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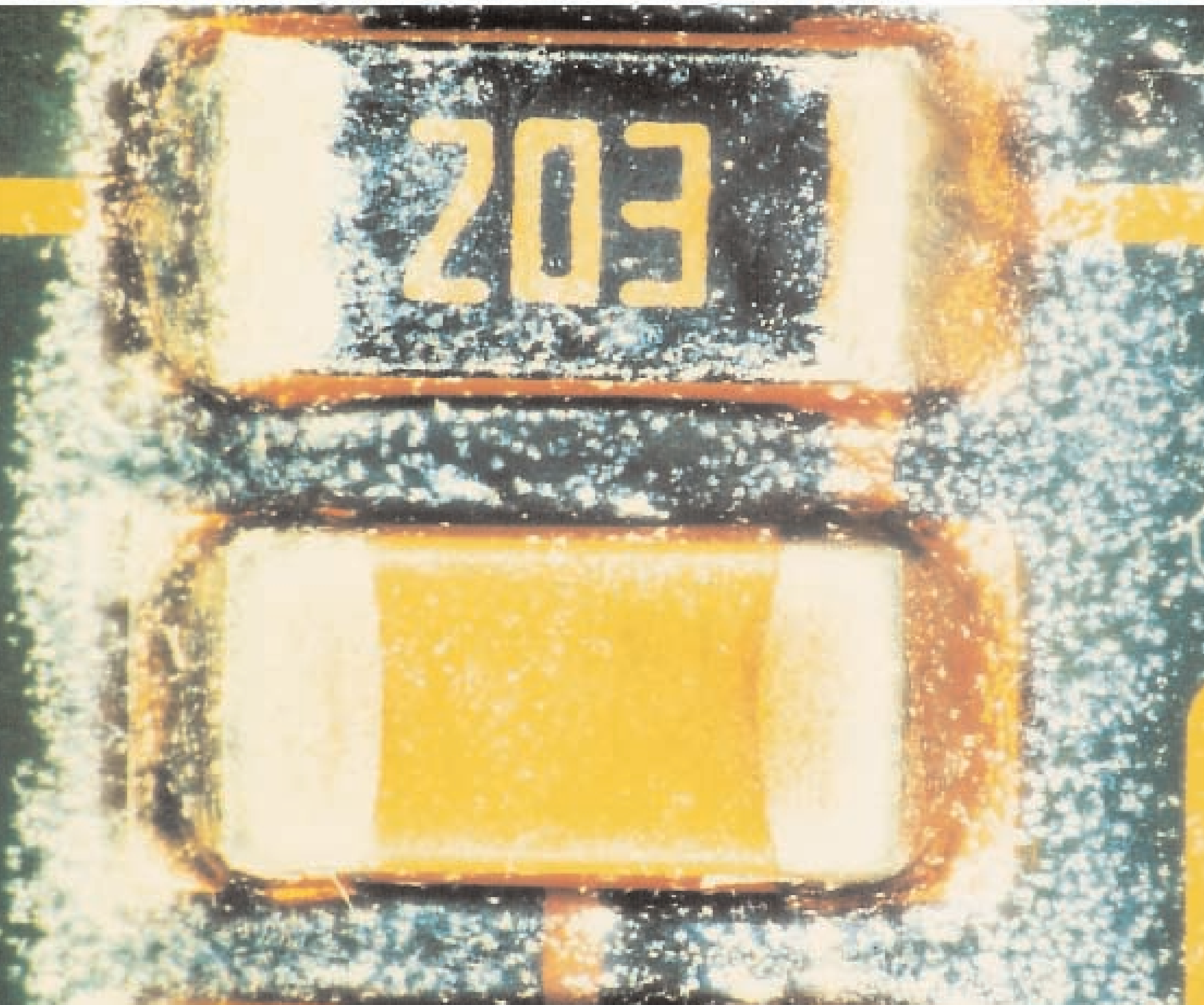
Cleaning before Coating

Requirements on the cleanliness of surfaces prior to coating



Conformal coating issues: When reliability goes astray

The requirements on electronic assemblies used for high-tech applications in the automotive or avionics industry are steadily increasing. Therefore, conformal coating of assemblies is often inevitable. To guarantee the reliability of assemblies, highest standards are placed on the surface cleanliness to ensure optimal adhesion of the coating. These standards can often only be met by integrating an additional cleaning process.

This article describes the requirements on the surface cleanliness of assemblies prior to coating and presents fast and cost-effective test methods to analyze the cleanliness level. Additionally, the reader gets an extensive overview about the various cleaning systems to meet the respective requirements.

