Adapted version from the German original: WERKSTOFFE in der Fertigung, issue 1/2009

Werkstoffe

Topic

Plasma polymerisation at normal atmospheric pressure

What hitherto was only possible in vacuum can now take place in-line at normal atmospheric pressure. Whether used for corrosion protection, as an adhesion promoter or for the microfine cleaning of a surface, a newly developed plasma technology offers an abundance of differently functionalised layers for the locally selective coating of the surfaces of materials. The new process is based on the Openair atmospheric-pressure plasma technology employed by Plasmatreat, Steinhagen. This zero-potential plasma system is characterised by a threefold action: it activates surfaces by selective oxidation processes, simultaneously discharges them and brings about microfine cleaning and high activation of the surfaces of metals, plastics, ceramics and glass. Its intensity is so high that treatment speeds of several 100 m/min. can be achieved. In addition, the plasma energy of this system is exploited for film formation. From the economics point of view the jet systems used can always be integrated in-line by the user, that is to say integrated directly into a new or already existing production line.

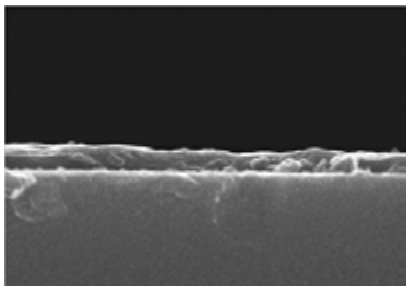
Vitreous protective layers

Until recently plasma coating used to be a process that could only be carried out in vacuum. In close collaboration with the Fraunhofer IFAM in Bremen Plasmatreat developed, patented and applied on an industrial scale a new technology which now makes it possible to apply

To provide a nanocoating on an electronics housing by the Openair PlasmaPlus process an organosilicon compound is added to the plasma
Photo: Plasmatreat

nanoscale thin plasma coatings to the surfaces of materials in-line under normal atmospheric conditions. The technology, called PlasmaPlus, is economically efficient since in contrast with low-pressure processes it operates without a vacuum chamber. The number and size of components treated in vacuum are always constrained by the chamber required and production processes must be interrupted prior to the pretreatment. Furthermore, Openair technology is compatible with robots and capable of in-line integration. The system can very easily be integrated into new or already existing production lines so that in consequence the production speed can frequently be increased by a significant factor.

By exploiting the high energy content of plasma for plasma polymerisation at normal atmospheric pressure thin coatings can be deposited on the most varied materials. At the same time these undergo very strong bonding to the surfaces so that their properties can be deliberately altered and the range of possible applications made more diverse. To produce a coating an organosilicon compound is admixed with the atmospheric-pressure plasma employed here. Due to the high-energy excitation in the plasma this compound is fragmented and is deposited on a surface in the form of a vitreous layer. Depending on the application in question the chemical composition can be varied in order to achieve the best results on the different materials being treated. To assess the thicknesses of the layers



The picture shows a cross-section through an approximately 100 nm thick Openair PlasmaPlus layer (scanning electron microscope: 50,000 times magnification)
Photo: Saint-Gobain

scanning electron microscope studies were carried out. At 50,000 times magnification the photomicrographs of coated

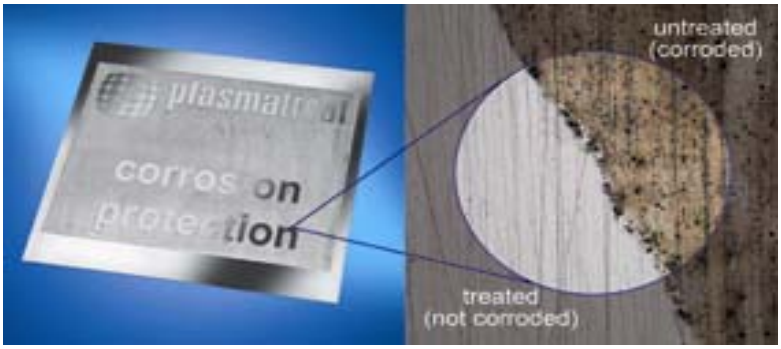
sample cross-sections reveal a homogeneous and non-porous layer structure. This is very important for corrosion protection since what we have here is a passive protective layer, i.e. attack by corrosive media is prevented by a barrier effect. The material in the layer itself is not sacrificed as would be the case, for example, for a galvanized steel surface (active corrosion protection).

