CASE STUDY /

Ansys Sherlock for Predicting Thermal Stress Fatigue in Solder Balls – Continental Automotive

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The use of electronics is ever-increasing in automotive applications. New innovations such as active and passive safety systems, electric propulsion and semi and fully autonomous vehicles have all contributed to this increase. Automotive designers however must still adhere the same size and packaging constraints to ensure vehicle size and weight does not increase. Because of this, there has been a push to make electronic components and packages smaller, while increasing performance.

One example of a company facing these demands is Continental Automotive. Continental has seen increased use of Ball Grid Array (BGA) components and High Density Interconnect (HDI) FR4 boards in their Printed Circuit Board Assemblies (PBCA), where components are tightly placed on both sides of the PCB to ensure the most efficient use of board space. These changes have not been without their issues and Continental has noticed additional reliability issues in solder joints due to solder fatigue. Therefore the capability to predict these failures is critical, allowing Continental to avoid these failures with design changes.

Currently the ability to predict high cycle fatigue (vibration) solder and copper leads can be accomplished using Miner's Rule. However the ability to predict low cycle fatigue due to thermal cycle is required. Continental chose to overcome this obstacle by employing Ansys Sherlock to model their board and components. Sherlock's key advantage for this project was its ability to model and run multiple iterations quickly, minimize thermal cycle and shock validation tests, determine the largest contributor to stress/strain and allow for changes to layout.

/ Approach

To begin the Sherlock analysis, engineers at Continental imported a Zuken ODB++ file into Sherlock. Sherlock was able to quickly read all the information in this file and generate a representative board with complete stackup data, all components and mounting conditions with their location and material characteristics.
The board featured some mirrored BGA components, where the board had BGAs placed in the same location on both the top and bottom sides of the board. Both sides of the board also had conformal coating applied that Sherlock modeled using the available Potting functionality.

Sherlock effortlessly modeled individual components with a high level of detail, including modeling each solder ball on the BGA to ensure that even small solder fatigue failures would be captured. This was accomplished by using the built-in Package Manager which contains numerous common industry packages with instructions on how to best model them. For non-standard components, users could input those properties into the Package Manager and Sherlock would still be able to model them accurately as well as retain this information for future use.

Continental engineers defined the life cycle for the board which included vibration, temperature and shock loads. Engineers also defined the life cycle goals and acceptable failure rate and time. The board was modeled with both steady state conditions as well as cycling temperature from (-40)˚C to 127˚C.

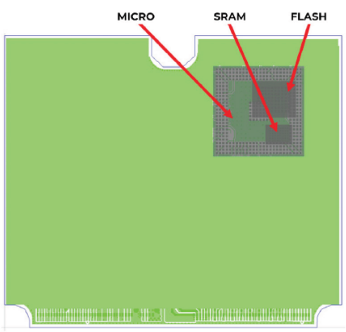

Figure 1. Board Layout - Micro (Top), SRAM & FLASH (Bottom).

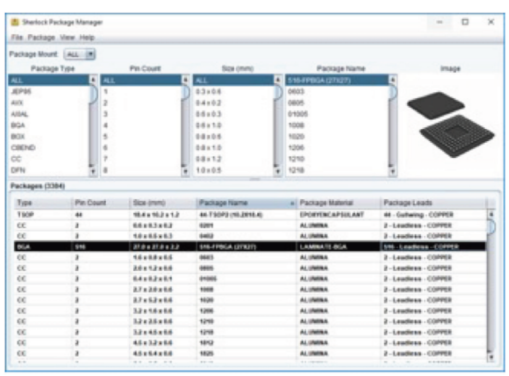

Figure 2. Sherlock Package Manager.

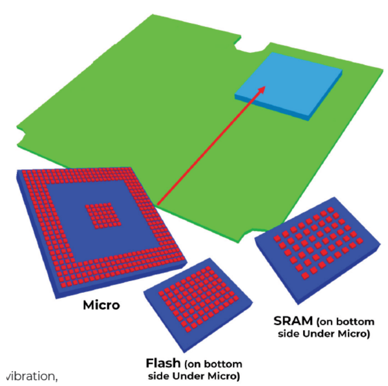

Figure 3. Detailed BGAs including Individual Modeling of Solder Balls.

