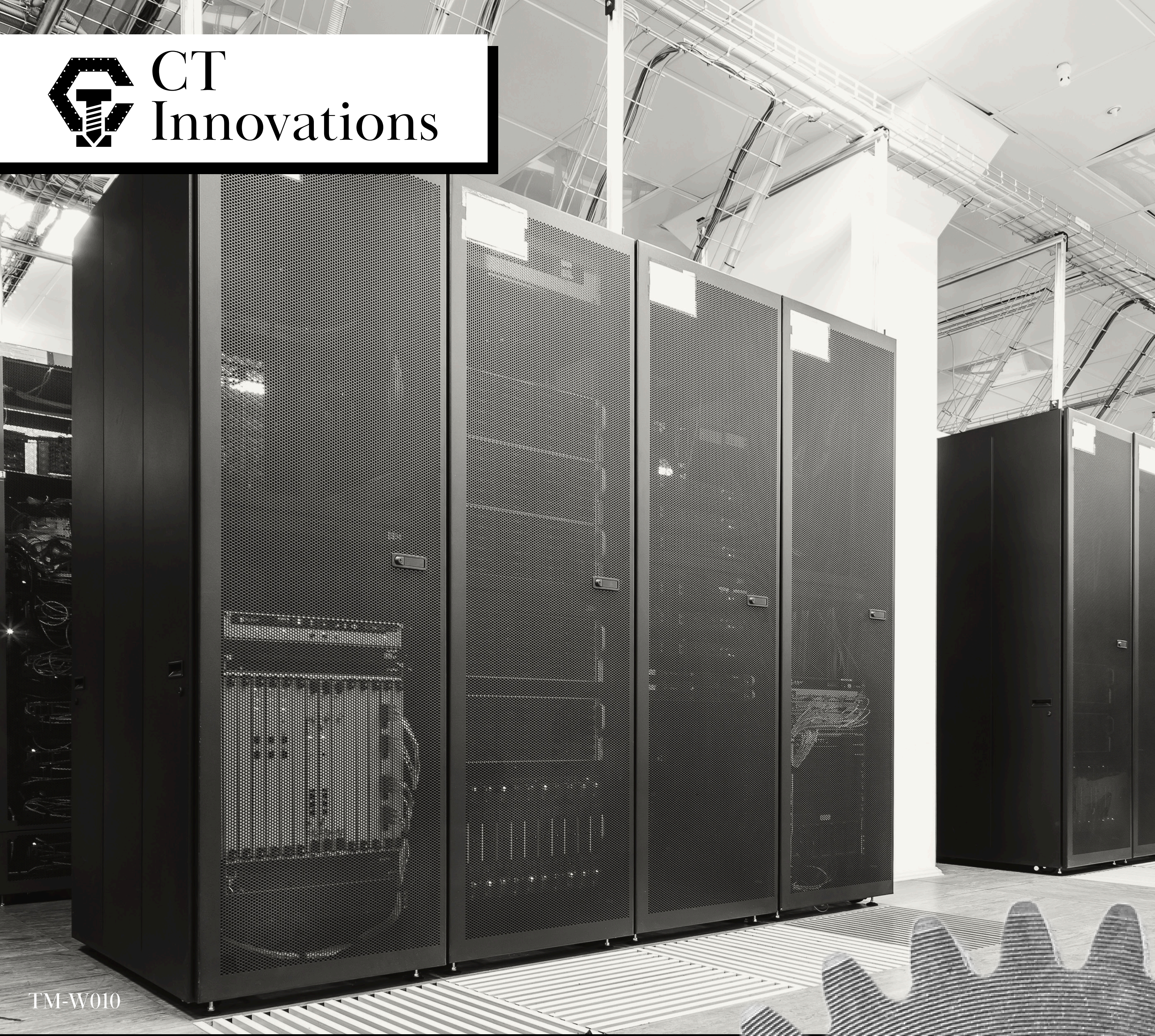
CT Innovations



TM-W010

Mitigating Electronic System Risks:

Zinc Whiskers

1.0 Abstract

Zinc whiskers are tiny, hair-like metallic filaments that form on the surface of electroplated zinc coatings, particularly on steel surfaces. These whiskers pose significant risks in electronic environments, including short circuits and electronic system failures. This paper explores the causes, growth mechanisms, detection, mitigation strategies, and impacts of zinc whiskers on electronic equipment.

2.0 Introduction

Zinc whiskers have been a known phenomenon since the 1940s. They are particularly relevant in environments with a high concentration of electronic equipment, such as data centers, telecommunications facilities, and aerospace applications. Understanding their formation, growth, and mitigation is crucial for maintaining the reliability and performance of electronic systems.

3.0 Causes & Growth Mechanisms

3.1 Electroplating & Residual Stress

Zinc whiskers typically grow on electroplated surfaces due to residual stresses within the zinc layer. These stresses can be a result of:

a) Mechanical Deformation: during electroplating process, mechanical deformation can introduce stress.

b) Thermal Expansion: differences in thermal expansion coefficients between zinc and its substrate can lead to stress accumulation.

