzle, which conceals a complex coating system (figure 1). The process is environmentally friendly, needing nothing other than compressed air, electricity and the so-called precursor, which is added to the plasma. A variety of different materials including metal, glass, plastics and

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ceramics can be coated by varying the chemical composition of the precursor and delivering it directly to the plasma. The precursor is exited within the plasma or respectively fragmented and is deposited on the material, where it forms a cross-linked layer.

Apart from the inline-use, the main advantage of this technology compared with other systems is the locally selective coating technique. The use of a plasma nozzle enables locally selective coatings to be applied in a highly targeted manner, which makes efficient use of resources. Processes can be so accurately controlled that layers, which confer different functions, such as corrosion protection, adhesion, or even anti-adhesion, can be applied using the same nozzle. Furthermore, only very small quantities of coating material are required. A big advantage also is the extremely high speed by which a coating can be created. While the low-pressure plasma technology, already frequently used in medicine, takes one to two minutes to form a 100 nm coating thickness, a deposition layer can be achieved in milliseconds with the new coating technology. This process can be used in different medical fields.

Self-cleaning coatings

This process can already be used to deposit photocatalytically-active titanium-dioxide coatings. When exposed to sunlight and moisture, these coatings have a self-cleaning and germicidal effect. This application is used to prevent the formation of biofilms on all surfaces that come in contact with light or are light conducting surfaces. The process is therefore of particular interest for coating medical and sanitary products since it allows manual cleaning intervals to be extended or omitted altogether.

Antimicrobial coatings

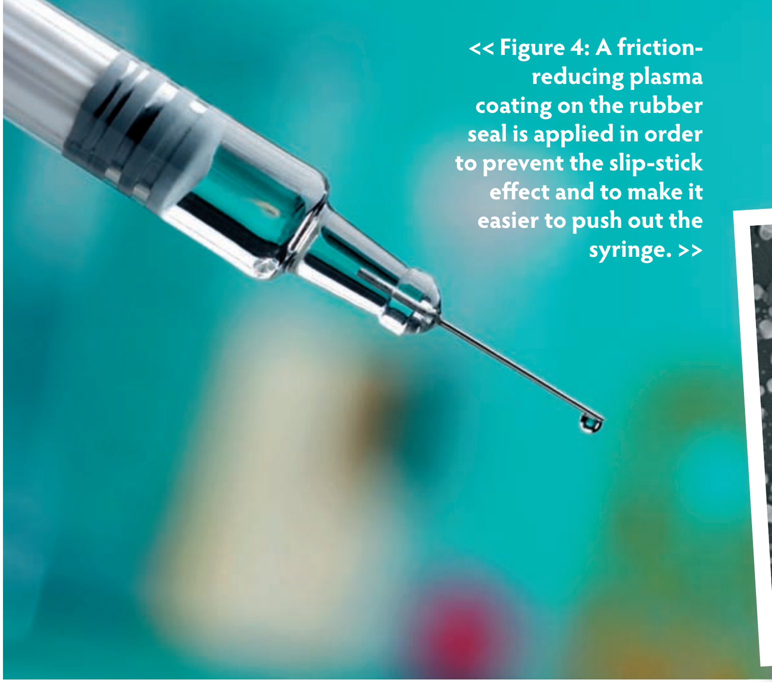
A further focus of research is the deposition of antimicrobial coatings containing silver (figure 2). Within APASI, a joint project funded by the German Federal Ministry of Education and Research, the Fraunhofer IFAM and Plasmatreat have set themselves the task of producing antimicrobial plasma coatings. The aim is to bind silver nano particles to an organosilicon layer. Germs on the surface are killed by the continuous release of silver ions. The silver nano particles are not added externally, as with other coating processes, but generated directly in the nozzle and deposited in situ, where they bind to the surface of the layer (figure 3). The new nozzle design enables layers containing silver, and even copper, to be deposited in a simple and cost-effective single-step process. Coatings of the kind are not new. The innovative aspect of this research project is the deposition process. Until lately such coatings could only be created in costly chemical or low-pressure plasma processes. The new atmospheric plasma polymerisation offers an environmentally friendly and efficient solution, which is easy to integrate inline.

Anti-friction coatings

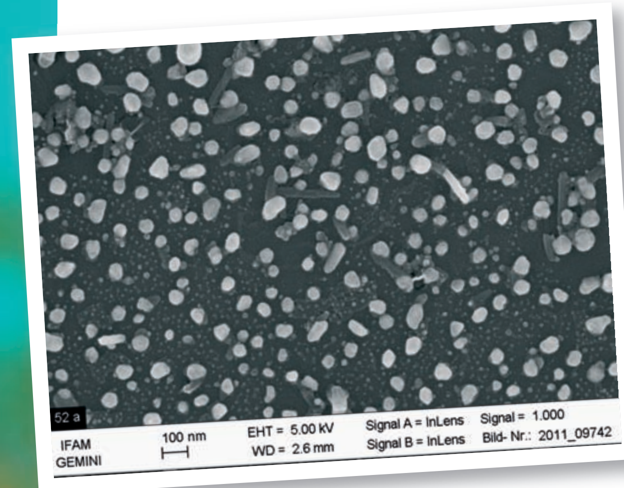
The rubber seals of syringe plungers are often subject to the 'stick-slip' effect, the jerky motion that occurs when two surfaces slide over each other. To prevent this and make it easier to eject the syringe, the new plasma polymer anti-friction coating has already been successfully applied to seals. The new coating ensures that the rubber surface glides smoothly (figure 4).

Barrier layers

Barrier or diffusion layers produced with AP plasma are an important research goal of the plasma company. Barrier layers can be applied to various plastics and constitute an effective barrier against carbon dioxide, oxygen and water. In medical packaging barrier layers protect the active ingredients and flavourings, and preserve the quality and integrity of the contents. With the aid of highly cross-linked plasma polymer



<< **Figure 4: A friction-reducing plasma coating on the rubber seal is applied in order to prevent the slip-stick effect and to make it easier to push out the syringe.** >>



<< Figure 3: **Courtesy of Fraunhofer IFAM. The SEM image (200,000 x magnification) shows silver nano-particles sputtered by atmospheric plasma to create an antimicrobial coating.** >>

layers, the process can already create oxygen diffusion barriers, which achieve a BIF (Barrier Improvement Factor) of up to 5. Typical materials include polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET).

Adhesion promoting layers for hybrid components

The plasma process has also improved adhesion between rubber-to-metal and plastic-to-metal bonding in hybrid injection moulding. This involves applying nano-coatings with active adhesion to the metal surface, then moulding the plastic components onto the surface. The deposition of adhesion-promoting coatings with this plasma process is a technique that will allow solvent-based primers to be entirely replaced in the future.

Nanocoating with atmospheric pressure plasma enables substances tailored specifically to the application to be deposited deep into the nanostructure of the material surface. This technique creates a highly effective functional coating, which confers completely new surface characteristics on the materials. Manufacturing products with selectively functionalised surfaces opens up a completely new dimension in innovation capability for companies working in the field of medical engineering.

www.plasmatreat.co.uk