Corrosion Protection and Bonding on Openair® Plasma-passivated aluminum surfaces

For many years adhesion to aluminum has required complex and often costly processes. The most successful cases occur when bonding can be performed between an artificially changed surface and an adhesive.

Surface Passivation

Depending on the application in question and the ageing stability, eloxed, chromated and titanized surfaces have proven their worth in this matter. These methods treat the entire part, often requiring masking or subsequent removal steps. Because only a small area of the entire component surface comes into contact with the glue, partial treatment would be of considerable interest.

With Openair® Plasma we have now succeeded under atmospheric pressure in alloying the natural oxide layer in such a way that it is stable enough to chemically bond with the adhesive polymer. Partial passivation of aluminium with the use of multi-step wet chemistry is now possible as well. This has been developed in close cooperation with Volkswagen AG and Sika AG and is ready for implementation.

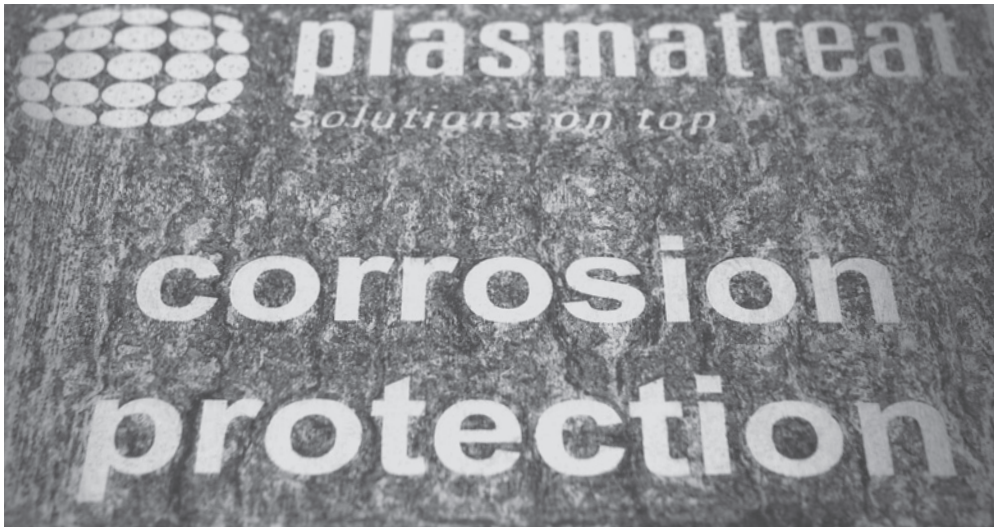

Fig.1 (left) Plasma source RD1004 Fig. 2 (above) partial corrosion protection on aluminium after salt spray test

Coating the aluminium surface with a PT Bond® coating

Degreasing of the surface to be bonded (wiping it with solvent) in some circumstances is not sufficient to cause the adhesive to form a firm joint. Subsequent ultracleaning with plasma improves this bond but may not always be sufficient in harsh environments. Environmental exposure testing (salt spray test in accordance with DIN 50021) shows that in this case the adhesive joint becomes detached from the substrate.

Only by coating the aluminium surface with a PT Bond® coating is a full cohesive bond achieved, both in the initial bonding and after weathering (see Figure 3).

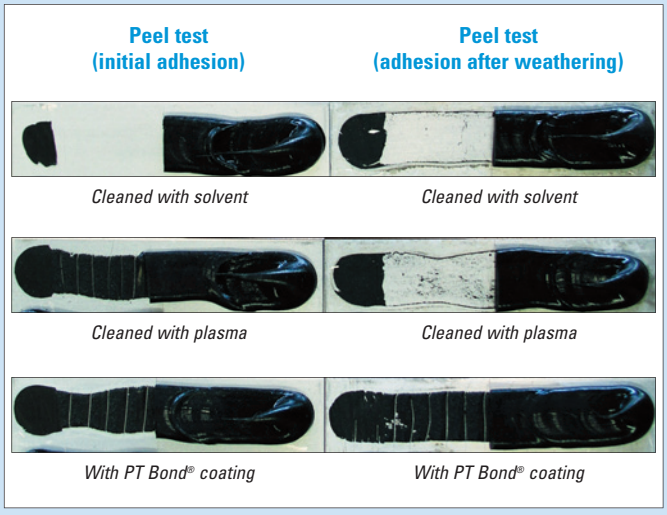

Figure 3: Peel tests on cleaned and coated aluminium plates. Only the Cleaned with plasma with PT Bond® coating exhibits good adhesion even after weathering.

