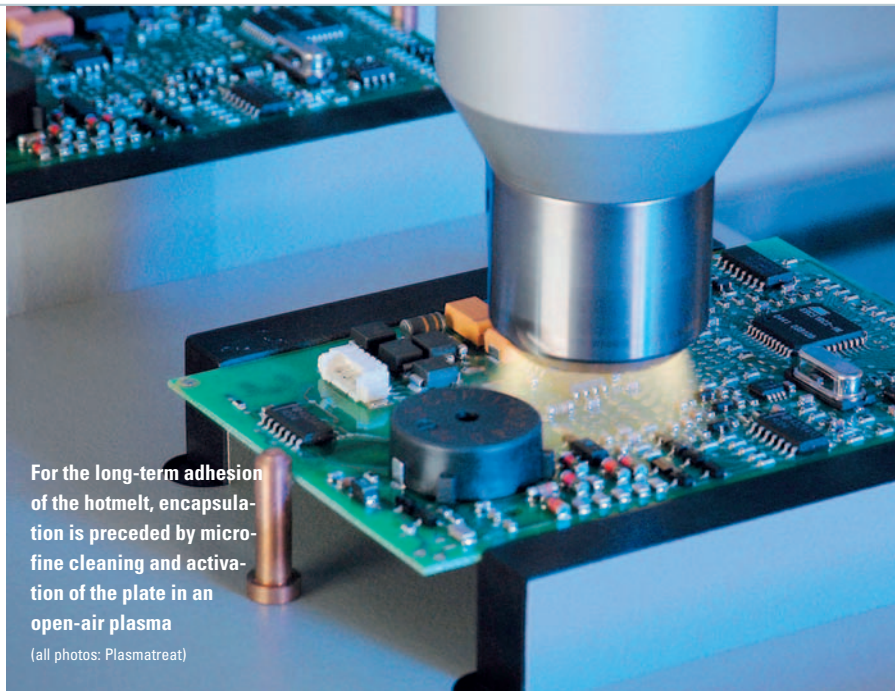
Open-air Plasma. Electronic circuits and components have to be reliably encapsulated to protect them against dust and moisture. Many electronics companies now use a surface-pre-treatment technology that up until now was only found in the automotive sector: open-air plasma.



For the long-term adhesion of the hotmelt, encapsulation is preceded by micro-fine cleaning and activation of the plate in an open-air plasma

(all photos: Plasmatreat)

Give Leaks No Chance

PETER LANGHOF

Whether in daily manufacturing or the development of new processes and products: surfaces and their properties are playing an increasingly important role in nearly all industrial areas. The surfaces of the materials employed often have to be pre-treated in order that additional properties may be imparted which will qualify them for further application areas. Open-air plasma is a method of producing new surface properties and optimising existing manufacturing processes. The open-air plasma, applied by special nozzles, effects micro-fine cleaning and extensive activation of all kinds of surfaces and leads to optimum adhesion of coatings, paints and adhesives, such as the epoxy adhesives and hotmelts frequently used in electronics.

The process permits continuous in-line application to all or only some parts of the surface at high speeds. If the nozzle is guided by a robot, high-precision localised effects can be obtained and the finest contours cleaned, activated and coated. Pretty often, a material cannot be used until its surface has been custom treated with open-air plasma.

Translated from Kunststoffe 5/2007, pp. 106–108

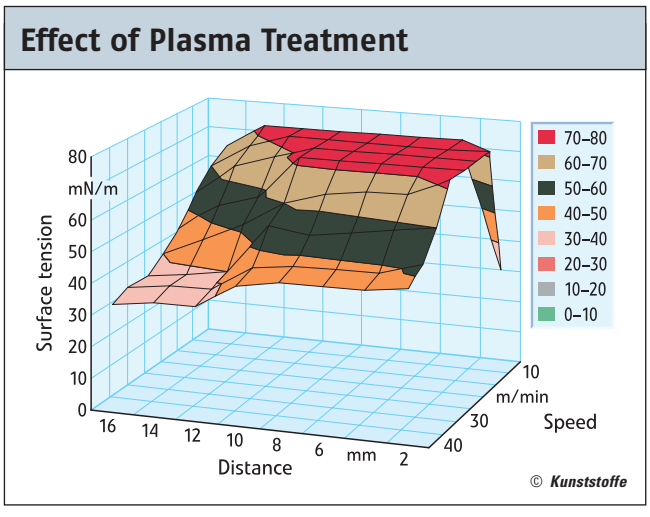


Fig. 2. A plastic surface that was pre-treated as a function of distance and speed with plasma. Treatment renders the surface polar and the surface tension rises to >72 mN/m with a large processing window

