Design of Experiment Analysis of the Lid of An Electronics Package Using Finite Element Analysis

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Abstract

A design of experiment analysis is reported on data from warpage simulations using finite element analysis of a lidded electronics package. Warpage in a lid of an optical electronics package can detrimentally affect the reliability of the package as well as its optical performance. The present study focuses on the variety of materials and designs of lids relevant to recent technologies in electronics packaging. The finite element analysis (FEA) formulation in this study accurately predicts deformation and warpage in the elastic region with optimal computational time achieved through a choice of boundary conditions and mesh sensitivity studies.

Although experimental methods provide more realistic measurements of the deformation/warpage, they may have constraints of expensive hardware, limitation over skills to operate, calibration accuracy, possibility to introduce human error. Similarly, finite element analysis method has the advantage of creating a prototype and solve under different loading conditions with less time but validation of the method is necessary and skills to operate software along with the cost to use this commercially available software. An analytical method has limitations for providing a suitable solution for all types and designs of the package. The analytical method also focuses more on estimating warpage on the mid plane of the package where as in simulation focus of the study can be associated with different components of the package. In this work, the results from FEA are compared to analytical calculations made using the classical laminate plate theory (CLPT) as well as the modified Suhir's theory. It is observed that FEA results are more accurate as they account for the performance of die attach/ under fill materials regardless of the small thickness of the layer. The FEA data is finally used to conduct a design of experiments (DOE) analysis to investigate the influence of three distinct designs and six material choices on warpage of a lid. The analysis indicates that there is no significant interaction between the two parameters expected to affect the warpage in the lid. Material properties of the lid are found to have a greater effect on the warpage of the lid as compared to variabilities introduced in lid designs in this study. The FEA simulations performed consider only material behavior within the elastic limit and in some situations, plastic deformation may occur which is more permanent and as such requires a more comprehensive analysis in the plastic region to enhance the data set for DOE studies.

This study mainly focuses on how warpage is affecting the lid deformation and techniques to characterize it. As discussed, FEA tool is used in this study to create a prototype which is similar to the actual product. The experiment is designed considering different variables such as the design of the lid and the material of the lid. Methods of the design of experiment analysis are applied to understand the correlation between these parameters. The most significant parameter in terms of the warpage deformation is addressed. Based on this study the appropriate design and material are suggested for the development of the lid over the package. This becomes helpful when there is an optoelectronic package undergoing thermomechanical loading; warpage may not only adversely affect solder joints but other parts of the package as well. So in this work, characterization of the lid of the package affected by warpage is the focus area. This study will be helpful for the development of the technologically advanced packages associated with optoelectronics.