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Trendsetting Corrosion Protection

New plasma technology allows the nanocoating of aluminium under normal pressure

What was until recently only possible in a vacuum can now be achieved in-line under normal atmospheric conditions: a plasma technology by the name of PlasmaPlus offers an abundance of different functionalised coatings for the selective coating of material surfaces.

The basis of the process is the Openair atmospheric-pressure plasma technology from the Germany based Plasmatreat GmbH. The plasma-jet technique developed by today's market leader has been used throughout the world for over 15 years in the most varied industries.

The zero-potential plasma system is characterised by a threefold action: it activates surfaces by selective oxidation processes, discharges them at the same time and brings about microfine cleaning and high activation of the surfaces of metals, plastics, ceramics and glass. Its intensity is so high that treatment rates 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.

Scarcely any bounds are set to the versatility of application of the eco-friendly technology. Conventional pretreatment methods such as cleaning using wet chemicals are completely displaced by the high quality plasma process and certain working steps are rendered unnecessary. This gives rise to significant cost savings in production workflows.

Until recently plasma coating used to be a process that could only be carried out in vacuum. In close collaboration with the Fraunhofer Institute IFAM in Bremen, Plasmatreat developed a new process by the name of PlasmaPlus which for the first time allowed nanoscale thin films to be applied to the surfaces of materials at atmospheric pressure. As a world premiere this plasma polymerization process was brought to industrial application by Plasmatreat in 2007 by coating engine pump housings for steering units against bondline corrosion at TRW Automotive.



Photo: Plasmatreat
High corrosion protection on aluminium is achieved by the Openair®-PlasmaPlus® system through microfine precleaning and nanothin plasma-coating

Plasma Polymerisation Under Normal Pressure

To produce a layer, the atmospheric-pressure plasma employed here is admixed with an organosilicon compound. Due to the high-energy excitation of the plasma this compound is fragmented and is deposited on a surface in the form of a vitreous film. The chemical composition can be varied according to application in order to

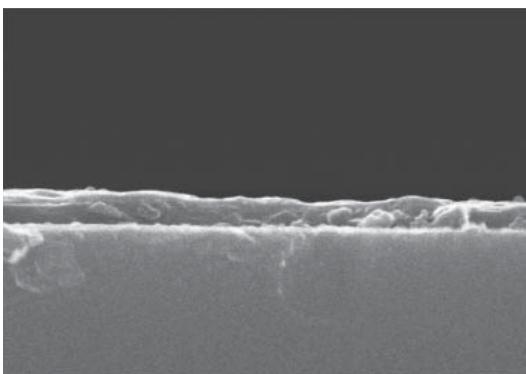


Photo: St. Gobain
Cross-section through an approximately 100 nm thick Openair®-PlasmaPlus® layer (50,000 times magnification by scanning electron microscope)

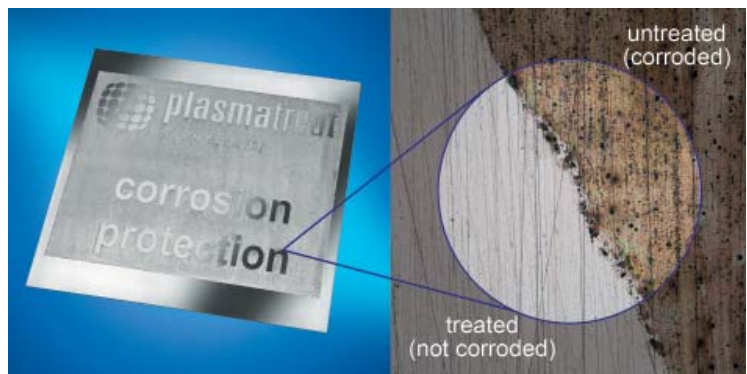


Photo: Plasmatreat
The area protected by the PlasmaPlus® coating exhibits no sign of corrosion even after exposure for 96 hours to the salt spray test

