Adapted version from the German original: „Alles aus einer Hand– Reinigen, Aktivieren, Beschichten mit atmosphärischem Plasma“, published in **Galvanotechnik July 2007**
Photos: Plasmatreat

Adapted version from the German original: „Alles aus einer Hand– Reinigen, Aktivieren, Beschichten mit atmosphärischem Plasma“, published in **Galvanotechnik July 2007**
Photos: Plasmatreat

One-stop shop - Cleaning, activation and coating with atmospheric-pressure plasma

For some years now “Openair” atmospheric-pressure plasma technology has been opening up numerous novel applications, especially when used in processes involving the cleaning, activation and coating of the surfaces of the most varied materials. In doing this the primary objectives are to achieve savings in material costs and process costs and to create environmentally friendly composites.

Plasma, the fourth state of matter, is the name given to a material at a high, unstable energy level. Energy is input to the solid, liquid and gaseous states of matter always in the form of heat. Plasma technology, however, does not stop at the gaseous state of matter. If additional energy is pumped into the material by means of electric discharge the electrons achieve a higher level of kinetic energy and leave their atomic shells. Free electrons, ions and molecular fragments are produced. This state, however, can scarcely be used at normal pressure due to its instability (Fig. 1).

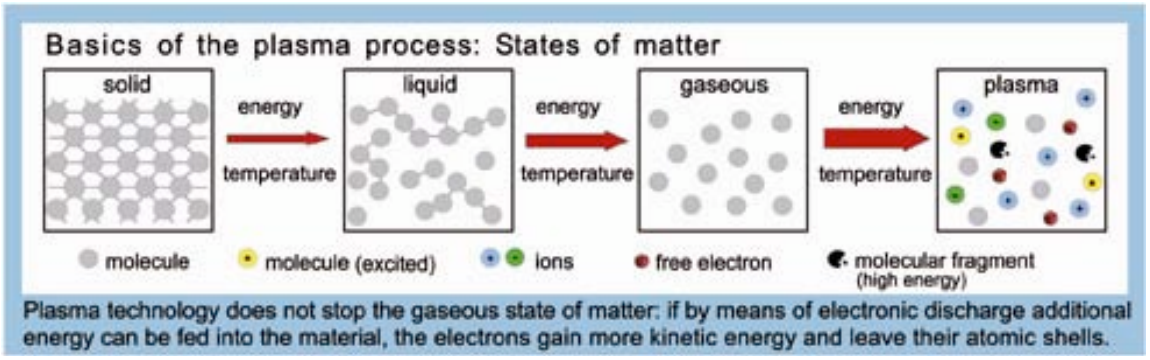

Fig. 1: States of matter (Diagram: IFAM)

Only the Openair atmospheric-pressure plasma process developed and patented by Plasmatreat GmbH afforded new opportunities: by developing and using plasma jets this state of matter scarcely used in industry up to that point was successfully employed for the first time in production processes, even in-line (Fig. 2)

Adapted version from the German original: „Alles aus einer Hand– Reinigen, Aktivieren, Beschichten mit atmosphärischem Plasma“, published in **Galvanotechnik July 2007**
Photos: Plasmatreat

Electrically neutral plasma beam

The jets are operated solely by air, possibly together with a desired process gas, and high voltage. Depending on the geometry of the jet the emergent plasma is effectively available over an operating width of 25 mm wide or at a treatment distance of 40 mm.

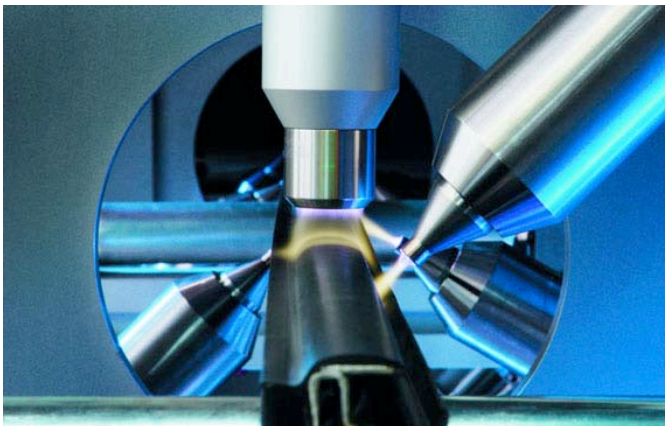

Fig. 2: Pretreatment with atmospheric-pressure plasma. The jet systems used can be integrated in-line into a new or already existing production line.

A particular characteristic of the emergent beam of plasma is that it is electrically neutral, which greatly extends and simplifies opportunities for use. Its intensity is so high that machining speeds of several 100 m/min can be achieved. Heating up of plastic surfaces during treatment typically amounts in this case to less than 20 °C. The Openair system is characterised by a threefold action. It activates the surface by selective oxidation processes, discharges the surface at the same time and also brings about ultrafine cleaning (Fig. 3). The jet systems used can be integrated in-line into a new or already existing production line.

