Vitronics Soltec

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Voids in BGA solderjoints in mixed reflow technology

Introduction

When a BGA with tin-lead solderbumps is soldered in a lead-free reflow solderprocess, using a SAC alloy solderpaste; it is possible that the joints may contain globular voids.
Next the origin of the mechanism that will create these voids will be explained.

Joint alloy changes in mixed technology

The solder volume for a soldered BGA connection consists for about 80% of the original BGA solderbump and 20% of the applied solderpaste.
If the solderbump consists of SnPb37 solder and the paste of Sn3.8Ag0.7Cu, then the final alloy composition will be 69.5Sn29.6Pb0.76Ag0.14Cu.
This alloy will finally completely be molten at about 194°C and will solidify at 179°C, giving a melting range of about 15°C.

Note: If the relation solderbump/solderpaste would be 70%/30%, than the alloy composition would be 72.75Sn25.9Pb1.14Ag0.21Cu, shifting the alloy melting range to about 19°C.

This shows that the amount of paste in this case can have a great effect on the melting behaviour. In fact each joint will have the presence of more alloys, SnPbAg, SnPb, SnAgCu.

Joint formation

During the soldering process the solderbump from the BGA will start to melt at 183°C.
As this solder melts it will wet the solderparticles from the paste and the solderpad underneath. During this action the solder becomes less fluid, due to the dissolving paste particles that have originally a higher melting point at 217°C.
During this process it is possible that part of the flux in the solderpaste will be encapsulated if the wetting on the outside circle of the bump is faster than at the inside (encapsulated) area.

Flux encapsulation and void formation

Due to the fact that the solder will become less liquid or even pasty as it starts to wet the solder particles from the solderpaste, the encapsulated flux has no direct escape possibility due to the surrounding solder that starts to get pasty.

As the solder starts to melt at 183°C, most solvent from the flux in the solderpaste has already evaporated, so that in this case mainly high boiling flux particles will be encapsulated. These particles will, while heated by the surrounding solder, still evaporate. In fact this process extracts heat from the molten solder and will so also reduce the liquidity of the solder in the void area. This liquidity was already reduced due to the shifting alloy composition as the joint formation proceeds.

At the same time however the process temperature, which is normally set at about 235°C, is still rising. Finally all the paste particles will be dissolved in the solderbump during the joint formation.
Due to the heat extraction of the encapsulated evaporating flux parts, the liquidity of the solder will be marginal. This means that there is no easy way for the flux vapour to escape, although the solder alloy at the joint has now a melting point of about 194°C.

As a result 'globular' voids in the final solderjoints might be present after the joint is solidified. These voids can have a various volume. Values up to 16% of the total joint volume have been measured from cross sections. Often also irregular void shapes can be found in the joint. These are normally the result of the 4% volume reduction during the solidification of the solder.

Conclusion

This void formation is finally a result of the mixed reflow technology process.
If this effect is inadmissible one should refrain from this mixed reflow technology.
The normal 4% shrinkage voids can however not been avoided.