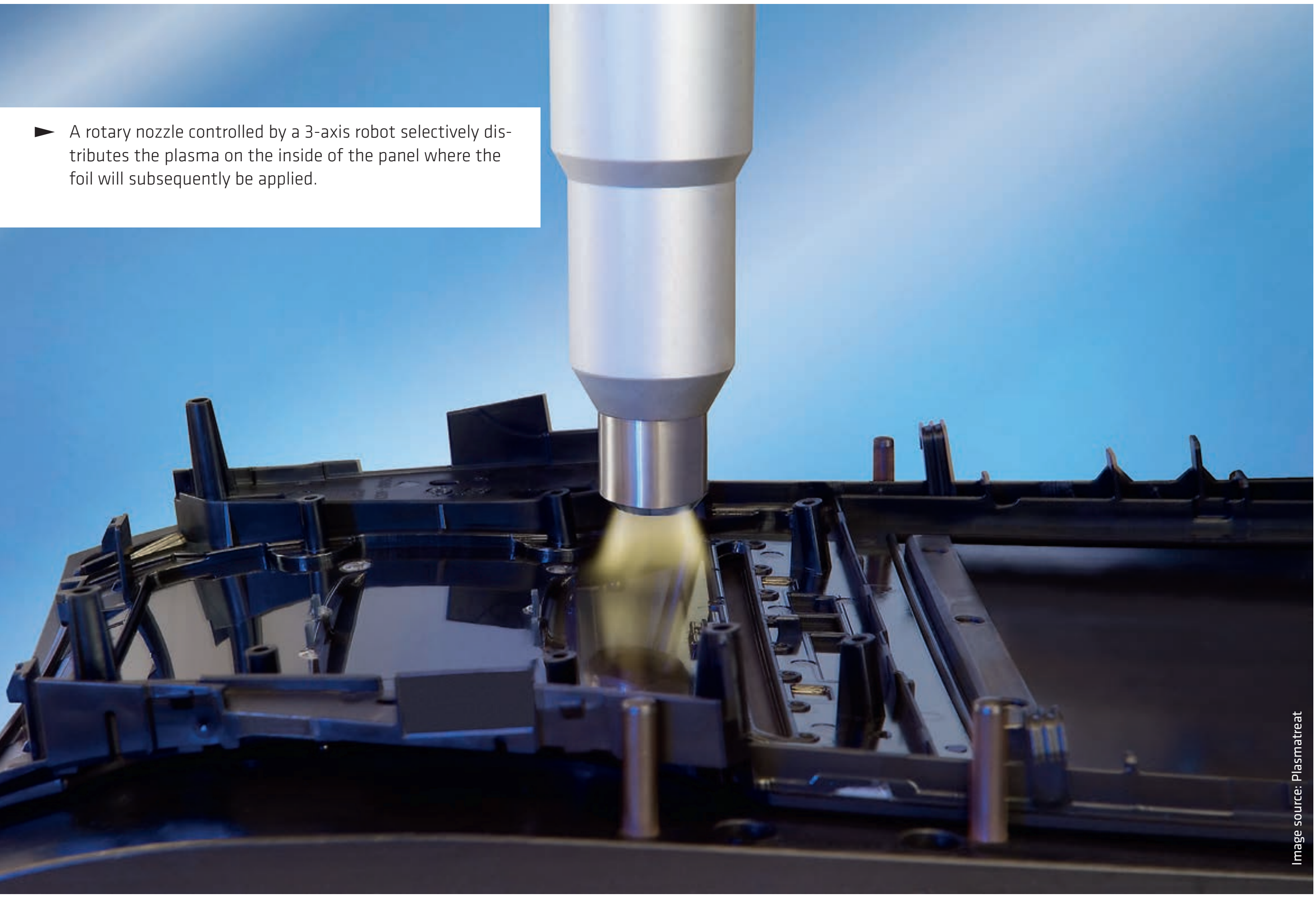
Process for bonding foils

Plasma connects

Touch-sensitive controls are becoming increasingly popular in cars. A South German automotive component supplier now uses a touch foil in the central console of one of its models. Initially, however, the adhesive bond failed the climatic test; bubbles formed in the boundary layer. So he turned to atmospheric pressure plasma to bond the touch foil to the polycarbonate 3D control panel – and this time it proved successful.

The most likely cause for the inability of additive-free plastics to be bonded or coated effectively, or indeed at all, despite having clean surfaces, is their low polarity and resultant low surface energy. This is ultimately the most important measure for determining the probable adhesion of an adhesive layer, paint or coating. If the surface energy of a plastic is too low, the material surface will require activating before a durable adhesive bond can be obtained. Whether or not this is successful sometimes comes to light only when a stress test is performed, for example a climatic test. Automotive component supplier Preh made this discovery during the developmental phase of a new control system for a vehicle model. The Preh Group, part of Joyson Electronics, develops and



► A rotary nozzle controlled by a 3-axis robot selectively distributes the plasma on the inside of the panel where the foil will subsequently be applied.