Fig. 3. The electrically neutral plasma beam allows ultrafine cleaning, high activation and wafer-thin coating of surfaces

Surface modification

Plasma modifies the surfaces of plastics. The most important fields of application in the treatment of this type of material are:

- the cleaning of surfaces, for example the removal of mould release agents and additives;
- activation, that is the production of functional groups, enables adhesives and coatings to bond to the surface;
- full enhancement of the properties of the bond by a plasma-polymerised coating.

Adapted version from the German original: „Alles aus einer Hand– Reinigen, Aktivieren, Beschichten mit atmosphärischem Plasma“, published in **Galvanotechnik July 2007**
Photos: Plasmatreat

Improvement of plastic joints

Figure 4 clearly shows that non-polar materials, plastic joints for example, effectively cannot be bonded without pretreatment. This changes after activation with Openair plasma: the tensile shear forces now rise by a factor of approximately 50. Even after storage for eight weeks prior to adhesive bonding these results are still very much in evidence and so the treatment is durable over a long period of time.

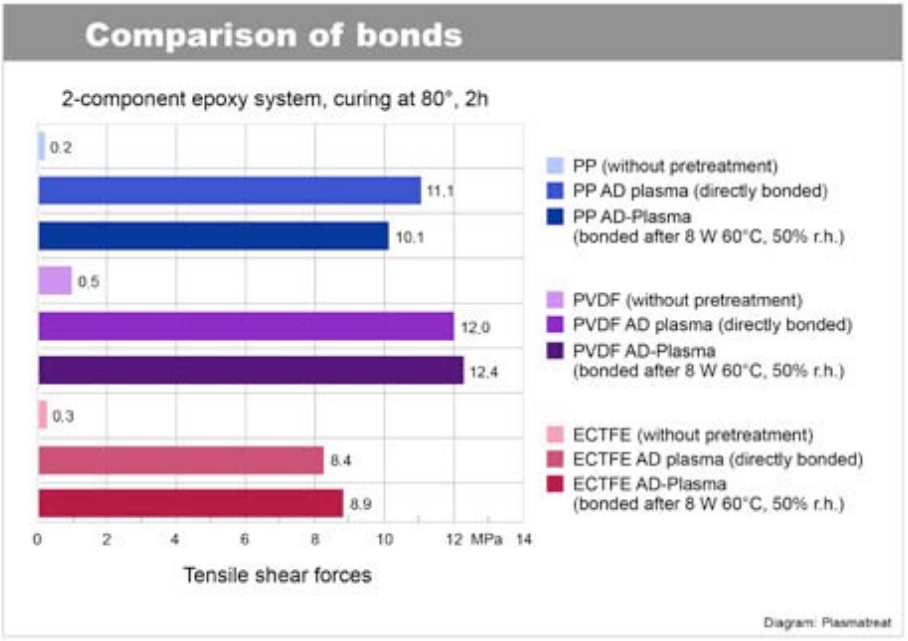

Fig. 4. Comparison of bonding strengths of adhesive joints due to plasma treatment

Applications

Cleaning and removal of coatings

Plasmatreat has succeeded in decisively rationalising processes such as the removal of mould release agents on polyurethane mouldings, for example in furniture profiles, air bag covers or bicycle saddles, by using Openair plasma instead of the traditional methods. The layer-by-layer removal of organic coatings, paint-stripping or the partial removal of metallised coatings prior to bonding, the production of motor car headlights (Fig. 5) as well as the treatment of reflectors are just some examples of the successful in-line deployment of Openair plasma in cleaning and coating processes.

Adapted version from the German original: „Alles aus einer Hand– Reinigen, Aktivieren, Beschichten mit atmosphärischem Plasma“, published in **Galvanotechnik July 2007**
Photos: Plasmatreat

Fig. 5. High demands are imposed in automotive engineering. Pretreatment with Openair plasma ensures an immaculate visual appearance of painted surfaces and absolutely airtight fitting of headlights

Environmentally friendly improvement of adhesion

A decisive advantage of Openair plasma technology consists in that hitherto incompatible substrates can be made to stick to one another so that aqueous and often even UV-based adhesives stick to highly adhesion-resistant surfaces such as non-polar plastic. Additional pretreatment with chemical primers or by brushing and rinsing surfaces can be completely eliminated. By this means emissions of VOCs (volatile hydrocarbons) are prevented from the outset. The treatment is extremely uniform and can be monitored by means of a process control system.

Fig. 6: Pretreatment with Openair plasma ensures ultrafine cleaning of mobile phone housings prior to painting

Plasma prior to painting

To take an example, the painting of mobile telephone housings (Fig. 6) today imposes the highest demands on their surfaces. The paint coating must be absolutely flawless and under no circumstances may the overall appearance be impaired by contaminants. Even a grain of dust scarcely visible before painting results after painting in an unsightly rough patch which customers generally will not accept. Electrostatic effects may be mentioned here as the principal cause of the adherence of dust.

