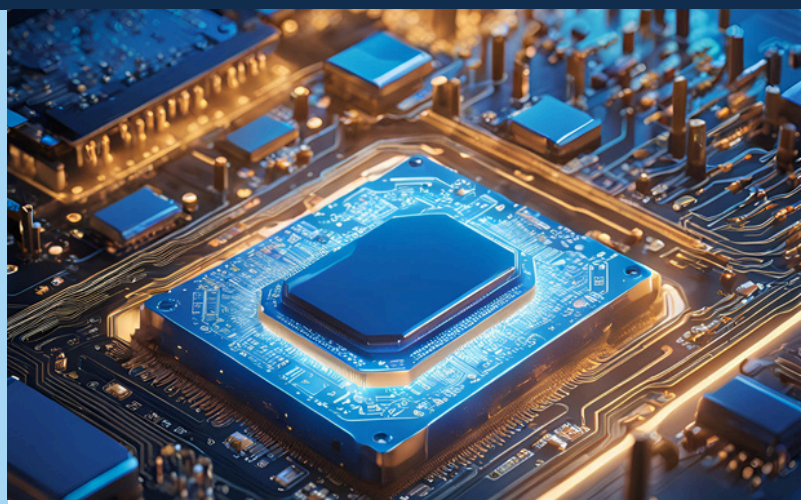
HeatSync Case Study

Thermal Cycle Testing for Defect Detection and Lifetime Estimation of Customer Package

OVERVIEW

HeatSync was approached by a client seeking to evaluate the reliability of their custom electronic package by detecting defects, such as solder joint failures, and estimating the lifetime of the package under operational conditions. HeatSync utilized advanced thermal cycling techniques and industry-standard methodologies to conduct comprehensive testing tailored to the client's needs.



1. CLIENT REQUIREMENTS

- Identify potential defects, including solder joint fatigue and delamination, caused by thermal cycling.
- Provide an accurate estimation of the package's lifespan based on its intended operating environment.
- Ensure testing aligns with JEDEC standards, including JESD22-A104F.

2. CUSTOM PROFILE DESIGN

The HeatSync team analyzed the package design, including solder joint configuration, material properties, and operating conditions. A custom thermal cycle profile, based on JEDEC standards, was developed with temperature extremes of -40°C to +125°C, a ramp rate of 10°C/min for solder joint fatigue evaluation, and a 10-minute dwell time at each extreme to ensure thermal equilibrium. The 1,000-cycle test simulated 15 years of use under normal conditions, calculated using the Coffin-Manson equation.

3. TESTING FRAMEWORK

Thermal Cycling Setup
The package was subjected to air-to-air thermal cycling in a dual-chamber setup. Thermocouples were placed at critical locations to monitor temperature variations and ensure the package reached the desired soak conditions.

Defect Detection
Defect detection was achieved through continuous electrical monitoring, allowing for the identification of intermittent or permanent failures in solder joints. Additionally, visual inspections, including microscopic imaging, were performed to detect physical defects such as delamination and cracking.

Lifetime Estimation
The Coffin-Manson equation estimated the package's lifespan under the client's conditions. Using a test temperature difference (165°C), a use temperature difference (40°C), and a Coffin-Manson exponent (3), the test simulated 15 years of operational life through 1,000 accelerated cycles. This analysis provided accurate insights into the package's long-term reliability.

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4. RESULTS AND INSIGHTS

The thermal cycle testing revealed critical insights into the package's reliability. Fatigue cracks in solder joints were identified in high-stress areas after 800 cycles, highlighting vulnerabilities in the design. Microscopic imaging further detected minor delamination in specific regions of the package. Real-time electrical monitoring confirmed that failures occurred as fatigue progressed, correlating with observed physical damage.

The operational lifespan of the package was estimated at 12–15 years under the client's defined conditions. However, the early onset of solder joint fatigue underscored the need for material or design improvements in high-stress regions to enhance long-term reliability.

5. VALIDATION & BENEFITS

HeatSync's thermal cycle testing identified critical defects, including solder joint fatigue and delamination, and provided an accurate lifespan estimate of 12–15 years using the Coffin-Manson methodology. To address vulnerabilities, recommendations were made to reduce stress, and further validation through thermal cycle tests.

The testing adhered to JEDEC standards, ensuring reliability and consistency. These insights and design adjustments enhanced the package's robustness, longevity, and overall performance.

6. CONCLUSION

HeatSync's expertise in thermal cycle testing enabled the detection of critical defects and the accurate estimation of the package's operational lifespan. By combining custom testing profiles, advanced monitoring techniques, and rigorous standards compliance, we provided the client with actionable insights to improve the reliability of their product.

Contact HeatSync today to learn more about our cutting-edge design, simulation, testing, and training services for reliable thermal management solutions.

HeatSync: Consortium of Thermal Management

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