Vitronics Soltec

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Spikes and flags on solderjoints

Information Sheet 088

Introduction

There are cases that after soldering one finds excess solder on joints or joint leads in the form of solderspikes. These spikes can have the same direction as the lead, or they make an angle. Such angled spikes are usually called flags.
This document will explain the reason for spike or flag formation and the remedies that can be taken.

The formation of spikes and flags on solderjoints

A spike or flag can be formed when during the solder separation process too much solder oxides are present on the soldersurface.
If liquid solder is covered with an oxide skin, the surface tension of the solder is not able to give the solder on the joint its ideal shape. This is due to the fact that the solder is encapsulated in an oxide envelope.

When the solder separates between solderwave and joint surface, the solder has a tendency to hold on the joint, due to the capillary forces, while at the same time the solder will drain back to the wave. The cohesive forces in the separating liquid will make the connecting 'liquid column' between the joint and the wave thinner as the board departs from the wave. At a certain distance the thin solder column will break due to the fact that the separation force exceeds the tensile strength of the thin liquid solder column.
During this process the 'liquid column' between the joint and the wave changes from 'massive' to 'zero', so that the liquid column gets a 'diabolo' shape. In that shape the column finally breaks and the wave and joint are separated.

The 'half diabolo' solder column that remains on the joint (lead) will normally melt back to the joint, so that finally no remains of this separating process will be found. However this melting back process will only take place properly when the solder is still liquid and has a high surface tension. Therefore it is necessary that the solder is clean and not covered with an oxide film. Because an oxide film will keep the solder at the position and shape it gets during the separation from the wave. The oxide film acts as a strong hull that makes the solder inside this hull immobile, even when it is still molten.
That is why the solder joints get spikes. And when there is a horizontal force component during this separation process, this spike gets a flag shape.

Reducing or avoiding these effects

To avoid these effects it is important that the solder separates in a 'clean' environment, where no excess oxide formation can take place.
This is where flux has to fulfil a job. But then there should be flux available and that flux should still be active enough to create a reducing atmosphere at the solder separation area.
If there is lack of flux, or if the flux is already spent at this phase of the process, then the normal oxide formation on the liquid solder that always takes place, can not be reduced sufficiently.

It is therefore important that a flux is used that fits with the process, one that has a sufficient 'tail' activity.
One should also be aware that this remaining flux in this phase of the process will only be present on the board surface. It is not available anymore on the solder joints, because these are covered with solder.
If there is scarcely space in-between the soldered joints, then there could be not sufficient flux available to do this job properly.

Design and process optimization

Now one knows the mechanism, one can try to optimize the process conditions. To prevent flux exhaustion, one should try to keep the total solder dwell time as short as possible e.g. increase the solder separation speed. Also the soldertemperature should be reduced as much as possible. These measures will prevent flux exhaustion, while a lower solder temperature will also reduce the oxide formation on the liquid solder.

What also will help is to reduce the protruding lead length on the solder side, because longer leads are not only longer in contact with the solder, but also the flux on the board will be at a greater distance at the final solder separation point. The further this separation point is away from the board surface, the more difficult it will be for the flux on the board to explore its activity at the separation point.

The oxidation of the liquid solder can also be reduced with the application of nitrogen. Since that is not always a practical solution, one should first take the measurements as discussed in this document.

Note: In most cases (small) solderspikes are just an effect and not a defect. However they should be avoided when possible.