

# Mitigation and Verification Methods for Sn Whisker Growth in Pb-Free Automotive Electronics

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This work describes mitigation methods against Sn whisker growth in Pb-free automotive electronics using a conformal coating technique, with an additional focus on determining an effective whisker assessment method. We suggest effective whisker growth conditions that involve temperature cycling and two types of storage conditions (high-temperature/humidity storage and ambient storage), and analyze whisker growth mechanisms. In determining an efficient mitigation method against whisker growth, surface finish and conformal coating have been validated as effective means. In our experiments, the surface finish of components comprised Ni/Sn, Ni/SnBi, and Ni/Pd. The effects of acrylic silicone, and rubber coating of components were compared with uncoated performance under high-temperature/humidity storage conditions. An effective whisker assessment method during temperature cycling and under various storage conditions (high temperature/humidity and ambient) is indicated for evaluating whisker growth. Although components were finished with Ni/Pd, we found that whiskers were generated at solder joints and that conformal coating is a useful mitigation method in this regard. Although whiskers penetrated most conformal coating materials (acrylic, silicone, and rubber) after 3500 h of high-temperature/humidity storage, the whisker length was markedly reduced due to the conformal coatings, with silicone providing superior mitigation over acrylic and rubber.

**Key words:** Whisker, growth mechanism, mitigation, conformal coating, automotive electronics

## INTRODUCTION

Pb-free solder is in wide use in electronic assemblies because of restrictions on use of hazardous substances (RoHS). However, Pb-free automotive electronics are relatively new, due to end-of-life vehicle (ELV) requirements. Pb-free solder is already used in cases of electrical connections for parts without electronic components, and will be used in all manner of car electronics that include components mounted on printed circuit boards (PCB) in the future (after 2016). In light of the use environment and service life of automobiles, use of

Pb-free solder in automotive electronics is quite different when compared with use in normal electronics such as installed in buildings. Because of the very long service life, spanning 10 years/100,000 miles, and high reliability expectations of cars, whisker formation in automotive circuits is a critical concern. Table I provides a comparison between lifetimes and operational temperatures for electronic assemblies and automotive electronics. Whisker-growth-based circuit failure in applications such as spacecraft and automobiles has already been reported.<sup>1,2</sup> Whisker formation and growth mechanisms and mitigation methods have been studied extensively,<sup>3–14</sup> For example, it is well known that tin (Sn) whiskers grow at solder joints and on plated surfaces under certain compressive

(Received April 29, 2012; accepted September 28, 2012; published online November 10, 2012)