Image source: Plasmatreat

Original article in german language published in Plastverarbeiter issue 10/14

Image source: Preh

▲ The so-called center stack is the heart of the central console, a function unit which combines climate control and infotainment functions, including telephone, navigation, radio and music systems and temperature control. The lower half of the center stack has sliders with capacitive touch function for volume and fan adjustment as well as touch-sensitive areas with corresponding icons for other functions.

manufactures climate control and driver control systems, sensors, ECUs and instruments for vehicle manufacturers.

When in early 2011 the company received an order to produce a control system for the new Ford Lincoln MKZ, it was decided that one of the three versions would be manufactured at Preh, Bad Neustadt a.d. Saale. The so-called center stack is the heart of the central console, a function unit which combines climate control and infotainment functions, including telephone, navigation, radio and music systems and temperature control. The lower half of the center stack has a slider control for volume and fan adjustment as well as touch-sensitive areas with corresponding icons for other functions.

A laminator is used to bond the PET touch foil complete with adhesive backing to the back of the injection-molded polycarbonate panel of the center stack. Several superimposed layers of printed circuit containing specific electrical functions are screen-printed onto the foil. The bonding process went very well until it came to the climatic test.

Delamination during climatic testing

Adhesive tests in the automotive industry are conducted under extreme conditions and place very rigorous demands on the foil bond, especially during the climatic test. This process is designed to simulate the long-term behavior of the product under severe environmental conditions. The aim is to reveal product weaknesses which would otherwise only become apparent after a certain period of use. Ford required the adhesive bond to withstand one hundred hours in the climatic chamber at 85 °C and 85 percent air humidity. But on removing the panel from the climatic chamber, the developers were confronted by an unwelcome phenomenon, albeit one which is familiar to foil adhesion experts: Large bubbles had formed in the boundary layer between the plastic substrate and the foil, and the contact adhesive had detached. Martin Geis, production engineer at Preh explains: “Delamination like this would ultimately cause functions to fail. To solve the problem we initially looked for alternative adhesives, ranging from simple industrial adhesives to optical clear adhesives (OCAs), and subjected them to a variety of tests.” The simple adhesives produced large bubbles, the high-tech adhesives produced smaller bubbles, but the problem remained the same: The adhesive film lifted.

Troubleshooting

Tracking down new adhesives and evaluating them was very time-consuming, and failed to provide a solution. So the focus then turned to the component itself, the polycarbonate panel. It was thought that gases released from additives in the plastic due to high temperatures in the climatic test and moisture penetrating the boundary layer were causing the bubbles to form. Neither could the experts rule out air pockets caused by invisible dust particles. However, since changing the panel material was not an option, there was only one solution: an effective pretreatment of the plastic surface. When it came to choosing a pretreatment method, Preh turned to a technology which the company had been using since 2002 for microfine cleaning and activating sensor circuit boards prior to printing; Openair atmospheric pressure plasma jet technology from Plasmatreat in Steinhagen, Germany. Martin Geis elaborates: "Our laboratory in Bad Neustadt had a small plasma system so we sent our PC panel there for a preliminary plasma test."

Pretreatment in an instant

The plasma process operates in-line under normal atmospheric conditions. Peter Langhof, marketing and Preh project manager at Plasmatreat, explains: "Our process performs three operations in a single step lasting only a matter of seconds: It simultaneously brings about the microfine cleaning, electrostatic discharging and activation of the plastic surface. The result is homogeneous wetability of the material surface and long-time stable adhesion of the adhesive bond or coating even under challenging load conditions." Non-polar plastics generally have a low surface energy between 28 and 40 dyne, too low for liquid adhesive or paint to fully wet the surface. With these types of plastics, the surface energy needs to be increased by activation, since experience shows that only surface energies from 38 to 42 dyne offer the right conditions for adhesion.