In the Spot Light: Cost Efficiency

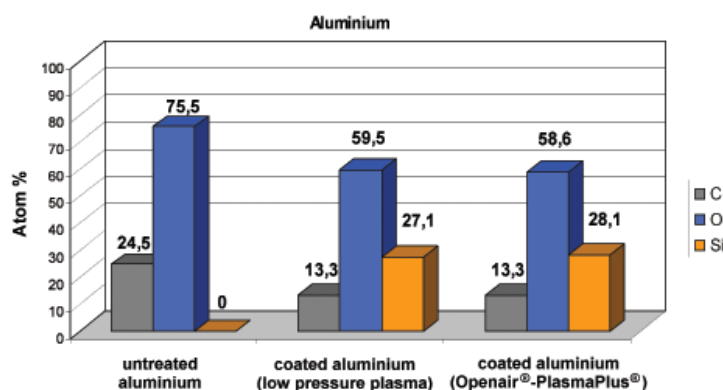
Surface treatment with Openair® atmospheric-pressure plasma compared to low-pressure plasma and other methods

- In comparison with low-pressure methods described PlasmaPlus technology is far more efficient since the pretreatment process makes do without a costly vacuum chamber and takes place in-line in the production line under completely normal atmospheric conditions.
- The number and size of parts treated at low pressure, i.e. in a vacuum, are limited by the chamber required. Pretreatment production processes have to be interrupted and assembly is usually carried out manually.
- Openair atmospheric-pressure plasma technology is without restriction compatible with robots and capable of in-line integration. The system can be very easily integrated into new or already existing production lines. Production rates are increased by a significant multiple and the deployment of manpower is considerably reduced.
- With low-pressure plasma neither cleaning processes for strip-like products, as in the coil coating process, nor large-area pretreatments prior to bonding processes, can be implemented.
- Chemical treatments require consumables and often leave behind residues that are difficult and very expensive to dispose of. The plasma technology described completely replaces chemicals in the precleaning process.
- Mechanical pretreatment methods (scoring) are very difficult to implement reliably and also operate with consumable materials.

Atmospheric-pressure plasma technology, however, is not suitable when surfaces are not accessible to the atmospheric-pressure plasma beam due to very complicated geometries or when the production layout is already designed for chamber processes.

achieve the best results for the different materials involved. To evaluate the thicknesses of the layers SEM (scanning electron microscope) studies were carried out.

At 50,000 times magnification scanning electron micrographs of coated sample cross-sections reveals a homogeneous and nonporous layer structure. This is very important in corrosion protection since we are dealing here with a passive layer, which means that attack by corrosive media is prevented due to a barrier effect. The material in the coating itself is



XPS Analysis: Openair®-PlasmaPlus® is as efficient as low pressure plasma

not sacrificed during the corrosion process, as would be the case, for example, in a zinc-coated or galvanised steel surface (active corrosion protection).

Protecting Aluminium Against Corrosion

Apart from its in-line use, the great advantages of PlasmaPlus technology compared with other coating techniques lie primarily in the technique of selective coating.

The anticorrosive action is particularly effective in aluminium alloys. The coating is able to protect the aluminium for several days against direct salt spray fog (DIN 50021) without the visual appearance of the metal being affected. To demonstrate the mode of action an aluminium plate (Al 99.5) was partially coated, while the remaining area was left in the unprotected initial state. After 96 hours of exposure to the salt spray test the uncoated aluminium surface was highly corroded (matt area) while the coated area still exhibited its original lustre. The boundary between the corroded and uncorroded areas is clearly discernible in the photomicrograph at 100 times magnification. If plasma coating is used for corrosion protection a thick layer (several hundred nanometres) is advisable since this is more resistant to corrosive media, such as electrolyte solutions, acids and alkalis. When the layer is used as a bonding agent just a few nanometres suffice in principle since this thin film comprises all the important functional groups with which the adhesive can react and undergo strong bonding.



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