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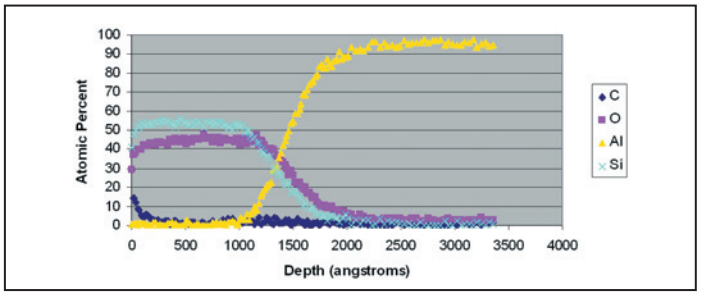
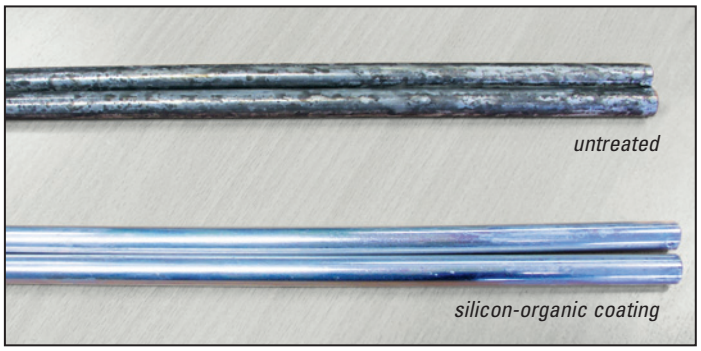
Corrosion Protection

Different substrate materials can be protected against corrosion. Aluminium alloys, stainless steel, galvanized steel sheets and zinc sheets were examined after a 96 hour salt spray test (DIN 50021).

The result of the test series is shown in fig. 4. The substrate materials were selected as follows: aluminum AlMg1 non-anodized, aluminum non-anodized, aluminum automotive alloy, stainless steel 1.4301, hot-dip galvanized steel, electrolytic zinc-plated steel, zinc sheet (from left to right). All uncoated sheet metals (with exception of the stainless steel) exhibit strong corrosion (upper row), whereas the corrosion protected sheet metals (lower row) performed significantly better. The corrosion could successfully be prevented or slowed down in all cases. The aluminum alloys showed the most advantageous results in these tests.





Corrosion protection of aluminium pipes, salt spray test (DIN 50021)

- the corrosion behaviours of aluminium tubes (initial state / coated)
- after 96 hours salt spray test, the untreated aluminium shows strong corrosion
- a silicon-organic coating on aluminium effectively prevents corrosion

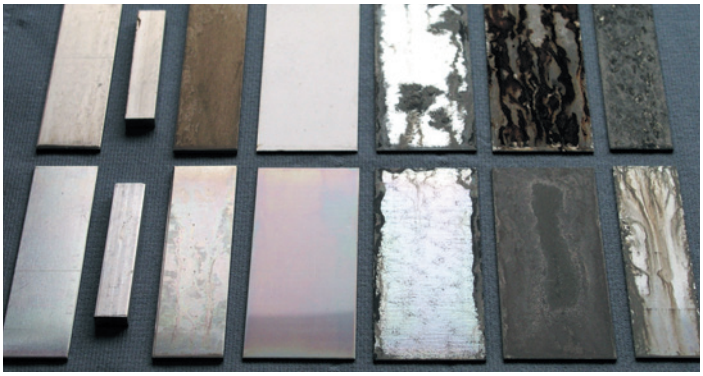


Fig. 4 Comparison of raw (top) and coated (buttom) samples after salt spray test

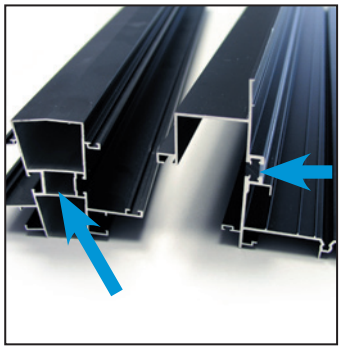
An AES depth profile of an aluminium sheet is shown in fig. 2.

The coating in this case has a thickness of approx. 130–140 nm. However the layer thickness can be varied by changing the coating parameters within a wide range.

Fig. 2 (left)

Structural Bonding of aluminium car door chassis

Results have proven: Plasma Passivation avoids corrosion between adhesive layers and aluminium.



Long term production experience with aluminium window profiles has shown that Plasma Passivation can improve the adhesion of PUR resins. In the picture: temperature barriers.

Conclusion

An applied layer can protect many different surfaces efficiently from corrosion. This was shown on a variety of materials through the salt spray tests. If different adhesives on aluminium are to be used, then the coating has to be selected to suit the chemistry.

This is due to substantial differences in the interaction between adhesives and coating. However, under optimal conditions the adhesive can still possess the full adhesion after a salt spray test.

Plasmatreat US LP
2541 Technology Dr., Suite 407
Elgin, IL 60124
United States of America

Phone: 847.783-0622
Fax: 847.783-0991

www.plasmatreat.com
sales@plasmatreat.com

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