CASE STUDY /

Investigating the Effect of Solder Geometry and Board Boundry Conditions on Solder Thermal Fatigue

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Thermal fatigue is a major source of solder failure in surface mount electronic components, particularly in industries with high reliability applications such as aerospace, automotive and defense. For a company such as Continental Automotive, that designs and manufactures printed circuit board assemblies (PCBA) for these industries, it is critically important to understand how different designs can affect solder failure. Each variable must be tested to determine what influence it has on solder fatigue and thus the reliability of the board.

Continental's objective was to identify solder geometries and boundary conditions that yielded the lowest probability of failure. The mounting conditions of the board were also varied to see what effect this would have on solder fatigue. Ansys Sherlock was chosen to model each of these scenarios for its ability to accurately generate representative models of complex geometry as well as provide predictions based on reliability physics.

/ Approach

Continental engineers imported their baseline model into Sherlock. This took the form of an ODB++ file that came from their ECAD designers. In a matter of seconds, Sherlock interpreted this data and built a detailed model of their PCBA. The data contained the stack-up layer in the PCBA and could be viewed individually as well as combined to see the overall properties of the board. Sherlock also populated all the data for each component on the board with the location, size and properties of each component. To ensure the highest level of accuracy, the component data was cross-checked with that of verified data in the Sherlock Parts Library, a repository of all known part information built for Continental by Ansys. With minimal effort from the engineers, a functional baseline board was built and ready for design studies and analysis.

The board was modeled using FR4 HDI (High Density Interconnect) under three different boundary conditions. Condition one was a free-standing board. Condition two was a board secured to a 5mm thick aluminum plate using TCA. The third condition was similar to the second but the area beneath the 1210 capacitors was void of any material between the board and the aluminum plate.

Each configuration was subjected to 1000 temperature cycles. The temperature cycle was created directly in Sherlock by defining a Life Cycle Condition. A user can input the thermal profile by specifying hold, ramp temperatures and time interactively.

Sherlock easily modeled different solder thicknesses by utilizing the Parts List. Here, the properties for every part are listed and can be modified or loaded in from a library. A Continental engineer edited the solder thickness directly in the Part-Card for each 1210 capacitor to represent each solder geometry.

Similarly, Sherlock made it easy to model the different mounting conditions through the Ansys Sherlock Layer Viewer. Continental

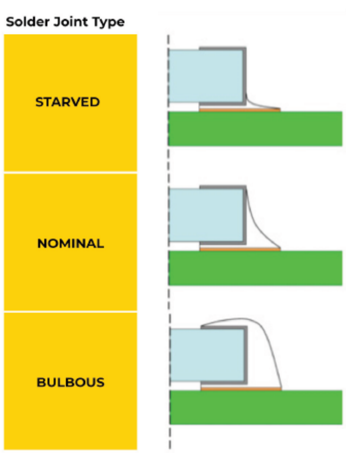

Figure 1. Different solder joint geometry modeled.

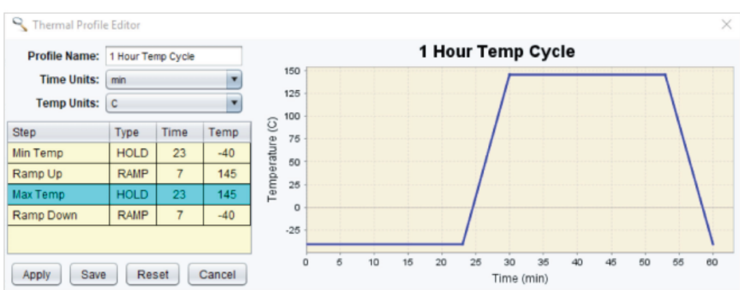

Figure 2. Temperature Cycle.

Automotive's engineers added a mount pad to the underside of the plate and material properties of the TCA layer to the Sherlock Material Manager ensuring that it was accurately represented and could be used again in future projects. The effect of the aluminum base plate was defined along with the mount pad as the chassis material in Sherlock. This step allowed continental engineers to skip physical modeling of the base plate while still retaining all its mechanical effects.

After successfully modeling the board under its various conditions, Continental defined its reliability goals and input them into the Life Cycle for the board.

