Time 0 Void Evolution And Effect On Electromigration

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Nowadays, As the revolution of advanced packaging technic, such as 2.5D and 3D packaging. The electronic package has a shorter electrical path between different ICs and achieves more I/Os, in the meanwhile, the scale down of the package size led to a shrinkage of interconnect size and a significant increase in electrical current. This trend will result in higher current density and joule heating in the interconnections, which significantly enhance the Electromigration (EM) damage. In this regard, EM become a critical issue in the reliability of electronic packaging.

Solder and copper are two most common used conductor materials in a electronic package. Due to the material properties, solder is weaker than copper in EM perspective. In previous research, most of EM acceleration test for solder were performed at 150C and 104A/cm2 or higher, but, for copper, it was conducted at 350C and 107A/cm2 at least. In the meanwhile, time 0 void are easier induced and hard to avoid in solder joint during manufacturing process. This initial void have great impact on the EM, because EM failure will have the initial void and accelerated the void nucleation and grow process. There are rarely research shows relationship between time 0 void and EM.

In this report, both experiments and numerical were studied to investigate the time 0 void effect on EM in lead-free solder (SAC305) joint. We used X-ray to observed the time 0 void in the solder joint and then cross sectioned at the center of the void. Three void location on the substrate side were chosen, the first on is at the right corner near the current entrance site; the second one is at the left corner far away from the current entrance site, the last one is near the middle. The samples were placed in the oven chamber at ambient temperature 125C and stress at 12A. temperature and voltage was monitored in-situ to observe the change during the test. The tested sample pulled out and investigated the void and micro structure evolution per 50hrs. we found that void located at the corner near the current entrance site will significantly enhance the EM, Void will depleted the growth along the Cu-SAC interface; on the opposite, initial void will not change when a new void was formed on the current entrance corner, after that two voids would grow and merge together along the Cu-SAC interface; when the void near the middle, void would grow on both direction (left and right) along the Cu-SAC interface. Copper trace was depleted in all test cases. A Finite Element Analysis was performed based on the experiment. It shows that void at the corner will increase the current density and joule heating about 2 times than without void at the same time 0 void size. When the diameter of void larger than 20% of the open windows, the meat time to failure will significantly reduce not matter where the void located. Copper will be accumulated around the void to form CuSn. Overall, the simulation is well agreed with the experiment.