Japan Institute of Electronics Packaging FY2005 Scientific Paper Award

Research Paper: Thermo-Viscoelastic Analysis for Warpage of Ball Grid Array Packages Taking into Consideration Chemical Shrinkage of Molding Compounds
Molding compounds for use with BGAs (HC-100XJAAMF, GE-100S5)
Semiconductor package residual stress analysis technology

═ Date of Award ═

May 26, 2005

═ Award Recipient ═

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═ Features of Award ═

Once a year, research papers from among those published in the Japan Institute of Electronics Packaging magazine that have been peer reviewed by specialists and others in the industry are nominated by the editorial board or through general nomination for selection by the selection committee before the board of directors selects one to receive the award.

═ Reason for Award and Outline of Award-Winning Item ═

The reason that the awardee was selected was that in addition to introducing chemical shrinkage to viscoelasticity analysis techniques and comparing analytical and experimental results and verifying the value and reliability of analysis techniques in analyzing the warpage of Ball Grid Array (BGA) packages, the research paper was considered outstanding from both an engineering and industrial perspective. Furthermore, it is hoped that this form of analysis will reveal predicted warpage and control indices for BGA packages at the time of reflow — something that was previously difficult — that can be reflected in future development and mounting of BGA packages.

Characteristics of the new method include the following:

1. Assuming a linear viscoelastic media, temperature-reliant data for the modulus of elasticity can be converted to frequency dispersion using the time-temperature superposition principle in place of the relaxation test data. The least squares method was applied to the frequency dispersion in order to calculate general Maxwell viscoelastic model constants.
2. Chemical shrinkage due to chemical reaction can be calculated from the amounts of measurable overall molding shrinkage and heat shrinkage. The amount of chemical shrinkage can, for the sake of convenience, be replaced by the amount of heat shrinkage and the coefficient code can be defined by inverting the degree of cooling and the degree of heating from the molding temperature.
3. It is also possible to calculate general Maxwell viscoelastic model constants using the macro commands in Microsoft Excel® and use the MARC® multipurpose finite element software in stress analysis, making it a comparatively simple method.

Using this technique it is possible to clarify the warpage phenomenon of BGA packages, which is difficult to control due to their asymmetrical structure, and the following two guidelines are helpful when seeking to reduce warpage.

Guideline 1. Molding compound Tg is raised to ≥200°C in order to decrease the thermal expansion mismatch between the substrate and the package at high temperature during the reflow process.

Guideline 2. The degree of elasticity of molding compound at ≥200°C is reduced in order to reduce the dynamic stress in the opposite direction to warpage that is usually seen during the reflow process.

As the temperature reliance of the modulus of elasticity is increased, especially under Guideline 2, it is possible to verify an increase in the viscoelastic (stress relaxation) effect and a decrease in warpage not only at reflow temperature, but also at room temperature. When compared with products from other companies, it was determined that it was possible to reduce warpage in products developed using this technology. Many companies have adopted the technology, including Intel Corporation.