Coating tests are required during development to avoid the expensive redesign of assemblies at a later point in time. Until now test methods have been time consuming and expensive. We take a look at a fast and cost-effective test method, which puts conformal coatings to the ultimate test.

PCB use in consumer and industrial applications has significantly increased over the years. Nowadays, for example, electronic components make up 30% of the value of a car. The increasing use of electronics in different applications has caused reliability concerns for circuits operating in some ambient conditions. As such automotive manufacturers use identical components for both the European market and vehicles destined for tropical regions. The functional reliability of microelectronic components must be guaranteed under both conditions.

Conformal coating

The exposure of electronic assemblies to different environmental conditions causes electronic stresses that not only threaten the individual circuit but the reliability of the entire product. Failure mechanisms such as electrochemical migration, corrosion-induced creepage currents and interruptions are common complaints.

A reliable conformal coating can be an adequate solution for avoiding such failure mechanisms and ensuring the operational safety of the assembly as well as the entire product.

Conducting suitable stress tests of the conformal coating during the development phase has become increasingly important for high-end applications in order to avoid layout changes and great expense later in the process.

A fast and cost-effective test method was recently devised for a major railway electronics manufacturer. The target was to establish the climatic reliability of a key electronic assembly during the development phase. The particular specification for the electronic assemblies was to ensure proper functionality over the 30-year usage period. This included an average daily operating span of 16 hours (180,000 total hours of operation) within a given temperature range of –40°C to 85°C, and full exposure to the operating environment.

Test methods

The main objective of this study was to determine the adequacy of the protective coating process used. Aspects such as permeability, durability and required adhesion forces of the coating systems were examined.

The coated electronic assembly, which is used as a multi-feature control unit in most demanding railway applications, was subjected to Zestron’s “Coating Reliability Test” (CoRe Test). Based on the water stress test method, the CoRe Test (Table 1) is a point-of-weakness analysis test, not a life cycle test. It allows the customer to quickly carry out a cost-effective analysis during the development phase so expensive changes to the circuit layout can be avoided. This rapid test method was specifically designed for the development phase but does not replace the lifetime test. The Coating Reliability Test displays several advantages over the lifetime test, as shown in Table 1.

The CoRe Test is considered a "worst case" test and ensures that all sources of error are identified. All weak points can then be discussed with regard to their relevance to the future application.
Combining the CoRe Test with a lifetime test significantly reduces development time and ensures that no aspect of the application will be overlooked, guaranteeing a cost-effective development process. The CoRe Test also ensures that no issues will remain outstanding before starting the type approval.

**Test implementation**

The CoRe Test (Figure 1) requires that the coated electronic circuit is placed in de-ionized water, or de-ionized water with specific additives, to simulate exposure to harmful gases (de-ionized water + 5% ammonium sulphide). The electronic component is then placed under a normal operating voltage (in this case 24V). This can be accomplished using either the standby or sequenced mode. The operating current is measured and plotted against time to determine whether electrochemical migration and consequent failure of the electronic circuit assembly occurs. The connectors were initially covered by wax to ensure water-free exposure. In addition to the current plot, the electronic circuit boards were also examined visually to detect the presence of electrochemical migration and corrosion (Figure 2).

To fully simulate the actual in-service exposure to harmful gases, the CoRe Test was performed in de-ionized water as well as in a 5% ammonium sulphide solution.

**Tests conditions and results**

In cooperation with the railway manufacturer, three different types of assemblies were tested. Every circuit board was soldered with two different solder pastes - Multicore RM 92 DAS 90 Sn62Pb36Ag2 and Cobar Flux 388 - and partially coated (dip-coating) with silicone coating. The visual inspection following the CoRe Test was performed by microscope and by means of UV-spectroscopy (360nm) (Table 2).

**Observations**

Based on the analytical experiments, various observations were made in relation to the coating: inter-connector parts were partially protected by coating material, there was light delamination of coating on edges and components (Figure 3), and corrosion was observed between inter-connector spacings.

**Summary of results**

The study was successfully able to assess the potential risk of corrosion induced by leakage currents. The completed ten-hour CoRe Test was deemed sufficient to simulate maximum lifetime exposure by the railway manufacturer. Furthermore, the influence of sulphuric and other toxic gases was found to be insignificant for products that are used in the automotive and railway industry. These gases can lead to failure mechanisms mainly when assemblies are exposed to sufficient moisture films. The properties of the protective coating applied are therefore of the utmost importance.

Three main conclusions regarding the coating material were drawn from the study: the quality of the coating product was deemed sufficient, even under sulphurous conditions; damage caused by normal and sulphurous conditions is comparable; enhancements to the protective coating, especially for inter-connector areas, were necessary.