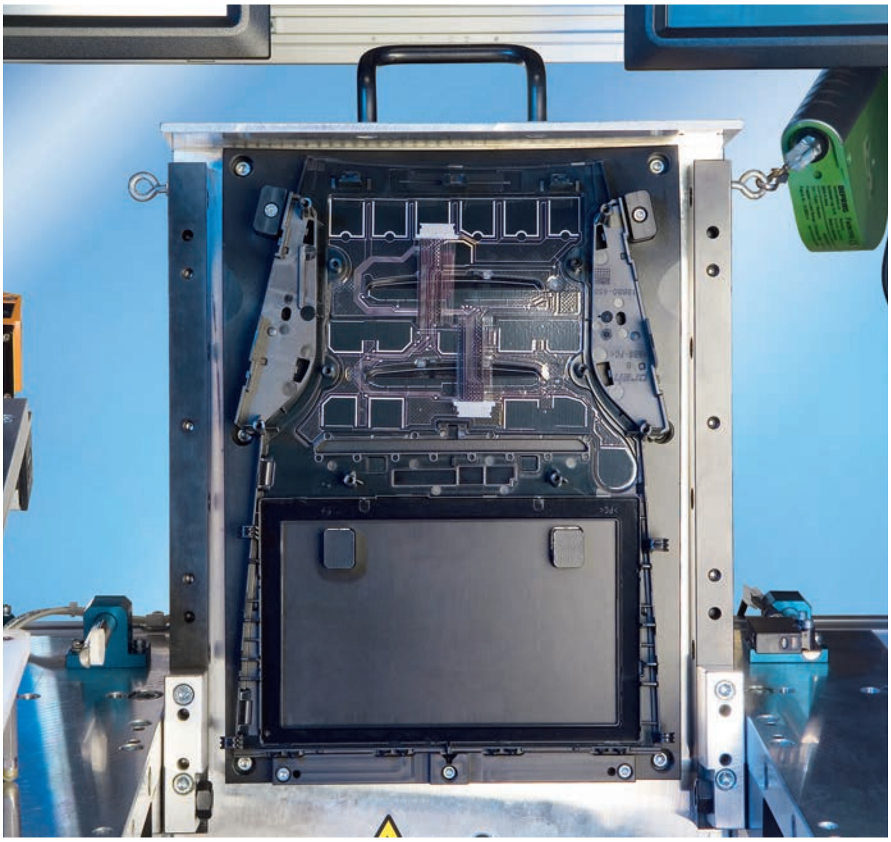
Subsequent processes such as coating, bonding or printing can be carried out immediately after the plasma treatment. The surface of the material is exposed to the high-speed plasma for too short a time for components to sustain either thermal or other damage. Furthermore, the Openair plasma process is virtually potential-free, which simplifies its practical application, especially in the electronics sector. "For electronic or other sensitive components", Peter Langhof goes on to explain, "we use gently working rotary nozzles, which distribute the pretreatment action due to the rotation principle evenly across the surface of the component."

When the plasma hits a plastic surface, as in this case the polycarbonate panel, it enables additional groups containing oxygen and nitrogen to become incorporated into the non-polar polymer matrix. The surface is subsequently modified. Energy-rich radicals, ions, atoms and molecular fragments present in the plasma release their energy at the surface of the material that is being treated and thus initiate chemical reactions which bring about this effect. The functional hydroxyl, carbonyl, carboxyl and ether groups that are created form strong chemical bonds with the adhesives and coatings and so help to enhance adhesion.

Strong bond with plasma

Preliminary laboratory tests were very encouraging. Surface tension measured using test inks increased from 25 dyne in untreated state to over 50 dyne following plasma treatment. However, whether this would be enough to prevent bubble formation

Image source: Plasmatreat



◄ The PET foil complete with adhesive backing (recognizable by the white contours) is equipped with several layers of printed circuit containing all the electrical functions.

Image source: Plasmatreat

◄ The center stack production line arranged in a semicircle. From left: Peter Langhof (Plasmatreat) accompanied by Martin Geis and Markus Lederman (both from Preh) supervising the plasma process.

and delamination of the foil remained to be seen. Initially Preh obtained a larger plasma system on loan and then began to conduct a series of specification tests. Everything went well and the atmospheric plasma process was found to be process-reliable and reproducible. But the climate test still lay ahead; the ultimate test of adhesion.

This time when the polycarbonate panel was removed from the climatic chamber after four days' storage under extreme temperature and humidity, the developers breathed a sigh of relief. Markus Ledermann, manufacturing technology engineer at Preh, recalls: "There was not a bubble to be seen. With the foil adhesion fully intact, the adhesive bond had met the requirements." A subsequent functional climatic test of the fully assembled center stack went equally well. Not only did plasma cleaning ensure that the surfaces were cleaned to a microfine level; the plasma-activated plastic surface — and this was critical — had formed a stronger bond with the adhesive. The adhesion between the foil and the panel was now so strong that gases emitted from the plastic or humidity within the foil could no longer penetrate the boundary layer.

Plasma in series production

On the strength of this positive experience, the automotive supplier decided to buy a system of his own and start series production. The plasma system was seamlessly integrated into Bad Neustadt's semi-automated production line. The first step is to fix the chrome trims for the sliders to the polycarbonate panel — injection molded in-house — by thermal staking. Pretreatment with atmospheric pressure plasma comes next. A RD1004 rotary nozzle controlled by a 3-axis robot selectively distributes the plasma on the inside of the panel where the foil will subsequently be applied. The rotating jet reaches every part of the 3D contour. It takes just 10 seconds to complete deep-pore cleaning and activation of the plastic surface. Every two minutes, a technician removes a treated component and inserts a new one. The production line incorporates a control system which enables the technicians to monitor every stage of the operation. The touch foil is applied immediately after plasma treatment. As the plasma ensures good initial adhesion, the press can be quickly reopened, which reduces cycle times. ■

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