Vitronics Soltec

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The origin of solderbridging in dip and wave soldering

Introduction

During machine soldering all parts to be soldered must come in contact with molten solder for a sufficient time to make reliable joints.
However, also the parts in-between the joints to be soldered are in most common solderprocesses in contact with the molten solder during the soldering operation. In that phase of the solderprocess solderbridging is a normal part of the process. It is during separation between the soldersource and the soldered joints, that we want to get rid of this unwanted solderbridging.
Next we will explain why solderbridges may, or will be present on a soldered PCB, and what can be done to avoid them.

Joint formation

Soldered joints are formed due to capillary forces acting on the joints during the wetting action of the solder on the metal parts to be connected.
This will only work well, when the solderability, both for the metal surfaces and the thermal solderability which is part of the design, are sufficient to provide good wettability within the allowable process settings for time and temperature.

The capillary forces that keep the solder on the joints, is also one of the reasons that the solder may be left in-between the soldered joints. But here also other factors are involved, such as the effectiveness of the flux and the solder drainage conditions during the separation of the soldered parts from the solder source.

Difference between dip and wave soldering

In dip soldering where the PCB is vertically lifted from the solderbath, the solderseparation behaviour is affected by the length of the row of connections with the same pitch. During separation the solder will 'jump' stepwise from the sides of such a row towards the middle section. The speed of this separation is very much depending on the length of the row of joints and is therefore more or less uncontrolled. Due to this uncontrolled behaviour the reproducibility and the soldering results may be different between the same PCBs, resulting in possible solderbridging.

In wave soldering such joints, the same effect may occur, when they are positioned perpendicular to the transport direction. However, when such joints are positioned in the transport direction, the 7° drainage angle will improve the drainage conditions, giving a more uniform and better reproducible process, in general resulting in less solderbridging compared to dip soldering. In most cases the result of wave soldering will therefore be better than the dip soldering results, especially on critical layouts.

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How to prevent bridge formation

To improve the solderdrainage conditions in general, we must improve the layout. The main reason why solder is left in-between joints is in the first place the capillary behaviour of the solder between the joints. The magnitude of this force is related to the capillary spaces which are depending on the distances between the parts which are joined. If the space between the joints is increased, the capillary forces will become lower. The same will happen if the protruding lead length on the solderside will be shortened.
By reducing the solderpad size and the lead protruding length, the solder has less tendency to stay in-between the joints and so solderbridging will be reduced or avoided.

The effect of lack of flux activity on solderbridging

So far we have not taken into account the effect of lack of flux activity during the solder drainage state.
If the flux has insufficient activity at the point where the solder should separate from in-between the joints, that solder will be covered with an oxide layer, which holds the solder like a bag.
Due to this oxide skin the embedded solder is not completely free in its movements, which hampers a smooth solder drainage and so create solderbridging.

Due to insufficient flux activity at the point where the PCB is leaving the solder wave, also solder webbing can sometimes be found on the PCB. This solder webbing is caused by solder oxides which adhere to the solderresist. On these oxide particles also solder residues may adhere.

Solderbridging by intermetallic crystals

Another source for solderbridging may be found in the contamination of a solderpot by insoluble intermetallics, such as Cu_6Sn_5 copper-tin crystals. These needle like crystals may be kept fixed or entrapped in-between joints if they are floating in the solder.

These intermetallics may be formed when too much copper is dissolved into the solderpot. This copper will dissolve during the contact between the liquid solder in the wave and the copper parts on the joint area, such as leads and pads. The amount of copper which can completely be dissolved in the bath is depending on the tin content and the bath temperature. The amount of copper that comes above the solubility level will precipitate out in the solder as copper-tin crystals with a needle like shape and a length up to several millimetres.

This precipitation starts at so called 'cold spots' in the solderpot. This are areas in the solderpot where the solder does not take so much part of the normal solderflow from wave to pump. These are also often the places where these intermetallic crystals are concentrated. When the flowing solder in the pot is passing such spots, the solderflow may pickup these intermetallics and deposit them onto the soldered PCB.

The appearance of such intermetallic also depends on the solderpot temperature and the refreshing rate of the solder. At lower temperatures and a high solder consumption the problem will be less prominent.

If the problem shows up, often a regular removal of the intermetallic lumps from the corners of the solderpot will eliminate it. It is therefore not necessary to refresh the whole content of the solderpot.

After the removal of the contaminated lumps, scoop the contaminated solder with a perforated ladle from the solderpot at a temperature just above the melting point of the solder. Top up the pot with fresh solder to the desired level.