Process technology

The installation developed by Plasmatreat consists as in the case of plasma activation of a generator, high-voltage transformer and a plasma jet. In addition the process fluid (precursor) is fed via a vaporizer unit into the emergent plasma beam. In order to obtain uniform and reproducible coatings the parameters for both the plasma and precursor have to be kept within narrow ranges. The preconditions for this are provided by suitable generators due to their digital control electronics. The entire process proceeds completely under microprocessor control.

Anticorrosive protection of aluminium

Apart from its in-line use, the great advantages of PlasmaPlus technology in comparison with other coating methods lie primarily in the technique of locally selective coating. The anticorrosive action is particularly effective in the case of aluminium alloys. The coating is able to protect the aluminium for several days against direct salt spray (DIN 50021) without the visual appearance of the metal being affected. If the plasma coating is to be used for corrosion protection, a thick layer (several hundred nanometers) is recommended as this is more resistant to corrosive media such as electrolyte solutions, acids and alkalis. When used as an adhesion promoter layer just a few nanometers suffice in principle as these thin layers already comprise all the important functional groups with which the adhesive can react and undergo secure bonding. The very good adhesion of the coating to the substrate effectively prevents infiltration of the adhesive joint (bondline corrosion). For an adhesively bonded component, e.g. a motor or PCB housing in the automotive industry, infiltration would be particularly harmful since then the transmission of force in structural adhesive joints would no longer be ensured or leaks could occur in housings sealed with a sealing adhesive.



The photomicrograph shows that the region protected by the PlasmaPlus layer exhibits no sign of corrosion even after 96 h exposure to the salt spray test
Photo: Plasmatreat

New properties of materials

Plasma-polymerized coatings can generate new surface properties such as:

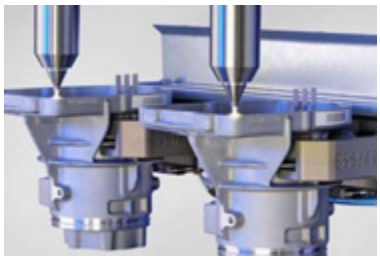
- permanent primers confer paintability of long-term duration and allow greater flexibility in production
- dirt-repellent surfaces
- anticorrosive layers on aluminium which allow adhesive bonds of long-term stability
- mould release coatings in the injection moulding of plastics

The new system allows plasma-polymeric coatings in the most varied fields of application.

Thus, by way of example, the process extends the use of polycarbonate in optical data media in that water absorption is greatly reduced and as a result a compact disc remains dimensionally stable even when exposed to high levels of atmospheric humidity. Polypropylene films permanently accept print due to a coating produced in the plasma and fogging properties are positively affected. The subsequent modification of surfaces opens up new possibilities for compound compositions and a higher proportion of recycled material can now be used. Plasma-polymeric coatings on metallised plastics not only provide good protection against corrosion, e.g. in the shieldings in telephone housings, but also ensure great expansion of the range of applications of these plastics overall.

Plasma coating in the automotive sector

Since 2007 PlasmaPlus technology has been employed at TRW Automotive in motor pump housings for assisted steering. To prevent corrosion in these safety-related components adhesive joints of metallic surfaces in the component are selectively coated in-line at atmospheric pressure by the new process. Coating ensues in-line and ensures the highest possible protection against the penetration of moisture. Even microscopically small leaks due to corrosion can result in short-circuiting and in failure of the assisted steering system. In comparison with the original process, in which after adhesive bonding a fluoropolymer-based anticorrosion agent was sprayed manually from the outside onto



The TRW motor pump housing is given a microfine cleaning by Openair plasma prior to plasma coating. Photo: Plasmatreat

the adhesive joint, substantially better leak-proofing was achieved with the plasma-polymerized coating.

Summary

In the near future plasma-polymerized coatings will greatly extend the range of applications for the most varied materials. The plasma technology described here now provides a tool which can deposit these layers very efficiently and selectively under atmospheric conditions. Due to the low volumes and non-toxicity of the chemicals employed for coating the process is very environmentally friendly. No additional solvents are needed. Removal of the coatings prior to recycling processes is not necessary since they do not contain any harmful compounds. The coatings together with the substrate material can be passed on for recycling.

bri

Contact details: Plasmatreat GmbH,
33803 Steinhagen, Germany
Tel. +49 (0)5204 9960-0,
mail@plasmatreat.de
www.plasmatreat.de