Ram Logic | Metal Whisker Modeling

Project Report

SPONSORS
Missile Defense Agency
National Aeronautics and Space Administration
Naval Surface Warfare Center

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I. PROJECT DESCRIPTION

I.1 Introduction

Metal whiskers are microscopic, hairlike protrusions that spontaneously grow from metal surfaces, particularly off materials like tin, zinc, cadmium, or other metals[1]. These whiskers spontaneously grow over time as a result of internal stress within the plating, thermal cycling, or mechanical strain [1].

Metal whiskers are cause for significant concern in electronic systems due to their potential to cause short circuits, arcing, and electrical malfunctions. These risks are especially critical in high-reliability environments such as aerospace and defense where failure leads to catastrophic outcomes.

Galaxy IV, a telecommunications satellite operated by PanAmSat, was lost on May 19, 1998 causing nearly 80% of pagers in the US to stop functioning [2]. The attitude control system of Galaxy IV relied on tin-plated printed circuit boards (PCBs), the attitude control system had redundant PCBs in place; however, the reliance on tin-plating resulted in failures of all PCBs in the attitude control system as tin whiskers shorted each one [2].

Pagers are reliability-critical components in hospital settings, and, granted the Galaxy IV loss occurred in 1998, these reliability-critical pagers extended across emergency services as well. While there are no statistics on indirect loss of life, there was a loss of life-dependent communications during this time.

The primary aim of this project is to statistically measure the impact of detached metal whiskers on PCBs. To this end the preceding team, the **Tin Whisker Investigative Team**, simulated forests of metal whiskers landing on simulated PCBs. The nucleation and growth of metal whiskers, however, are not within the scope of this project. This project is positioned in the domain of PCB reliability.

I.2 Background and Related Work

Previous work has been conducted by the Tin Whisker Investigative Team at WSU and will be continued by our team, Ram Logic. The project mentor, Jay Brusse, has mentioned this preceding metal whisker modeling project is state-of-the-art in this context.

The program generates metal whiskers of random dimensions according to the lognormal distribution [3]. The metal whiskers are then dropped on a PCB in a user-defined area [3]. The metal whiskers modeling framework then creates an Excel spreadsheet of bridged components [3].

Building on this lognormal metal whisker generator, the preceding team implemented Monte Carlo simulations for statistical analysis of whisker bridges.

I.3 Project Overview

The core PCB simulation framework is functional, users can import a PCB, configure conductive components, and run Monte Carlo simulations for metal whisker bridge statistical analysis. Key improvement areas include the following:

- UI fixes for enhanced workflow
- GPU acceleration for quicker Monte Carlo simulation
- Enhanced results visualization
- Automated conductive material detection
- Unit and system testing
- User guided tutorials and tooltips
- Optimizing user input parameter ranges

By addressing these enhancements, this project aims to increase usability, efficiency, and reliability of the metal whisker modeling system.

I.4 Client and Stakeholder Identification

The sponsors of this project are the Missile Defense Agency (MDA), the National Aeronautics and Space Administration (NASA), and the Naval Surface Warfare Center (NSWC) which all require highly reliable electronics for defense and aerospace.

Beyond the sponsoring organizations, this project has far-reaching application in electrical engineering and PCB reliability analysis. Reliability-critical components such as pacemakers, car accelerators, telecommunication satellites, etc. reveal key stakeholders of this project.

GLOSSARY

Metal Whiskers: Microscopic, hairlike protrusions that spontaneously grow from metal surfaces, particularly off materials like tin, zinc, cadmium, or other metals.

Printed Circuit Board (PCB): Flat, rigid board providing mechanical support and electrical connections for electronic components.

REFERENCES

[1] “NASA Goddard Tin Whisker Homepage,” nepp.nasa.gov. https://nepp.nasa.gov/whisker/ (accessed Jan. 29, 2025).

[2] “Galaxy IV,” wikipedia.org. https://en.wikipedia.org/wiki/Galaxy_IV (accessed Jan. 29, 2025).

[3] “Tin Whiskers: Unity 3D App,” github.com. https://github.com/WSUCptSCapstone-S24-F24/-mda-unity3dapp-/blob/main/Project%20Report%20Final.pdf (accessed Jan. 29, 2025)