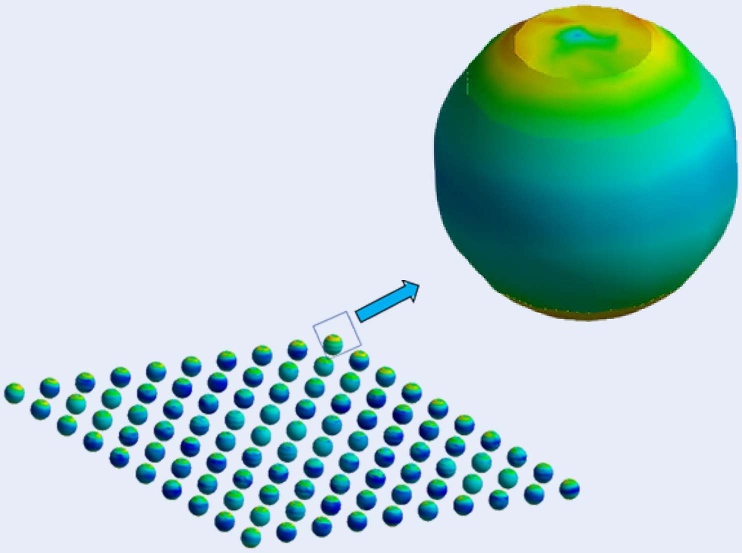
HeatSync Case Study

Optimizing 2.5D IC Package Design for Reliability

OVERVIEW

HeatSync was approached by a client to optimize the design of a 2.5D IC package, addressing key reliability challenges posed by thermal cycling, including solder joint fatigue, delamination, and warpage. The goal was to enhance durability while improving both thermal and mechanical performance. Using advanced simulation techniques, HeatSync delivered an optimized package design that met the client's reliability and performance requirements.



1. CLIENT REQUIREMENTS

- Ensure reliability under thermal cycling by addressing solder joint fatigue, delamination, and warpage.
- Provide cycles-to-failure estimates for solder joints and critical regions.
- Optimize the package design while balancing thermal and mechanical performance.
- Conduct advanced simulations to validate design changes.

2. INITIAL ASSESSMENT

HeatSync conducted a comprehensive reliability study to identify key failure mechanisms under thermal cycling conditions. Simulations were performed using Ansys Mechanical, integrating temperature-dependent material behaviors to accurately predict solder joint fatigue life and stress variations.

3. SIMULATION FRAMEWORK

Fatigue Modeling
The Darveaux Method was implemented to predict solder fatigue life, leveraging strain energy density (SED) and plastic work per cycle. Detailed analysis focused on the top 25 µm of critical solder balls, with refined meshes near connection points to ensure accuracy.

Thermal Cycling Conditions
The system underwent four thermal cycles ranging from -20°C to 100°C.

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Domain Discretization

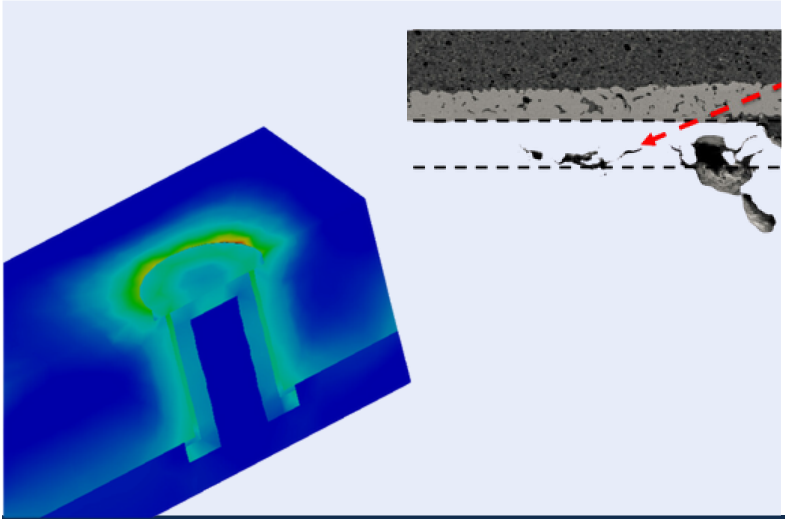
The computational domain was discretized with fine meshes near solder joints, through-silicon vias (TSVs), and key interfaces for accurate SED calculations. Coarser meshes were applied to less critical regions, optimizing runtime without compromising accuracy.

Material Assignments

Temperature-dependent elastic-plastic and creep properties were applied to solder to reflect realistic mechanical and thermal behaviors. PCB layers were modeled as multi-layer copper and dielectric stacks, integrating geometry and material data from an ECAD file in ODB++ TGZ format.

TSV Analysis

TSVs were modeled as thermal and electrical pathways connecting the silicon die to the substrate. Simulations accounted for CTE mismatches, identifying localized stress concentrations at these interfaces.



4. RESULTS AND INSIGHTS

High-Stress Regions: Critical stress locations were identified in solder joints and TSVs, providing targets for design improvements.
Fatigue Life: Solder fatigue predictions highlighted cycles-to-failure estimates, guiding durability enhancements.

5. DESIGN IMPROVEMENTS

Design improvements focused on optimizing geometry and material selection to enhance both thermal and mechanical performance while minimizing failure risks. Stress concentrations in high-risk regions were effectively reduced, leading to improved reliability under thermal cycling conditions.

6. CONCLUSION

HeatSync's advanced simulation techniques, including the Darveaux Method and detailed thermal cycling analysis, delivered a validated 2.5D IC package design optimized for reliability and durability.

Contact HeatSync today to learn more about our advanced simulation-driven solutions for optimizing IC package reliability, addressing solder joint fatigue, delamination, and warpage through cutting-edge thermal cycling analysis.

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