Materials Science & Engineering Doctoral Defense

On Quantifying Electromigration Processes in Sn-0.7Cu Solder with Lab-Scale X-Ray Computed Microtomography

School for Engineering of Matter, Transport and Energy

James Mertens

Advisor: Nikhilesh Chawla

abstract

For decades, microelectronics manufacturing has been concerned with failures related to electromigration phenomena in conductors experiencing high current densities. The influence of interconnect microstructure on device failures related to electromigration in BGA and flip chip solder interconnects has become a significant interest with reduced individual solder interconnect volumes. A survey indicates that x-ray computed micro-tomography (μXCT) is an emerging, novel means for characterizing the microstructures' role in governing electromigration failures. This work details the design and construction of a lab-scale μXCT system to characterize electromigration in the Sn-0.7Cu lead-free solder system by leveraging *in situ* 3D imaging.

In order to enhance the attenuation contrast observed in multi-phase material systems, a modeling approach has been developed to predict settings for the controllable imaging parameters which yield relatively high detection rates over the range of x-ray energies for which maximum attenuation contrast is expected in the polychromatic x-ray imaging system. In order to develop this predictive tool, a model has been constructed for the Bremsstrahlung spectrum of an x-ray tube, and calculations for the detector's efficiency over the relevant range of x-ray energies have been made, and the product of emitted and detected spectra has been used to calculate the effective x-ray imaging spectrum.

The obtained results indicate the conception of a powerful means for the study of failure causing processes in solder systems used as interconnects in microelectronic packaging devices. These results include the volumetric quantification of parameters which are indicative of both electromigration tolerance of solders and the dominant mechanisms for atomic migration in response to current stressing. This work is aimed to further the community's understanding of failure-causing electromigration processes in industrially relevant material systems for microelectronic interconnect applications and to advance the capability of available characterization techniques for their interrogation.

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