Leading suppliers in the mobile telephone industry in South Korea and Finland have long since responded to this problem. Here Plasmatreat very successfully installed systems for cleaning mobile telephone housings which allow extremely efficient cleaning in an in-line process. Immediately before painting several rotating plasma generators efficiently clean the plastic surfaces. In this way it was possible to reduce the proportion of rejects from 12 per cent to 5 per cent.

Adapted version from the German original: „Alles aus einer Hand– Reinigen, Aktivieren, Beschichten mit atmosphärischem Plasma“, published in **Galvanotechnik July 2007**
Photos: Plasmatreat

Fig.7. In the metallisation of plastics plasma pretreatment results in a significant improvement in the adhesion of the metal layers. Layers already applied by vapour deposition can also be selectively removed by plasma (Photo: Hella)

Metallisation of plastics

The Openair plasma process is equally of interest in the metallisation of plastics (Fig. 7) in two respects. On the one hand, the adhesion of the sputtered metal layers is significantly improved by the uniform conditioning of the surface since any clinging organic residues and particles are completely removed. On the other hand, however, it is also possible selectively to remove an already vapour-deposited layer by means of a sharply focused plasma beam operating at relatively low speed. The improvement in quality achievable by cleaning is frequently accompanied by a reduction in defective products of over ten per cent.

Selective corrosion protection on metals

The bonding of aluminium is state of the art. Today, however, high costs have to be incurred when using conventional pretreatment methods for adhesively bonding aluminium durably, especially when exposed to corrosive media such as moisture and salt. Wet chemical processes, such as chromatizing or anodising, are usually employed to meet the requirements. These, however, are cost-intensive batch processes which, moreover, are ecologically questionable.

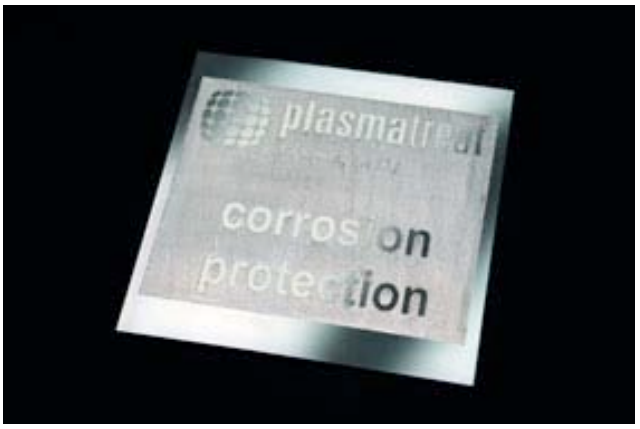

Fig. 8: To demonstrate the effect of a plasma-polymerised coating the logo and lettering regions on an aluminium plate were coated. The figure shows the results after 96 hours of exposure to the salt spray test (DIN 50021)

With Openair plasma reliable adhesive bonding of the most varied aluminium alloys can be achieved. In doing this the surface is very finely cleaned by the jet system and at the same time the oxide structure is modified. If particularly effective protection against corrosion is needed the surfaces may additionally be coated with AntiCorr a diffusion-resistant plasma-polymerised layer that bonds well. AntiCorr is an anticorrosion coating which can be applied by means of Openair atmospheric-pressure plasma to a wide range of metals. The coatings are particularly suitable for aluminium alloys. A direct salt spray test lasting

several days had no effect on the coating (Fig. 8). The coating adheres strongly to the substrate and is resistant to various corrosive media such as electrolyte solutions, acids and alkalis. Due to the low thickness of the coating and its non-toxicity it is not necessary to remove the coating prior to recycling, on the contrary it can be recycled along with the substrate.

Coil coating

One of Europe’s largest aluminium roller shutter manufacturers, Griesser AG, Switzerland, has recently started to pretreat all of its strip products with atmospheric-pressure plasma. The Plasmatreat installation not only accelerates production by a factor of four relative to previous levels but in this case also replaces a 21 m long cleaning line, i.e. large volumes of wet chemicals and effluent are avoided. The economic and environmental conservation benefits resulting from this are unique in the sector throughout the world.

Summary

These examples make clear that there are scarcely any limits to the versatility of pretreatment with Openair plasma. The system is capable of in-line integration and suitable for robots. The important advantages of using the system additionally include the reliability and quality of this procedure in the production process. Accordingly, the criteria - well known to be high - that are imposed in these respects can be met. Furthermore, other requirements such as simple integration into process workflows and higher efficiency in comparison with traditional methods can be met while compatibility with the environment is outstanding.

- I. A. Melamies -

Contact
Plasmatreat GmbH, Bisamweg 10, D-33803 Steinhagen; internet: http://www.plasmatreat.de