Dr. Helmut Schweigart, ZESTRON Europe

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Coatings on electronic assemblies must adhere perfectly to guarantee optimally working assemblies even under extreme conditions. For this reason, exceptionally high demands are placed on the cleanliness of the assembly surface. New, economical and fast analytical procedures to test assemblies for cleanliness are presented in this article. Additionally, an overview of common cleaning systems illustrates how the requirements for surface cleanliness can be met.

The requirements on electronic assemblies are steadily increasing, especially those used in automotive, military, avionics and telecommunications applications. In the face of increasing package density, this means that higher standards are being placed on the cleanliness of assemblies during manufacture and assembly.

The greater use of assemblies under ever harsher climatic conditions, such as temperature changes and moisture, also increases the danger of malfunctions. Leakage current and electrochemical migration generated by environmental influences are primarily responsible. *(Figures 1 and 2)*

With the introduction of lead-free solder pastes, the higher solid content and aggressive activators within these pastes must be taken into account. They are responsible for an increase in malfunctions, and a reduction in the reliability and life of electronic assemblies.

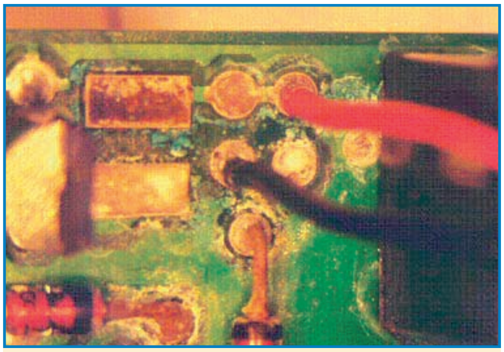

Figure 1. Massive corrosion on an assembly.

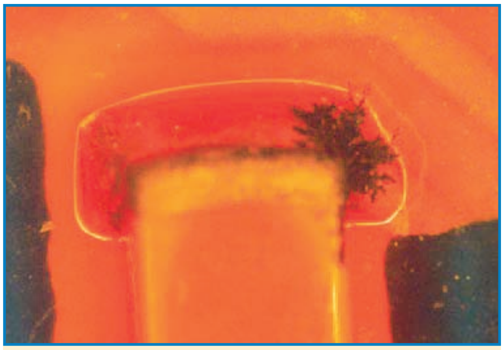

Figure 2. Electrochemical migration even under protective coatings.

Coating as a reliable protective measure

Providing electronic assemblies with protective coatings is therefore an important and necessary measure to ensure the reliability of electronic products. Since coating the assemblies is generally the last step in the manufacturing process, errors in this manufacturing step may have a drastic effect on production costs and lead to appalling field failures. To guarantee optimum adhesion of the protective coating and prevent subsequent crack formation and delamination, it is important to ensure the highest cleanliness of the assemblies before coating.

Minimum surface cleanliness before protective coating

The minimum cleanliness for coating processes is typically referenced through the established J-STD 001D, which is held to be the most used industrial standard for the cleanliness qualification of assemblies. The following methods are required for complete qualification according to J-STD 001D:

- Visual qualification 20x or 40x magnification (according to IPC A610D)
- Qualification of resin purity (< 40 µg/cm² for Class 3 assemblies)
- Measurement of ionic contamination (<1.56 µg/cm² NaCl)
- Proof of other organic impurities
- SIR measurement after or during climatic storage

The **visual inspection** can be performed with the assistance of a macroscope. No visual impurities on the assembly should be noticeable.

The **amount of resin** on assemblies plays a significant role since it influences the adhesion of the coating. Resin-residues can lead to insufficient adhesion of the protective coating and cause a peel off. The threshold for class 3 assemblies is only 40 µg/cm², which corresponds to the amount of resin on only one soldering joint. However, the amount of resin left by new, lead-free solder pastes has increased enormously due to their changed composition. So far, resin-residues have been detected by means of expensive procedures such as HPLC (high-pressure liquid chromatography). However, they can now be easily detected on an assembly by quick chemical tests (i.e. the ZESTRON® Resin Test). This test ensures that residual resin can be identified and cleaned directly during production to keep from exceeding the maximum value of 40 µg/cm².

In characterizing the purity of surfaces according to J-STD 001D, the **ion equivalent** represents an important factor as well. A high ion equivalent indicates the existence of a large amount of hygroscopic impurities. These impurities lead - mostly within a few years - to the delamination of the coatings and hence to their failure (*Figure 3*).

Other organic impurities such as flux residues can decisively influence the quality of the coating and trigger failure mechanisms under the coating. For **demonstrating such organic impurities** according to J-STD 001D, there are other quick and easy-to-use discoloration methods (such as the ZESTRON® Flux Test), which can serve as an alternative to existing expensive testing methods (such as infrared spectroscopy). By means of a color reaction, organic acids used as activators in fluxes are selectively demonstrated on the assembly *(Figure 4)*. Furthermore, these quick tests make the distribution of impurities on the assembly surface visible.

