Skyscraping Adhesion

Plasma technology ensures airborne radio-electronics

1 The safety of billions of air travelers depends on uninterrupted radio communication between air traffic controllers and pilots (Photo: Rohde & Schwarz GmbH & Co. KG)

ELECTRONICS_MACHINES and SYSTEMS – The high safety requirements in the aviation industry are far more rigorous than those in other industries. This is why a leading South German manufacturer of airborne radio communication systems pretreats his sensitive electronic SMD components with atmospheric pressure plasma to ensure optimum adhesion of the conformal coating.

According to the ICAO Air Transport Results 2015 three and a half billion1) civilian air passengers have relied on the quality and reliability of air traffic control systems in the past year. The main task of air traffic controllers is to guide aircraft on the ground and in the air by radio to prevent collisions. Passenger safety largely depends on undisturbed communication between the traffic controller and the pilot and this communication is itself reliant on the correct functioning of electronic aircraft radio systems »1. Crews on long haul flights use shortwave radios to communicate with air traffic control, and to stay in touch with their airlines from anywhere in the world. Barely a single long-haul aircraft on the planet lands or takes off without the assistance of an XK/FK 516 shortwave radio produced by Rohde & Schwarz Messgerätebau GmbH. At the core of the FK 516 antenna tuner - developed specifically for civilian airborne radio communication and long-haul flights - is the tuning control unit; a circuit board fitted with several hundred tiny plastic-encapsulated SMD components. The function of this assembly is to reliably tune the antennae, thereby ensuring overall radio communications.

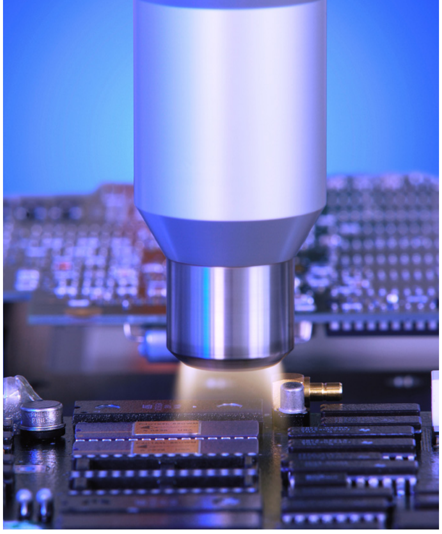
Unexpected adhesive problem

One day it was suddenly discovered that the protective coating on around 50 transistors had lifted, signaling an unexpected malfunction in the production process which the company had been using without a hitch for several years. Since nothing whatsoever had changed in the assembly, pre-cleaning or coating process, the root of the problem could only lie with the component material itself. And indeed: when questioned, the supplier confirmed that they had changed the composition of their plastic blend – a problem frequently encountered by processing companies that are reliant on plastic components produced externally. Even the slightest alteration to the composition can be enough to totally change the surface characteristics of the material. The supplier's news posed a problem since there was no alternative to the new plastic blend. No other certified manufacturer could produce these particular electronic components. "A solution had to be found as quickly as possible to ensure the adhesion of the conformal coating", explains Michael A. Schneider, engineer in charge of production technology at Rohde & Schwarz. "Without a reliable adhesive bond it would no longer be feasible to continue manufacturing the tuning control units."

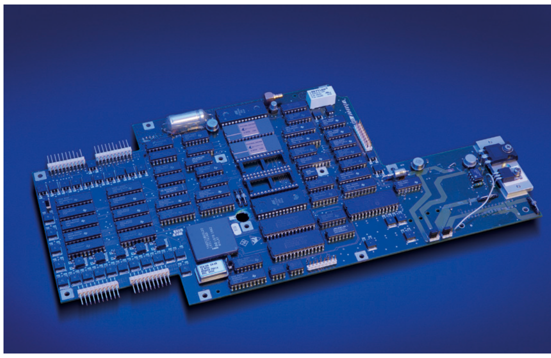
Surface activation – Several options, few solutions

It is well known that many materials are made more receptive to adhesion by means of "activation"; in other words by pretreating them to increase their surface energy »2. The latter is the most important measure for determining the probable adhesion of an adhesive layer or coating. Various pretreatment methods are available, with environmentally hazardous wet chemical substances still the most widely used.

