Vitronics Soltec

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Lean joints at wave soldered chip components

Information Sheet 112

Introduction

On wave soldered multilayer boards lean solder joints were found at some chip components such as resistors and capacitors.
It came out that the components were those lean joints were found were mounted at solderpads that contained a via hole. This via hole was near or at the position at which the component connection was present.
Especially on such positions different amounts of solder can be found after the wave soldering process. Some joints look very lean, while other joints show a more common massive fillet.
The question is how these differences can be explained.

Explication

A via hole in a multilayer board is connected to one ore more internal layers. This means that the thermal behaviour of such a joint depends also on the amount of internal connections.
If a board is soldered in a wave soldering process the temperature inside the board is not the same at every position. The thermal conductivity of the copper metallisation and the solder is very good, while this is rather poor for the surrounding epoxy glass material.
These aspects cause the differences in temperature at different positions of the board when it is in the wave.
As a result of that some joints (via's) might be filled with solder almost immediately when the board enters the wave, while other joints are heated up more slowly and as a result might be filled with solder when the board is further in the wave. Some of these via holes might even not be completely filled as the board separates from the wave.

Retarded heatflow

Depending on the mass of the joint area one can expect even a retarded heatflow after the board just was separated from the wave.
This retarded heatflow can be explained by the fact that the solder that is left on the joint will still heat the joint area as it starts to cool down. This is due to the effect that the solder at the solderside has at this stage still a higher temperature than the solder that is already in the joint. So part of the cooling energy from the solder is emitted to the joint area and can bring that area over 183°C. As long as the tin-lead solder has a temperature above 183°C the solder will be liquid and capillary forces can still act on the solder in the joint.

If the joint was not completely filled with solder just after the board did leave the wave, this process of retarded heatflow might just bring sufficient energy inside the via hole, so that it will be able to wick up the solder from the joint as the solder is still liquid at that stage. As no new solder is available since the board has left the wave, this solder is stolen from the original connection, leaving a lean joint.

This whole process is depending of the balance of thermal energy during the wave soldering process on that specific point. A small change can already give another joint appearance e.g. a joint that contains the right amount of solder.

In every wave soldering process such small changes can take place, depending on flux behaviour, solder drainage conditions during separation from the wave etc. That is why the process is often less repeatable as can be expected for standard joints.
With the process itself there is however nothing wrong. It might be that a small increase in dwelltime would give an improvement on this aspect. However one must be careful that this longer dwelltime might also create a risk of re-reflow for the joints at the reflowed components on the topside of the board.
To avoid this wicking process that causes these lean joints the design should be made so that these via's will not be a part of the joint with the chip component anymore.
Another reason that can some times be held responsible for the removal of the solder from such joints can be barrel cracking.

Barrel cracking

If during soldering the thermal expansion force on the copperbarrel exceeds the strength of that barrel; it might form a crack. Via this crack volatiles embedded in the epoxy base material will evaporate via the liquid solder that is inside the via hole. These escaping volatiles may blow the solder from the joint surface at the point where the board leaves the solderwave.
If this mechanism can be held responsible can however only be proved after a cross section of that hole has been made.

Skipped joints

A skipped joint is not touched by the solderwave. This will cause a non-soldered joint but not a lean joint since it does not contain any solder.

Conclusion

Unless the design is changed it is almost impossible to avoid this variable wicking mechanism when vias are involved in the connection.
In general it is not recommended to use via holes in combination with a solderpad that is part of a joint, unless the joint area is separated from the via in a way that the connection will not be affected by the via during the solderprocess.

Sometimes joints may look very lean but mostly they show perfect wetting, although it seems that all solder from the joint is wicked up into the via hole.
If such a lean joint is allowed or not depends on the quality requirements that are often related to the application of the product.
One should however also keep in mind that the joint gets also its strength from the metalized component part that is in direct contact with the solderpad. This parallel capillary is also filled with solder and provides a good electrical and mechanical joint. The solder in that gap can not be stolen since the capillary force that keeps the solder in that gap is stronger than the wicking force of the via hole.