Reliability Evaluation of Conformal Coatings against Tin Whisker Growth

Objectives:
• To develop a test procedure for conformal coatings to assess effectiveness of tin whisker failure mitigation
• To characterize the degradation of conformal coating subjected to operating and storage conditions
• To develop a PoF model to evaluate the performance of conformal coating to prevent short failure by tin whisker growth

Background
• Tin whiskers are conductive crystals that can spontaneously grow from pure tin and high tin content alloy finishes.
• The major failure caused by tin whiskers is electrical shorting due to bridging between adjacent conductors.
• Conformal coating is a polymeric layer, that was designed to protect the surfaces from harsh environments such as mold, moisture, and chemicals.
• In terms of tin whisker mitigation, a conformal coating may prevent whiskers from contacting a coated surface and contain whiskers under the coated surface.

Two Observed Failures of Coating
• Silicone (SR) Coating Tests
  – Simple puncture observed
  – Dominate failure mode: Puncture Failure
• Urethane (UR) Coating Tests
  – Whiskers were contained before breaking out of the coating
  – Failure Mode: Adhesive and Puncture Failure
• Each failure mode was tested in two accelerated testing environments

Testing Approach
• Blister-type Testing
  – Due to the nature of the coating, a larger experimental whisker diameter can be used during testing
  – Advantages
  • Mimics tin whisker growth
  • Allows for quantitative comparison of rupture and adhesion strengths
  • Specimens can be subjected to accelerated testing environments

* Panashchenko, "Long Term Investigation of Urethane Conformal Coating Against Tin Whisker Growth", http://npp.nasa.gov/whisker/, July 2010
Adhesive Strength Testing

Crack propagation

Laser triangulation sensor

Compressed air

Pressure profile

PID controlled pressure regulator

Displacement data

3-axes stage

Displacement data

Laser sensor

Specimen

Adhesion Strength from Test Data

\[ \Gamma = \left( \frac{P^4}{17.4Eh} \right)^{\frac{1}{4}} \]

\( \Gamma = 179 \, \text{J/m}^2 \)

Accelerated Testing:

Urethane

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Flow Chart of Proposed Modeling Approach

Tin whisker Coating

Substrate Nucleation

Lifting and delamination (penetration)

Outward puncture

Ein whisker Coating

Substrate Nucleation

Lifting and delamination (penetration)

Outward puncture

START

- Contact analysis
- Indentation analysis

Redefine deformed configuration

Input

Stress/strain in coating

Peel/lifting force

Input

Fracture analysis

Buckling analysis

Input

Puncture

Whisker containment

Adhesion analysis

Normalized propagation \( \left( \frac{U_y}{r} \right) \)

Strain values are to be used to determine the condition of fracture.

Lifting force is to be used to determine the delamination of coating.

Preliminary FE Modeling of Nucleation

Nucleation

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