Electrically Neutral Plasma Beam

The systems, which are based on a nozzle principle, work at atmospheric pressure and produce a plasma with the aid of an arc ignited in the nozzle and the air which serves as working gas. The plasma then flows potential-free onto the product to be treated (Fig. 1). It possesses sufficient numbers of excited particles to introduce targeted effects onto the surface (Fig. 2).

A special feature is the fact that the emitted plasma beam is electrically neutral, and this greatly extends and simplifies applicability. Its intensity is so high that processing speeds of several 100 m/min are possible. The heating typically undergone by plastic surfaces is less than 20 °C during treatment. The open-air system works in three ways: it activates the surface by targeted oxidation processes, discharging the surface at the same time and leading to micro-fine cleaning. The nozzle systems employed can be integrated in-line into new or existing production lines. The process of surface discharge means that the open-air plasma system offers cleaning effects which far exceed those of conventional systems. Here, the user is benefiting from the high ▶

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Fig. 1. The electrically neutral open-air plasma beam facilitates micro-fine cleaning, high activation and extremely thin coating of surfaces

electrostatic discharging effect of a free plasma beam. This effect is additionally boosted by the very high emission speed of the plasma, as a result of which loosely adhering particles are also effectively removed from the surface.

Whether of metal or plastic, the geometries of work pieces are becoming increasingly sophisticated. The fact that the tips of the plasma nozzle can be readily adapted to the work piece geometry opens up a broad range of applications. This adaptability is crucial for pre-treatment of highly complex, three-dimensional geometries with a large number of undercuts.

Plasma in Automotive Electronics

Electronic parts are playing an ever increasing role in automotive manufacture. Most innovations are electronics-based. Major automotive subcontractors use open-air plasma to protect their highly sensitive sensors and control elements. These perform important tasks, such as managing the engine and air-conditioning, regulating the braking and chassis systems and controlling the lighting system. The IEC standard and the IP degrees of protection stipulate that the sensors and control elements must be protected against penetration by moisture and contamination.

Automotive electronics are exposed to various risks, and so the requirements on the integrity of the protective plastic housing are high: the electronics must withstand temperature fluctuations of –40 °C to 140 °C in the test process and all moisture, liquids and chemicals must be kept at bay. With a view to achieving the best-possible seal, it is standard practice to treat the adherends of electronics packaging with plasma before applying the adhesive. This pre-treatment cleans and activates the housing surfaces to the extent that the increased adhesion properties of the subsequent bonded joint guarantee a seal against penetration of harmful influences, and the risk of short-circuits, malfunctioning and possible long-term destruction are virtually eliminated (Fig. 3).

Plasma pre-treatment not only provides for high quality, it can also be used in-line, is controllable and monitorable and the process is reproducible in line with ISO 9000 due to the constancy of the parameters.

Clean Displays

Wherever vibrations occur – in cars, car radios, on-board computers, mobile telephones, pocket calculators or computer monitors – displays are coated with a heat-sealed film. The film is the flexible connection between the printed circuit board and the contact surface or display, which usually consists of two thin glass panes. The foil is bonded to the pane, which has been coated with indium tin oxide (ITO). Glass surfaces, however, get dirty easily, whether during packaging, storage, handling or transport. Finger prints or dust on the glass surfaces are difficult to avoid and require additional cleaning.