Other weak points resulting from the aging process cannot be detected using this test method. However, other already existing assessment methods can be used.

Aging of the mechanical bond may be achieved using a temperature change test. Two different methods can be used for a temperature change test. The first method, temperature cycling, involves keeping the test sample in the climatic exposure test chamber and adjusting the temperature from warm to cold. The second method, the temperature shock method, involves rapid changes between hot and cold temperatures. During this test, the sample is transported be-

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**Table 1 - Comparison between CoRe Test and lifetime test**

<table>
<thead>
<tr>
<th>Weak point analysis (Coating Reliability Test)</th>
<th>Life time test (e.g. EC 48-2 Standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- During development</td>
<td>- Post development (type approval)</td>
</tr>
<tr>
<td>- Quick (max 10 hours)</td>
<td>- Time-consuming (up to 6 months)</td>
</tr>
<tr>
<td>- Low cost</td>
<td>- High cost</td>
</tr>
<tr>
<td>- Identification of all weak points</td>
<td>- Failures may remain undetected</td>
</tr>
<tr>
<td>- Exempt from pseudo-failure rate</td>
<td>- Exempt from pseudo-failure rate</td>
</tr>
</tbody>
</table>

**Table 2: Test conditions of the CoRe Test and results for the tested assemblies**

<table>
<thead>
<tr>
<th>Test Medium</th>
<th>De-ionized water, App. 0.5A</th>
<th>De-ionized water, App. 0.5A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Current</td>
<td>Time 10 hours, Single temporary current fluctuations</td>
<td>Time 10 hours, After a few hours the current steadily increased: if then fluctuated dropped, reversed increased.</td>
</tr>
<tr>
<td>Current Observations</td>
<td>Breakdown of a component after a few hours</td>
<td>Conformal coating was intact. Electrochemical migration and corrosion observed on non-coated surfaces similar to the de-ionized water test.</td>
</tr>
<tr>
<td>Interpretation</td>
<td>Conformal coating was intact. Electrochemical migration and corrosion observed on non-coated surfaces similar to the de-ionized water test.</td>
<td></td>
</tr>
<tr>
<td>Optical Observations</td>
<td>Conformal coating was intact. Electrochemical migration and corrosion observed on non-coated surfaces similar to the de-ionized water test.</td>
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</tbody>
</table>

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Conclusions

This case study demonstrated that the Zestron Coating Reliability Test is an effective and inexpensive test method for optimising the development phase of assemblies and further increasing the testing quality.

In low-end applications, conformal coating is commonly completed as part of the required process flow and generally without cleaning. Nevertheless, for high-end applications, cleaning prior to conformal coating is a mandatory step to ensure proper adhesion and avoid any delamination.

Various contaminants formed during the soldering steps significantly impair the cross linkage of coating and surface, but can be safely removed with an adequate cleaning process. In comparison with a full no-clean production method, a fully integrated and optimised cleaning process increases long-term product reliability and often leads to process-related cost savings.

Therefore, electronics manufacturers are increasingly seeking the support of experts that can cater to specific cleaning requirements, as well as developing close relationships with cleaning equipment manufacturers.

RoHS Compatible Laminates And Prepregs

Polyclad Laminates, a business of Cookson Electronics, has introduced Getek HR high speed, low loss laminates and prepregs.

The CAF resistant, lead-free assembly compatible materials deliver enhanced thermal performance and high reliability required by PWB assemblers and OEMs, while enabling PWB fabricators to experience substantially improved FR-4 processability.

According to the manufacturer, Getek HR combines the well known and industry trusted electrical performance of Getek with the patented technology utilised in Polyclad 370HR high performance materials, as well as other best-in-class Polyclad Lead-free assembly compatible FR-4 products.

The resulting products exhibit low dielectric constant, low loss, very low Z-axis expansion, as well as a high decomposition temperature, suitable to manufacture thick multilayer PWBs.

Another outstanding characteristic of the new family of laminates and prepregs is the complete compliance with Lead-free processing and with the European Union’s Restriction of Hazardous Substances (RoHS) directive, which will be introduced in Europe in the near future.

This new generation of laminates and prepregs comes from a close collaboration with PWB fabricators, assembly and OEM partners.

With manufacturing in both the U.S. and Taiwan, Getek HR is readily available in prototype to high-volume quantities.

In addition, customers who have UL approval for manufacturing with Getek will also be able to use Getek HR.

Getek HR is may be used for a broad range of applications in different sectors, including telecommunications equipment, high speed computing and storage, test and medical electronics, IC substrates, and RF and wireless electronics.

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