An Experimental Study of Creep-Fatigue for Sn-37Pb Solder in Flip Chip Bonding

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Flip chip bonding of a semiconductor chip to substrate with solder is a key technology for packaging. Thermal fatigue tests were carried out using Sn-37Pb and Sn-95Pb solder joints consisting in a flip chip bonding package were performed to examine the effect of encapsulation by a resin underfiller. The encapsulation had a significant effect of prolonging the thermal fatigue life of the joints and which led to the practical application of flip chip bonding using a glass epoxy circuit board.

Thermo-mechanical finite element analyses were carried out to study the effect of encapsulation on thermal fatigue life of the joints. The encapsulation lowered the strain amplitude of the joints by distributing the strain over a whole package and reduced the thermal strain by the bending effect of glass epoxy circuit board. Fatigue lives of the flip chip joints were roughly estimated from those of bulk solid bar solder specimens but the dimensions of solder and ratcheting effect should be taken into account for a more accurate estimation.

For an improved life prediction of solder joints, reversed torsion creep-fatigue tests were carried out using four strain waves. The linear damage rule, strain range partitioning method, frequency modified fatigue life and ductility exhaustion model were applied to the experimental data, but no methods accurately predicted the creep-fatigue life. A new method based on the strain rate ratio was developed and it predicted the creep-fatigue life within a factor of 4 scatter band.