To The Point
Tin Whiskers

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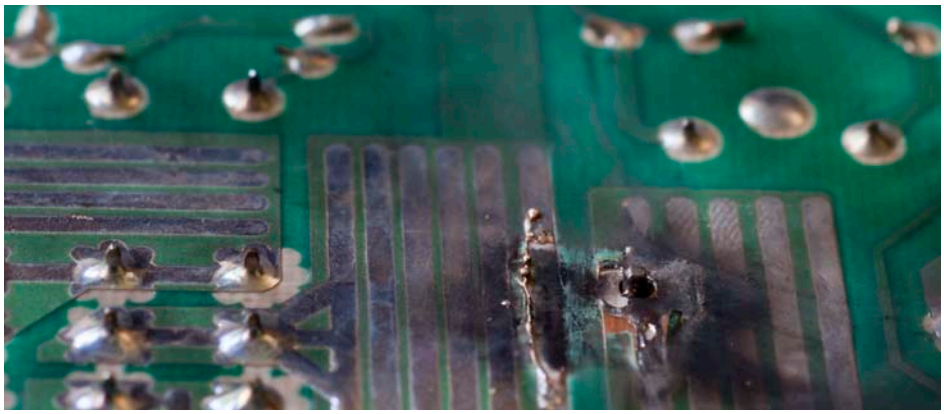

Mitigating Failures

Tin whiskers are metal crystals that grow spontaneously from electronic components with tin-containing finishes. Tin whiskers can grow over time, from months to years. Whisker formation generally occurs as a result of compressive or intermetallic stresses between soldered or plated coatings and base layers. Tin whiskers can grow from a few microns to more than 10 millimeters in length.

This phenomenon becomes problematic when whiskers grow or break off and make contact between adjacent conductors of differing electric potential. This contact causes transient or permanent electrical shorts. This in turn can cause component-specific or widespread system failure.

The metal whisker phenomenon was first recognized in the 1940s through evidence of electrical shorts caused by cadmium, tin, and zinc whiskers growing from plated and soldered electronic components. Bell Labs discovered that adding a small amount of lead to tin coatings inhibited whisker development. After the military and aerospace industries began experiencing whisker problems during the 1980s and 1990s, lead content became standard for the electronics industry. Environmental concerns arose during the late 1990s resulting in a resurgence in pure tin applications.

Restriction of Hazardous Substances

Environmental initiatives implemented in Europe, China, South Korea, and California have banned lead from electronics and electrical equipment. The most common and least costly approach among electronic component suppliers to meet Restriction of Hazardous Substances (RoHS) requirements was to eliminate lead from solder, thus reintroducing the tin whisker problem of the past. While most RoHS countries or states allow tin and lead use for certain “high- reliability/ safety-critical” exemptions, China is still in the process of developing an exemption application procedure through their RoHS catalog. This is particularly important as 80% of global electronic components are manufactured in Asia.

In addition to the resurgence of tin applications under RoHS, industry trends toward circuit miniaturization and lower power requirements are expected to increase failures induced by tin whiskers. New lower current requirements may prolong whisker life, instead of vaporizing them as in the past. Whiskers are increasingly identified as a cause of failure due to rising incident rates and electronics industry publicity.

High-reliability manufacturers have identified a trend of tin parts slipping into the supply, often undetected. With the rush to RoHS, slippage of tin parts into tin and lead supplies occurred due to lack of parts number differentiation and communication issues with suppliers or subcontractors. In 1995, the U.S. military adopted a commercial off-the-shelf (COTS) parts purchase program, commanding less than 2% of the market. It had concerns about the unavailability of tin and lead parts and slippage due to RoHS compliance market demands.

Failure Categories

- Stable short circuit in low-voltage, high-impedance circuits
- Transient short circuits
- Metal vapor arc
- Debris and contamination – bridge isolated conductors or interfere with optics or mechanical parts

Failure Consequences

Tin whiskers have been identified on both active and passive electronic components, hardware, and component housings and cases. Tin whiskers pose similar risks to battery-operated electronics. High-reliability or safety-critical applications pose the greatest single incident exposure. Past high-reliability failures have exceeded $1 billion in losses and include satellites and telecommunications, defense systems, power plants, and pacemakers.

Failure consequences of electronic components or products determine the degree of whisker-related failure risk. The failure of thousands of non high-reliability electronics products or components may result in appreciable aggregate risk and reputation damage.

Mitigation Measures

The International Electronics Manufacturing Initiative (iNEMI) Tin Whisker User Group published Recommendations on Lead- Free Finishes for Components Used in High-Reliability Products that lists mitigation practices, acceptable and unacceptable base materials, and the level of required whisker follow-up testing. The most common mitigation measures include conformal coating and hot solder dip, plus annealing, heat treating, fusing in hot oil, and underlayer nickel plating. New industry risk identification and mitigation developments should be incorporated into a risk management strategy along with iNEMI recommendations, such as the potential for slippage and studies identifying whisker development from tin, silver or copper finishes.

Specific standards have been developed for high-reliability and Department of Defense applications. The Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems authored by the Government Electronics & Information Technology Association (GEIA) has been adopted by the military and by commercial aerospace companies manufacturing or purchasing equipment that may contain lead-free tin finishes. This standard establishes communication and mitigation documentation requirements for tin finish product manufacturers and suppliers.

Test Program Development

The Joint Electron Devices Engineering Council (JEDEC) publication JP002 Current Tin Whiskers Theory and Mitigation Practices Guideline provides guidance in understanding the prevalent tin whisker formation theories, driving forces and mitigation practices used to minimize tin whisker formation in the electronics industry. Together with the acceptance testing and reporting methodology in JESD201 Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes and JESD22-A121 Test Method for Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes, these publications form a three-pronged strategy of mitigation practices, plating process controls and tin whisker testing that helps to reduce the risks of failures due to tin whiskers.

Testing strategies should be developed for manufactured, subcontracted, and COTS parts. Validation of Certificates of Compliance (COCs) and consideration of slippage should be incorporated into the program.

Resources

Recommendations on Lead-Free Finishes for Components Used in High-Reliability Products (Version 4, updated December 1, 2006), iNEMI Tin Whisker User Group thor.inemi.org/webdownload/projects/ese/ tin_whiskers/Pb-Free_Finishes_v4.pdf

Joint Electron Devices Engineering Council www.jedec.org

NASA Tin Whisker (and Other Metal Whisker) nepp.nasa.gov/whisker/

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