/ Results

The results from the Solder Fatigue Analysis showed that the solder thickness had a significant effect on the probability of solder failure. It showed that the bulbous shape was almost three times less likely to fail when compared to the nominal shape. The starved solder shape was over three times more likely to fail.

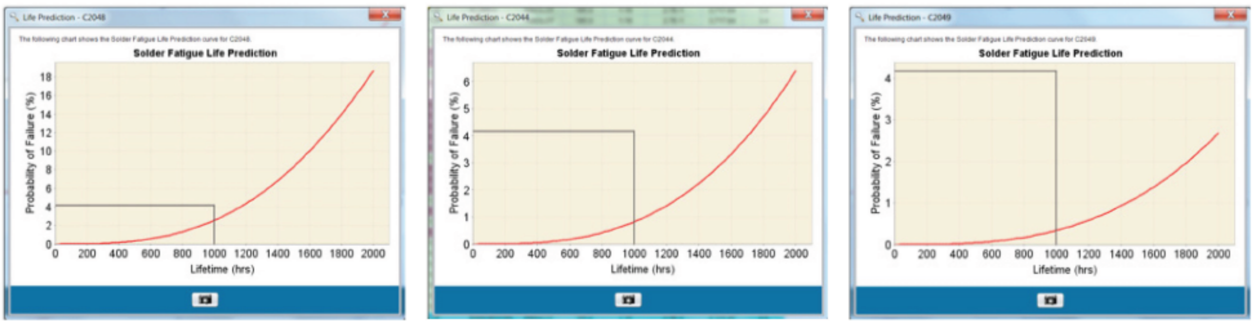

Figure 3. The Life Prediction of the starved, nominal and bulbous solder joints under 1210 Capacitor (left to right).

The results for the Thermo Mechanical Analysis investigating the effects of the board mounting conditions showed that when fully adhered to the aluminum base plate, the board was at a much greater risk of failing. The introduction of the void in the heatsink beneath the 1210 capacitors saw a drastic decrease in failure over 1000 hours. Both the partially and fully constrained boards still had a probability of failure higher than the unconstrained board. This indicates that the additional stiffness created by constraining the board is inducing higher strains when the board is subject to temperature cycling and therefore accelerating the failure within the 1210 solder joints.

/ Key Findings

Using Ansys Sherlock, Continental was able to identify the solder geometry and board boundary conditions that yielded the lowest probability of failure. Key findings included:

- The solder thickness under the component will determine its fatigue life, with the thicker solder having a lower probability of failure.
- When the board adheres to a baseplate with TCA material, the likelihood of failure drastically increases.
- The solder fatigue life improved with a pocket in the heatsink underneath the 1210 capacitors, indicating that the location on the board significantly impacted failure probability.

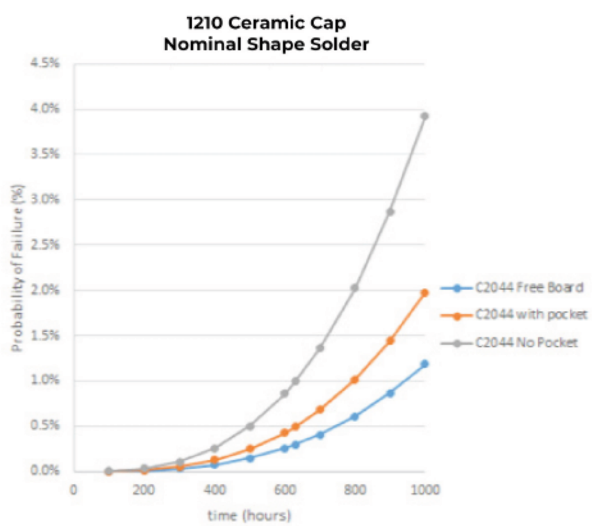

Figure 4. PoF of different mounting conditions of PCBA.

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

Continental used Ansys Sherlock during the Design of Experiments (DOE) phase to investigate the effects that shape, thickness and mounting conditions would have on their solder joint failure. With Sherlock, Continental obtained results within hours, rather than the weeks that would have been necessary if they had built and tested samples. This significantly saved time during product development by quickly eliminating unfeasible designs and allowing more time to optimize the final solution. With the failure prediction capabilities of Sherlock, Continental was able to identify not only how well their product would perform in the field, but also how reliable it would be over the course of its lifetime.

To learn more about Ansys Sherlock, please visit

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