



Long-term Reliability of Lead-free in Contaminating Environments Study

Objective:

To assess the long-term reliability of lead-free electronic assemblies subject to contaminating and corroding environments

Motivation:

Electrochemical migration (ECM) is a potential reliability problem in electronic soldering which might become more dangerous in lead free electronic devices due to harsher solder fluxes, and since many lead-free solders contain silver, which is known to migrate more readily than tin or lead in temperature-humidity-bias conditions. With continued reductions in conductor spacing, long-term reliability of electronic systems could be compromised by electrochemical migration under the influence of surface contamination and no-clean flux residues, which are no longer removed by cleaning. In addition, there may be other new failure mechanisms which might arise when electronic assemblies are used in contaminating environments.

One concern is hygroscopic contamination can lower the critical relative humidity in which electromigration occurs, down to 40% RH. Therefore, even in a normal office environment, electronic assemblies can be endangered. Adsorbed halide elements (such as bromine, chlorine) and SO₂ part of industrial atmospheres act as seeds for condensation and support the electrodisolution of the plating (e.g. immersion silver) or lead-free solder (e.g. Sn-3.0Ag-0.5Cu) to accelerate the progress of electrochemical migration. Moreover, in the presence of chlorides and other complexing ligands, the novel metals like gold, indium, palladium and platinum can also migrate.

Current industry standards, such as IPC-TM-650, IPC-TR-476A, IPC-9201 and IEC 61189-5, recommend the use of temperature-humidity-bias (THB) testing to assess the stability of surface insulation resistance and risk of electrochemical migration of electronic assemblies. However, these tests are designed to serve as short-term qualification tests, typically lasting 72 to 168 hours, and do not provide a prediction of reliability in long-term applications, because acceleration factors for electrochemical migration of lead-free assemblies have not been available. Thus, test times used in procedures described in industry standards cannot be translated to equivalent field life. The present study was intended to provide reliability of lead-free electronic assemblies subjected to long-term (approximately one year) THB condition.

In addition, mixed flowing gas (MFG) tests which subject the assemblies to various contaminating conditions will be conducted. These tests will be conducted to provide accelerated conditions of contaminants, to represent up to a 20 year life. The Telcordia MFG test standards will be used for the assessment.

Approach:

- Select test assemblies to include lead-free solder paste, plating and substrate according to industrial relevance and chemistry.
- Characterize no-clean fluxes using potentiostat measurements.
- Identify the ion-contamination level of board surface pre-testing and post-testing.
- Conduct step stress temperature/constant humidity (e.g. start at 25C/93%RH; progress to 40C/93%RH) or humidity/constant temperature (e.g. start at 65C/65%RH; progress to 65C/88%RH).
- Conduct the MFG testing according to the Telcordia Standards for various class environments
- Apply different voltage bias over different comb structures to varies the electronic filed.
- Conduct optical, electron-microscopy and X-ray mapping analysis on the tested samples.

Expected Findings:

- Risks in using lead-free electronics in the contaminating environments
- Potential risks induced by manufacturing processing, such as cracks within the solder mask, handling, reflowing, contamination etc.
- Evaluation of reliability performance of different combinations of lead-free solder paste, plating and substrate.
- The effect of environmental and electric field conditions on potential for electrochemical migration on lead-free PCB.
- Recommendations for accelerated testing and updates that are needed to current industry standards.

Participation Costs:

\$15,000

\$25,000 to participate in this study and the Long-term Reliability of Mixed (Pb-free Parts/SnPb Paste) Soldered Assemblies