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Impact of material models on immersion cooled electronics packages and reliability assessment for chip-package interaction

By

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Abstract

The immersion cooling for IT equipment has been around for decades. From thermal energy management perspective, immersion cooling is better than traditional cooling technology. However, there is need for more work in open literature when it comes to impact of immersion cooling on the reliability of IT equipment to make it commercially implemented. Detailed study of material compatibility of the various electronics packaging materials for immersion cooling is essential to understand their failure modes and reliability. The stiffness and thermal expansion are critical material properties for electronics mechanical design. This part of the study mainly focuses on two things. The first part studies the impact of thermal aging in dielectric fluid for single-phase immersion cooling on the low loss material printed circuit boards (PCB) thermo-mechanical properties. The weight of the PCB samples was measured intermittently to quantify absorption of the dielectric fluid into PCBs or leaching of the plasticizers from PCBs into the fluid. Second part studies the impact of thermal aging on thermo-mechanical properties of low-loss PCBs in the air. The low-loss PCBs, Megtron6 are aged in the mineral oil, and in the air at four different temperatures, 22°C, 50°C, 75°C, and 105°C for 720 hours. The complex modulus and coefficient of thermal expansion are characterized before and after aging for both part and compared.

Thermal interface materials (TIMs) are critical for the thermal management of electronic packages. Different kinds of TIMs are currently used in the industry to reduce the contact thermal resistance and improve performance of electronic systems. While designing electronic systems, attention is given to characterizing the performance of TIMs and understanding the reliability of the TIM materials under different environmental loading conditions. As the reliability study of TIMs is not a matured subject, there is a growing interest to understand the mechanical behavior of TIM materials and how they change under various environmental loading conditions. In this study, four commercially available TIMs are studied under high temperature storage and thermal cycling loading conditions. In the first part of the work, the change in the thermal expansion coefficient of a representative of the group due to high temperature storage test is studied using Thermomechanical Analyzer (TMA). For the second part of the work, an assembly was made to the test the performance of the TIM materials under thermal cycling conditions. Samples with different TIM thickness were prepared and tested in an environmental chamber. An inspection was performed visually and with the aid of microscope. The results and lessons learnt are presented. Chip package interaction (CPI) in combination with the ELK material presents novel challenges to reliability of electronics devices. As the geometric features gets smaller with advancing silicone technology nodes, the first level reliability presents more challenges. Multi-level sub-modeling approach is utilized to study the CPI reliability. Various approaches to evaluate fracture mechanics parameters numerically have been investigated and compare for chip-package interaction application. This study investigates effect of the metal densities, crack orientation; horizontal vs vertical, crack locations on the ELK/LK interface; LK/oxide interface on the chip package interaction reliability for BEOL stack.