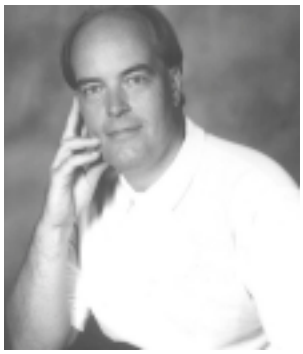
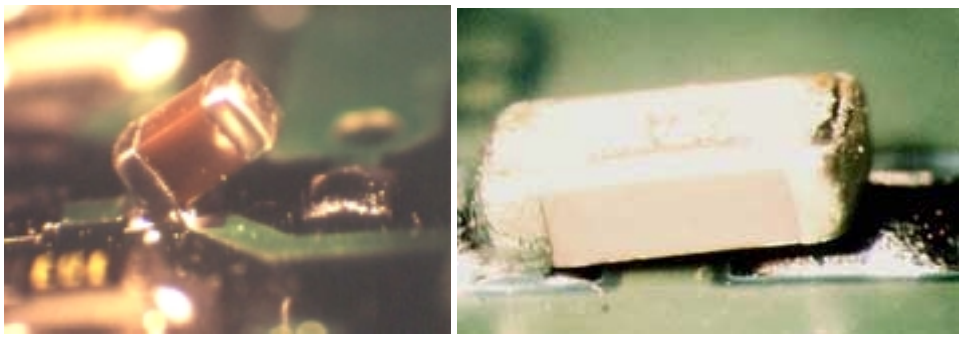
Causes and Cures of Tombstone Chip Components



First let us define what a tombstone is, or is it a Manhattan skyline, a crocodile, leaning tower, space rocket or one of the other terms used over the years to define this defect. A chip component which has partially or completely lifted off one end of the surface of the pad is referred to as a tombstone.

There are many reasons for tombstoning of chip components some of which are listed below:

Solderability variations on terminations
Different volume of paste
Different surface area of pad
Variations in thermal demand of pads
Solder mask thickness
Paste under parts
Limited placement force
Nitrogen usage



To obtain an understanding on how this problem can occur it is useful to watch the reflow process happen. A small board can be printed, placed and reflowed on a hot plate or under a rework station simulating the conditions of the reflow process. If you are lucky you will see the component lift.

As components get smaller the surface of the wettable area of the parts becomes significant and can develop high surface tension forces during reflow. The lifting of parts is becoming more of a problem as we continue to miniaturise products. Now let's look at the causes of lifting:

Incorrect Pad Design

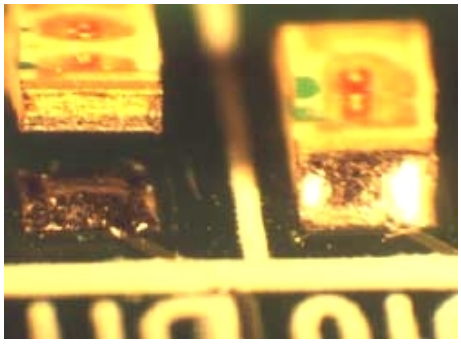
Ideally with reflow soldering the pads are designed so that the termination is positioned equally in the x & y so that during soldering the forces are fairly equal. If the termination surface is not positioned centrally on the solder paste deposit and pad there will be a tendency to pull the part in the direction of the highest energy promoting lift. When any movement occurs it is difficult to stop and often results in an open connection at one chip junction hence the lifting action.

Solderability of terminations

solderability of terminations on chip parts has been found to vary when subjected to testing. Either due to the original plating technique or the application of the final protective coating there can be variations on the solderability and hence the wetting forces acting on each pad.

If the solderability of the terminals is poor on one side the termination wetting forces will draw the part to the centre of the pad where the forces are balanced before the other termination wets. This all occurs in a couple of seconds and can be the cause of lift. Even if the lift is subtle there will be satisfactory wetting on one surface and none on the lifted termination even on the base.

In the case of a chip resistor most of the wetting force occurs on the base, then the end which tends to start the lifting action.



Different volume of paste

It is interesting to see that even when the copper pad surface is equal when paste volumes are different this can affect the point of reflow. If the deposit on one pad is smaller than the other it will reflow first and also wet the termination first.

This is an interesting phenomena which has been seen during process trials on BGA and uBGA. There are some differences in volume on very small apertures. The small volume will always reflow first.

Different surface area of pad
Variations in thermal demand of pads

It is important, for a number of reasons, to maintain equal pad sizes and track interconnections on each termination of a device. During reflow it is common for terminations not to reflow at exactly the same time. If there is a difference in the surface area of copper connected to the termination this may affect the wetting speed and increase the wetting forces applied to one side of a chip component. This will increase the possibility of lifting.

Solder mask thickness

A further area to examine is the resist or solder mask thickness on the surface of the board which can vary. Components have been found to rock on the surface of the solder mask between the pads. This can also be exaggerated where a copper track runs under the body of the parts.

I recall seeing this on vapour phase systems during reflow of 0805 chip resistors.

Paste under parts

If solder paste is allowed to slump under parts, or be forced under the chip body during placement, it can develop an upward force during reflow. All the individual particles of the paste reach reflow temperature and try to join together. As they combine the size of the group particles can lift the part. If it does not it often seeps out the side of the chip and is seen as a solder bead. An example of this lifting defect can be seen in the last issue of IPC 610 not the updated issue released in January 2000. Its a great photo, it was taken by the author. It is so good it was taken out of the current issue of the standard ?

Limited placement force

When any component is placed into the solder paste on the pad surface it should slightly break the surface of the paste which improves the termination wetting when part solderability may be marginal. It also overcomes any effect in paste dry out in warm production areas or where delays have occurred.

The parts should not be forced right into the paste as this can lead to solder shorts and an increase in solder beading after reflow.

Nitrogen Usage

The use of nitrogen during reflow is relatively limited in the industry although it does have its benefits. People have seen a far higher incidence of part float or lifting in nitrogen as opposed to air. The nitrogen does not cause the problem, it simply enhances the wetting forces and the part lifting.

Normally all the benefits of nitrogen soldering can be obtained in terms of wetting around 600-800 ppm. If the process is running at 50-100 ppm try saving money and reducing chip lift.

The best references to lifting and movement of chips is contained in a section of "Soldering in Electronics" by Klein Wassink,, or there is a technical report produced by Murata, the passive component manufacturer. They even produced a video on the subject to demonstrate the issues involved.

Bob Willis is a process engineer providing engineering support in conventional and surface mount assembly processes. He runs production lines for suppliers at exhibitions and also provides seminar and workshops world wide. Bob has one of the largest collection of training videos, interactive CD-ROMs and training material in the industry. Bob will be presenting four Master Classes at APEX in California, he will also be presenting classes at SMT Nuremberg in Germany for those engineers visiting the show. For further information on how Bob may be able to support your staff contact him via his web site **www.bobwillis.co.uk**