The **SIR measurement** serves to demonstrate the insulation of the surface. A high degree of insulation ensures that electrical signals on the assembly are not distorted. Flux residues and conductive impurities may cause leakage current bridges and can thereby lead to malfunctions. In the SIR measurement, a comb structure is stored in a climatic exposure test cabinet and the surface resistance between the individual comb structures are measured. This allows the surface resistance after soldering the assemblies to be deduced.

The presented methods reliably guarantee the detection of the various impurities. Nevertheless, the integration of a cleaning process is frequently required to be able to maintain all of the production thresholds set by J-STD 001D. This cleaning process should not only remove impurities, but should also positively influence the adhesion of the conformal coating to minimize the risk of later crack formation and delamination long-term.

Selecting a suitable cleaning procedure

When selecting a cleaning procedure, the technical requirements should be considered first. In case of subsequent coating processes, the cleaning must primarily ensure a high surface cleanliness. Thereby, the adhesion of the coating materials on the assembly surface is guaranteed. When selecting a suitable cleaning process, the cleaning parameters and chemicals must be optimally harmonized. The mechanical application method such as spray-in-air, spray-under-immersion or ultrasonics should be adapted to the requirements posed by residues to be removed, geometry and material sensitivities.

The cleaning processes can be categorized into organic solvents, aqueous-alkaline surfactant cleaners and water-based, surfactant-free MPC® cleaners (Micro Phase Cleaning).

The benefit of organic solvents is that they clean well and have a very wide process window. Their drawbacks are that they frequently have a high VOC content (Volatile Organic Compound) and some of them are highly flammable, which means that their use is restricted to explosion-protected cleaning equipment. Given the economic, ecological and safety technology advantages of water-based systems, low flashpoint organic solvents are increasingly losing ground.

The substantial benefit of conventional surfactant cleaners is that they are flashpoint-free and generally have a low VOC value. The primary shortcomings of using surfactants to clean assemblies lie within the working principle of surfactants themselves. The active cleaning elements of conventional surfactant cleaners bond permanently to the impurities.

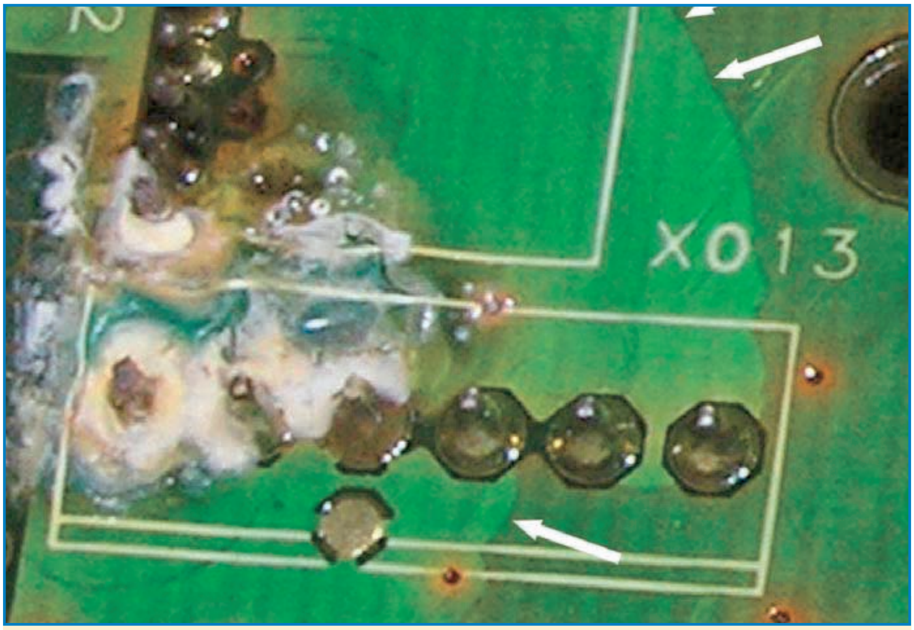

Figure 3. Delamination and crack formation in coatings.

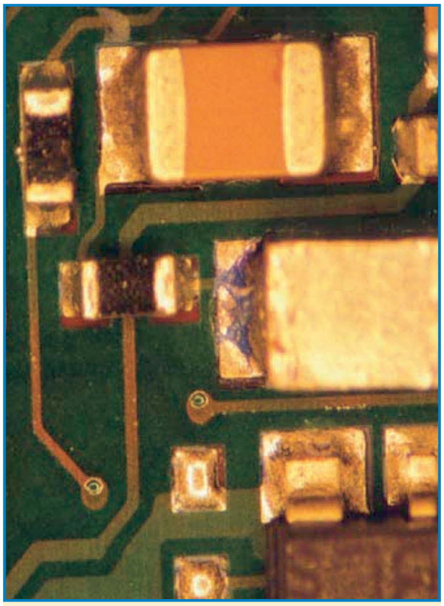

Figure 4. Colouration of flux residues by the ZESTRON® Flux Test.