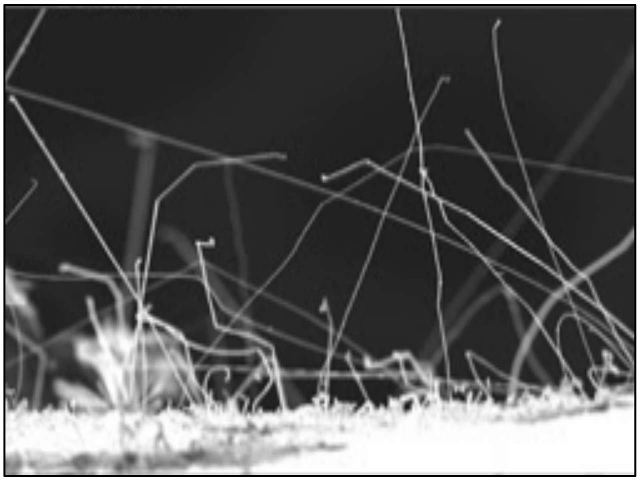
c) Diffusion & Alloying: interactions between zinc and other materials at their interface can contribute to stress.

3.2 Environmental Factors

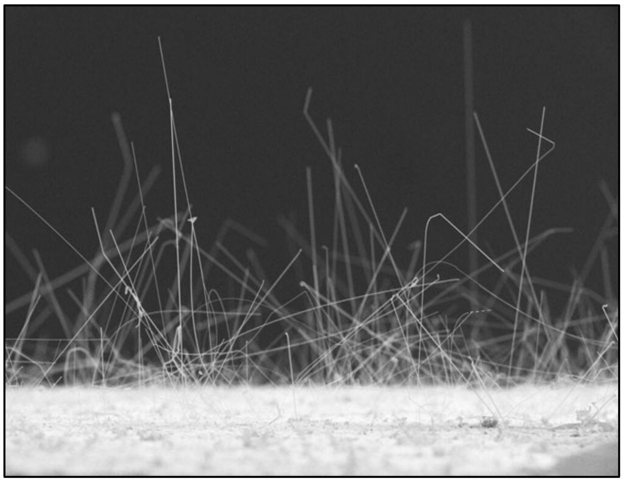
Environmental factors such as humidity, temperature fluctuations, and mechanical vibrations can exacerbate whisker growth. These factors influence the rate at which whiskers form and their ultimate length.

3.3 Whisker Growth

Whisker growth is a complex phenomenon that can occur over a period ranging from months to decades. It involves the extrusion of zinc atoms from the electroplated layer to relieve internal stresses. The growth is highly unpredictable and varies widely in length and density.



Magnified Image of Zinc Whisker Growth



Magnified Image of Zinc Whisker Growth

4.0 Impact on Electronic Equipment

4.1 Short Circuits

The most significant risk posed by zinc whiskers is short circuits. Whiskers can bridge electrical contacts or conductive traces, causing intermittent or permanent failures.

4.2 System Failures

In sensitive environments like data centers, the presence of zinc whiskers can lead to catastrophic system failures, data loss, and significant downtime.

4.3 Contamination

Whiskers can detach and contaminate cleanroom environments or other sensitive areas, leading to broader equipment reliability issues.

5.0 Mitigation Strategies

5.1 Prevention

a) Material Selection: the use of alternative materials such as stainless steel, aluminum or plastics that do not form whiskers.

b) Material Finish: the use of alternative material finishes such as bi-metallic (Zn-Al) TOUGHGalvanized or painted that do not form whiskers.

c) Stress Relief: annealing and other stress-relief techniques during the electroplating process.

5.2 Containment

a) Regular Maintenance: scheduled inspections and maintenance to identify and remove whiskers before they cause damage to electronic systems.

b) Environmental Control: maintaining stable temperature and humidity levels to minimize stress factors.

5.3 Remediation

a) Whisker Removal: manual or mechanical removal of whiskers from affected surfaces.

b) Surface Coatings: application of conformal coatings to prevent whisker formation and growth.

6.0 Bi-Metallic Finishes

The composition of bi-metallic finishes such as Zn-Al alloys, mitigates the development of zinc whiskers due to the addition of aluminum to the zinc. Zn-Al alloys are utilized in the electrical and electronic sectors for applications such as connectors, heat sinks, enclosures due to excellent thermal stability and corrosion resistance. Bi-metallic Zn-Al alloys are also used in medical sector in applications such as medical equipment springs making bi-metallic Zn-Al alloys suitable for clean room environments.

7.0 Case Studies

7.1 Data Center Incidents

Several documented cases have shown that zinc whiskers have caused data center outages, highlighting the need for thorough inspection and mitigation protocols.

7.2 Aerospace Incidents

In aerospace applications, zinc whiskers have been identified as a cause of critical electronic system failures, emphasizing the importance of stringent material controls and preventive measures.

8.0 Conclusion

The specification of materials and finishes that mitigate formation of zinc whiskers is of paramount importance when products are used in enclosed environments in close proximity to electrical and electronic equipment. Post hot dip galvanized finishes should be avoided. ElectroGalvanized finishes are widely used and are generally considered suitable for mitigating the formation of zinc whiskers. Bimetallic Zn-Al alloy finishes also mitigate the formation of zinc whickers and can be considered safe for use in electronic environments such as data centers.

9.0 References

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