Vitronics Soltec

By G. Schouten

Solderballs in wave soldering

See also INFORMATION SHEET 033

Introduction

During wave soldering, small solder balls can be formed. These balls appear mostly on the solder side of the printed circuit board, but can sometimes also be found on the component side. The risk of the formation of solder balls seems to increase with the increasing package density, especially when SMD's are mounted at the solder side. Just in that case they are the least desirable. We will discuss the reasons for the appearance of solder balls and methods to prevent solder ball formation.

Mechanisms of solderball formation

General

Solderballs are formed due to outgassing of volatiles on/or in the board material. The exposed gasses can have such high velocities that, at the interface between these escaping gasses and the liquid solder, solder- particles will be blown away. Solder balls can also be formed if the solder ruptures from the board at the wave exit, in combination with a very clean solder wave with inert gas wave soldering. Apart from the formation of solder balls there is the problem of adhesion to the board. In conventional soldering they adhere mostly on flux residues, while with inert gas soldering the weakened solder resist surface causes adhesion.

Causes in conventional wave soldering

1. Volatiles can come from the printed circuit board base material. In general these volatiles which will be emitted during soldering, will only cause solder balls in case of bad hole metallisation. Due to cracks in the metallized hole wall, these vapours can escape creating solder balls and craters (blowholes). In this case the solder balls can be found on both sides of the board.
   Another cause for solder balls on the component side can be found if the wave pressure is so high, e.g. due to bending of the board, that the solder temporally fill non-plated through holes. The vapours emitted from the hole walls will divide the penetrating solder column and small solder balls will be blown to the upper board surface.

In both cases, the effect can be minimised by preheating of the board at 105°C for several hours, just prior to component mounting and soldering. This is however not necessary if through metallized holes are of good quality.

2. Another cause for outgassing and thus vapour exposition, is also related to the printed circuit board and lies in the solder resist. If the solder resist components are not fully cured during the board- fabrication, they can emit vapours during the soldering process. These vapours escape at the solder side of the board. If the board has sufficient component holes, most of these vapours can escape via these holes and will not create solder balls. However, if the vapour is encapsulated between the board and the solder, solder balls will be formed as the board exits from the wave.

Information Sheet 013

Another effect of this vapour formation is that the adhesion of the flux on the board becomes very bad, so that most - or all - flux is washed off by the solder wave, causing solder bridging and/or solder webbing.

Certain types of solder resist are applied in a relative thick layer with sharp aperture boundaries. This can cause flux entrapment in the aperture edges. The outgassing of this entrapped flux can give solder ball formation.

3. A third main cause for solder ball formation finds its origin in the behaviour of the flux.

- The flux can be entrapped e.g. underneath SMD components.
- The flux solvent can attack or weaken the solder resist surface from which, in that case, vapours will be emitted.
- If the flux is not sufficiently pre-dried, the flux solvent will evaporate in the solder wave, creating a lot of vapour. This can also be the case if the flux is applied in a thick layer.

4. A special case of flux entrapment will take place if grid patterns are soldered. The flux inside the grid is totally encapsulated by the surrounding solder. During contact with the solder wave this flux cannot escape. The cooling effect of the evaporating flux creates a film of solidifying solder over the grid. As the board exits the wave, the vapour pressure sinks very rapidly, because the board temperature drops. The solidifying film of solder now implodes to the board surface. In most cases, the latent heat on the board surface, together with the present flux, will transform the imploded solder splash into a solder ball.

Causes with inert gas wave soldering

A special case is the solder ball formation in inert gas wave soldering. Almost no flux is used in these processes but a lot of solder balls can sometimes show up. The reason for this may be one of those phenomena already mentioned before, but the solder drainage at the board exit from the wave gives in this case a special effect. Due to the clean wave and the relative high surface tension of the solder, the ruptured solder from the board will give a splash reaction on the wave surface.
The surface behaves like a water surface on which a water droplet falls. A lot of small drop-lets are generated in a vertical motion as a reaction from the collision between droplet and liquid surface. In the solder wave the same reaction takes place. Since the wave is not covered by flux or oxide there is no damping force present, therefore the solder balls will hit the board and may adhere to it.