But finding the right pretreatment for these highly sensitive electronic components seemed almost impossible at first. Activation using a solvent-based primer was not an option. Partly because these substances are extremely harmful to the environment, and partly because they would incur enormous costs in terms of health and safety (e.g. explosion protection) and disposal. Laser pretreatment was ruled out on the grounds that the uneven surface of the material would have made the coupling efficiency unpredictable. CO_2 snow blasting, which cleans but has no activation capabi-



»2 The rotating Openair plasma jet strongly activates the plastic components in a matter of seconds without damaging the sensitive electronics (Photo: Plasmatreat GmbH)



»3 The coating's adhesion is visually inspected under UV light before the SMD assembly is mounted in the radio. Then a Burn-In test is performed to verify its stability (Photo: Plasmatreat GmbH)

lity, was also rejected. The final method under consideration was a low-pressure plasma treatment; a highly effective activation process, but not suitable for this purpose because the vacuum would have drawn the fluid out of the wet electrolytic capacitors contained in the SMD assembly. A solution to the problem still seemed a very long way off.

The solution – atmospheric plasma

The pretreatment process developed by Plasmatreat and now used throughout the world in almost every branch of industry provided the solution. The environmentally friendly in-line technology works under normal ambient air conditions, thereby dispensing with the need for a vacuum chamber. Openair plasma performs two operations in a single step lasting only a matter of seconds: It simultaneously brings about the microfine cleaning and strong activation of the plastic surface. The rise in temperature of the plastic surface during plasma treatment is typically less than 30 °C and substrates can be transported through the plasma beam of static jets at speeds of several hundred meters per minute. Rotary nozzles with a special gentle action are used for electronic components. Schneider was soon convinced of the plasma's powers of activation, but another question arose: Would the sensitive electronics survive the plasma treatment unscathed?

Extensive testing successful

It was clear from the very first tests performed on an Openair rental system that the plasma had not damaged the electronics. The surface energy of the plastic transistors which had caused the whole problem increased from below 30 dyne in the inactivated state to over 70 dyne following plasma treatment. The final visual UV inspection which every single SMD component undergoes before assembly also showed that there was not a single area where the coating had lifted »3. But for Rohde & Schwarz this was not sufficient proof, since the aviation industry's requirements regarding the integrity and service life of safety-relevant components far outweigh those of the automotive industry, whose requirements are themselves recognized as being very tough. One example of this is the burn-in test which is performed post-production on tuning controls at Rohde & Schwarz. This test requirement results from the fact that airborne radios are rarely installed in the plane's air-conditioned and pressurized engine area. Most are located in the nose of the aircraft where at 10,000 to 15,000 m above sea-level very different temperature and humidity conditions prevail. This is why it is so important to ensure that the protective coating is fully bonded to the electrical components. Even the smallest leak would result in moisture ingress, potentially leading to complete failure of the radio communications system.

The purpose of the burn-in test is to investigate continuous operation and accelerated ageing of electronic components. As the toughest load test available for electronic circuit boards, it is used to detect manufacturing faults which were not picked up earlier and to identify components that would fail in continuous operation. In the burn-in chamber the test is performed on the finished radios under operating conditions, i.e. powered up and with antennae. The test consists of a series of eight-hour cooling and heating cycles; after a 4 h cooling cycle at -55 °C, the temperature is pushed up to +70 °C in a matter of a few minutes and held for a further 4 h before plunging back down equally rapidly to start the next cooling cycle. These cold/warm cycles are repeated nine times, amounting to three days. In that period of time the airborne radio faces a non-stop exposure to rapid and extreme temperature variations. If the plasma had damaged the electronics, the components would eventually have failed during this test. It would have become equally apparent if the coating had been poorly bonded to the plastic.

Summary

After all tests, the results were conclusive: The electronics functioned perfectly and the coating adhesion was long-time stable. The plasma technology had proven its worth in all areas and under the most challenging conditions. The Memmingen-based airborne communications specialist returned the borrowed equipment and purchased its own, which is now running in continuous production.

Facts for designers

- Modified plastic blends can quickly lead to adhesion problems

Facts for buyers

- Highly cost-effective, since atmospheric plasma technology reduces the number of operations and can easily be integrated into fully automated production processes

Facts for quality assurance managers

- Passed comprehensive testing including the burn-in test and improved the quality of the product at the same time

More informationen

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