Due to this a depletion of active ingredients appears. The resulting bath ineffectiveness can only be counteracted by adding more surfactant or changing the bath completely. This results in increased costs for cleaning medium, labor, disposal and removal of the used cleaner. At the same time, many surfactants remain adhered to the substrate surface, which can lead to problems in subsequent processes such as coating.

The MPC®-Technology combines the advantages of aqueous cleaners and solvents without any of their disadvantages *(Table 1)*.

Microphases remove flux residues, resin residues and other impurities from the substrate surface. The active cleaning components do not bind to the impurities like traditional surfactants *(Figure 5)*. The dirt particles removed by microphases are stabilized on the edge of the phase and are released from the cleaner in a filter *(Figure 6)*. They can therefore be removed by simple filtration. MPC® cleaners do not lose active ingredients like surfactant cleaners.

The long lifetime of the cleaning agent results in lower consumption. The costs for changing the bath as well as disposal and transport are reduced significantly *(Figure 7)*. Due to the surfactant-free and solid-free formulation of MPC® Technology, no residues remain on the substrate surface. The subsequent coating process is therefore highly reliable.

Conclusion

The combination of a cleaning application with effective surface cleanliness tests yields an economical, cost-effective solution to coating processes and substantially enhances process reliability and operational reliability of the coated assemblies.

This statement is also confirmed by the GfKORR e.V. organization (Society for Corrosion Protection) in its current guideline, "Use and Processing of Conformal Coatings for Electronic Assemblies." This guideline, prepared by leading coating manufacturers, assists in the selection of processes for an economical and yet reliable solution.

By using an optimized cleaning and qualification method in the production step preceding the coating process, the adhesion of coatings is ensured, thus preventing field failures of the coated assemblies. The partnership between manufacturing process engineers, cleaning process suppliers and equipment manufacturers is becoming increasingly important in the face of this complex problem.

Table 1. Comparison of different cleaning systems.

Cleaning Medium	Benefits	Drawbacks
Organic solvents	- Can remove a wide range of different residues	- High VOC (volatile organic compound) content - Flammable - Explosion-protected systems are necessary
Aqueous-alkaline cleaners (surfactant cleaners)	- Little to no VOC content - Non-flammable	- Short bath life - Large amounts of cleaner must be disposed - Residue-free drying is difficult - possible problems with coating adhesion
Water-based Microphase Cleaners (MPC®)	- Little to no VOC content - Can remove a wide range of residues - Non-flammable - Residue-free drying - Long bath life	- Agitation of the cleaner must be adapted to the process

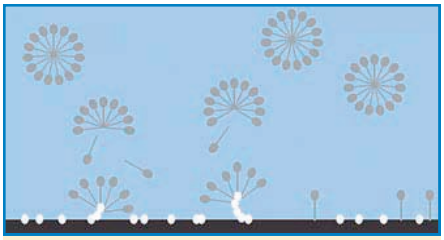

Figure 5. Surfactant cleaner.

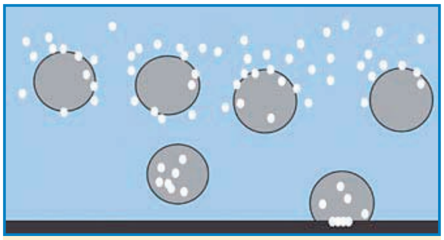

Figure 6. MPC® Technology.

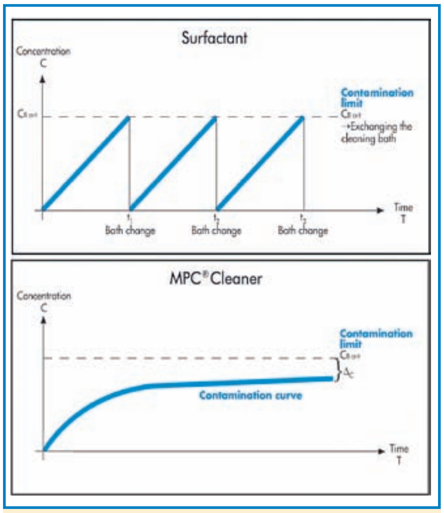

Figure 7. Comparison of the bath life between surfactants and MPC® cleaners.

Helmut Schweigart, Dr.-Ing., is head of Application and Process Technology at ZESTRON Europe, Ingolstadt, Germany, the world's largest precision cleaning services company. Helmut Schweigart has a diploma in mechanical engineering and did his theses concerning the reliability of electronic assemblies at the Technical University of Munich, Germany. He is chair of several working groups concerning corrosion and reliability of electronics.