The short-term or long-term consequence of this contamination is segment errors, which usually manifest themselves by the fact that too many or too few items appear in the display. The reasons are nearly always the same: the film adheres poorly and particles are present which are causing short-circuits. Most manufacturing processes today still employ conventional manual cleaning of the display glass with the aid of a cotton bud and solvents. The average fail rate of 12 % is common. The situation is totally different for those manufacturers who clean the displays by means of pre-treatment with atmospheric plasma: here the fail rate sinks to below 1 % (Fig. 4). Added to which, the protective plastic film, ITO layer and pole filters are not damaged by the careful, potential-free treatment and the entire in-line process is environmentally sound, monitorable and reproducible, as is also the case during circuit board cleaning.

Compliance with Protection Guidelines

Outdoor electronics require high levels of protection, since they are permanently ex- ▶

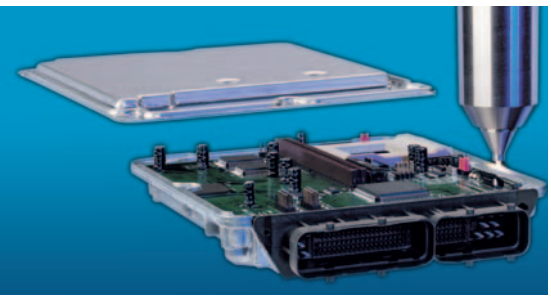

Fig. 3. Pre-treatment and activation of the housing adherends with open-air plasma prior to application of adhesive causes optimum sealing of the electronics packaging

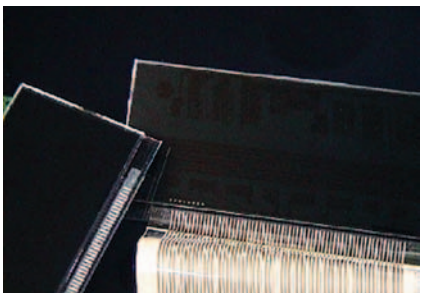

Fig. 4. High adhesion after plasma treatment: LCD with heat-sealing film (right) and after tearing of the film (remaining film strip, left)

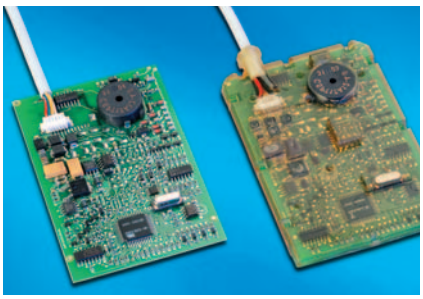

Fig. 5 Prior to over-moulding with hotmelt, the entire surfaces of the components are treated with open-air plasma (left). Subsequent sealing with hotmelt protects the printed circuit board against moisture and mechanical damage (right)

posed to the weather. Novar GmbH, Albstadt/Germany, the renowned security systems manufacturer attached to Honeywell Security AG, attaches special importance to open-air plasma treatment during the manufacture of its high-quality alarm systems. Unlike the case for control elements in cars, which must be accessible at any time and therefore are packaged in a sealed housing, the soldering process for alarm system is followed by electronic encapsulation with the aid of a hotmelt adhesive to protect the mounted boards against moisture or mechanical damage (Title picture). Without pre-treatment, however, the adhesive either does not adhere to the substrate or detaches itself after a while. Here, too, cleaning pre-treatment with open-air plasma is the answer. The plasma nozzle leads the jet across each square centimetre of the plate. The outcome of the microfine cleaning is that when the hotmelt is subsequently applied it adheres so well that

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the highest international degrees of protection (IP 68) and even the relatively new IP 69K are attained – the latter is aimed particularly at the stability of electrical components to high pressure jet cleaning (Fig. 5). After completion, the printed circuit board is inserted into an additional housing where it serves as a keyboard in the outer entrance area of a complete, highly complex intruder alarm system. Failure of this keyboard could lead to a malfunction of the security system, which is why Honeywell – going far beyond the requirements of the standard – subjects each individual board to a twelve-hour underwater functionality test.

Summary

Open-air plasma technology is a new process used in the electronics industry to process parts and circuits during production and/or assembly. High purity requirements are met along with potential-free treatment, i. e. the circuits do not make contact with electrical voltage during plasma treatment. ■

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