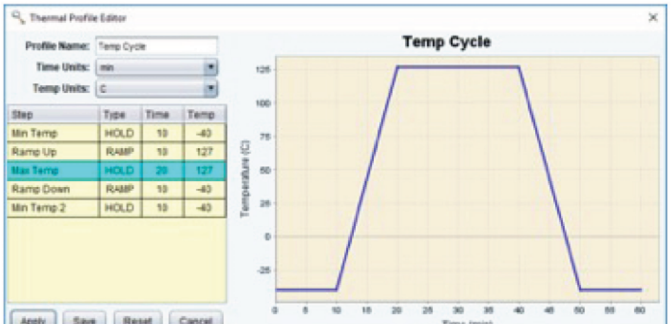

Figure 4. Temperature Cycle (-40)˚C to 127˚C.

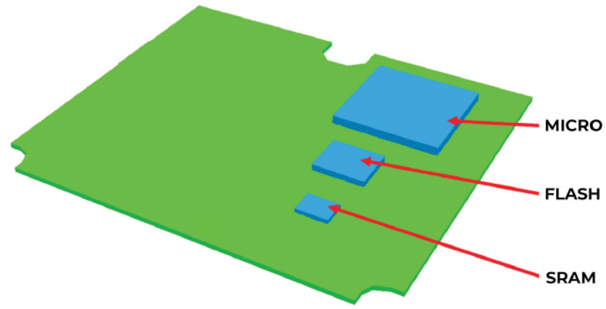

Figure 5. Modified Board with all BGAs on Top.

With the board, components, boundary and loading conditions defined, Sherlock analyzed the PCBA using thermal mechanical conditions. Once these results were obtained, the board was modified and remodeled to eliminate the mirrored BGAs. Instead the BGAs were moved so that they were all on the same side of the board. The thermal mechanical analysis was then rerun using the same conditions.

/ Key Findings

Using Sherlock, Continental identified the predicted life of the board when subjected to thermal cycling. The ability to model components with a high level of detail provided more accurate results. The initial results of the Sherlock analysis showed that:

- Having mirrored components does impact the predicted life of the board and results in a higher probability of failure when compared to an unmirrored board.
- Conformal coating can also increase probability of failure. However, a few different factors, such as component and location, can influence this effect. Engineers need further investigation to fully understand the effects of conformal coating as the coating, thickness and component coated may all have an effect on the final probability of failure.

/ Benefit: Why Ansys Sherlock was an Ideal Solution for Continental Automotive

Continental implemented Sherlock during the design validation phase to investigate the effects of mirrored components and conformal coating under low cycle fatigue (Thermal Cycle). Sherlock generated results in the form of PoF curves which allowed engineers to understand the predicted life of their PCBAs. These results were obtained in a much shorter time than traditionally possible if they were to build and test samples. Because Sherlock was used during the design stage, the engineers at Continental were able to use these results to modify their board for better design as well as identify areas that needed more investigation. Sherlock's ability to identify issues during early stages of development expedited the process of eliminating flawed designs and assisted in avoiding future complications.

To learn more about Ansys Sherlock, please visit

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or sign up for a Free Trial at

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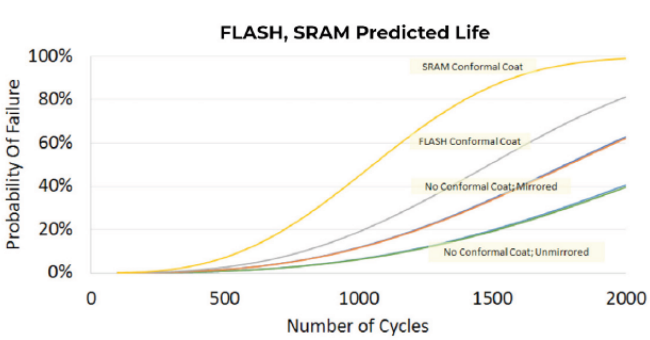

Figure 6. Thermal Mechanical Results.

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