Vitronics Soltec

Information Sheet 121

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The origin of solderball formation in wave soldering

Introduction

In most articles about solderballs found after wave soldering escaping vapours are brought up as the main cause for solderball formation.
In general this is true, but it will not explain the small solderballs that can often be found in-between the leads of wave soldered connectors or SO-component leads. These are often positioned with an amazing regularity. In fact the physical mechanism behind the solder separation process is responsible for the formation of this specific solderball pattern.

Formation of solderballs during separation from the solderwave

The formation of solderballs in wave soldering can not be avoided since this is part of the process of solder separation.
The liquid solder bridges all joints when the board is in the solderwave.
When the board separates from the wave all solder in-between the joints and between the wave and the leads must separate.

This separation process is like water behaves at a tap that is closing.

Figure 1

At first one see the massive liquid column that flows from the tap.

During closing the tap, this column becomes thinner and thinner.

At a certain point during closing one will see that the lower part of this column is separating into a string of single droplets. That is how a thinning freely moving liquid flow will behave.

It finally will find its optimal physical equilibrium by separating into single droplets. See Figure 1.

Figure 1 shows the behaviour of a very thin water flow form a tap. At some distance from the tap the flow separates into single droplets. Normally this can not be seen, because it is a rather fast process. This picture is made with a shutter time of 1/1600 s, so that the actual flow is 'freezed'. Although the single droplets are hard to follow by the eye, in the sink one can clearly hear the rhythm of the ticking droplets.

During separation of the solder, the surface tension will reduce the liquid surface area for a given liquid volume. This will cause the solder to withdraw from the space between joints in all directions, both horizontally and vertically. Although this seems a very uncontrolled process, as it occurs with a relatively high speed, it still obeys the physical laws.

The analogy with the separating solder from the joints is that the liquid solder behaves also like water. When the separation is almost completed the thin solder column that exists on that moment, between the joints on the board and also between the wave and the lead, will end up in one or more single droplets. Normally one will not find traces of that process, unless the solder has a tendency to adhere to the solderresist. In that case often a specific pattern of solderballs in-

between joints can be found. Especially in closely spaced solderjoints such as between SO-component leads one can find these small balls sometimes with a mathematical regularity.

Now the solderball formation is explained, but why are they found on the board?

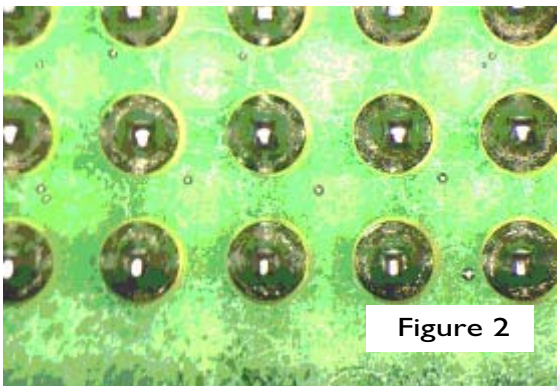
Figure 2

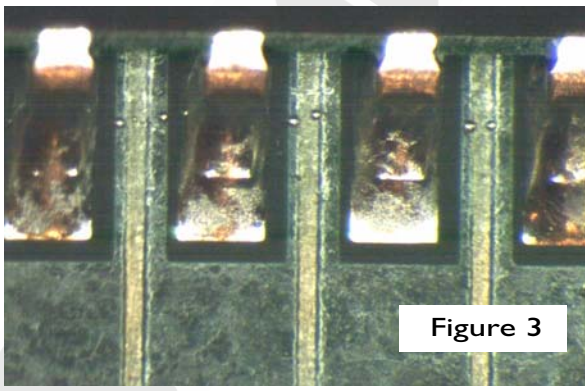
Figure 3

Figure 2 and 3 show the solderballs that remain on the board after soldering a connector (Figure 2) and a SO-IC (Figure 3). In Figure 3 one can see in-between the leads two small solderballs just beside the leads.

Note: The electrical clearance is not jeopardized by these tiny solderballs.

Adhesion of solderballs

The fact that solderballs are found on the board surface is only due to the adhesion of the solder to the solderresist in combination with the flux residues. Refraining from solderresist will in general eliminate the problem of solderball adhesion, but that is not always a viable option. A good combination of solderresist and flux can also prevent this adhesion.

Since the weakening of the solderresist during soldering might have an effect on this solderball adhesion. It is sometimes possible to reduce this adhesion effect by optimising the machine settings. In general however this problem can only be solved well by using the right selection of the materials.
Prevention is always better than trying to find a solution in the solderprocess settings.

Remark

For more in depth information about the physics that affect solder separation during solder drainage see Soldering in Electronics S.E. by R. J. Klein Wassink chapter 2.2.