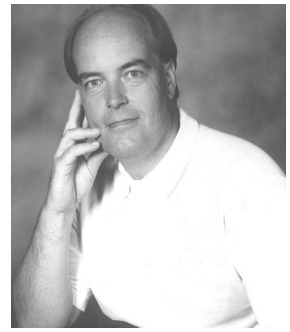
Lead-Free Components Problems - A Need for Change



Bob Willis

With the impending move to lead-free production there are really two main component issues that engineers must address as quickly as possible. These are the temperature requirements of processing lead-free solder alloys and the termination finishes used as alternatives to tin/lead. New design are being conceived every week and design engineers must consider component temperature requirements for all future design, now. They need to ask suppliers about process limitations at the same time as questioning the components electrical parameters. If not they need to pass on the specific requirements in a specification to purchasing staff as often the purchasing department are the main interface with component producers or distributors.

The most commonly adopted alternative solder alloy is Tin/Silver/Copper, Sn/Au/Cu which has a higher liquidus temperature of around 217 deg C as opposed to tin-lead at 183degC. This will probably equate to a reflow temperature on most convection processes of between 240-245 degC and 230 or 240 degC with vapour phase reflow. There are lower temperature alternatives available like tin/silver/bismuth, tin/zinc and tin/bismuth, some of which were initially adopted in Japan due to component peak temperature limitations. Tin/silver/copper will be the choice for the vast majority of users, with moves to this alloy in Japan when component compatibility issues are overcome.

There are temperature guidelines available in the industry for components from IPC, IEC and JEDEC, but very few people consider these on existing or future designs. Most suppliers have well documented component specifications which should be reviewed. Many companies use alternative suppliers for parts, some of which do not meet current temperature limits and are unlikely to meet future lead-free requirements. The move to lead free will hopefully focus attention on what is the component’s maximum rated temperature and hopefully, where alternatives are used both design and purchasing staff will ask the right questions of the supplier. Generally this question is not asked and design and development staff very rarely specify it to purchasing departments.

Don’t just think electronic components are an issue there are also the interconnections and mechanical parts that need to be considered. Wire insulation on cables and IDC’s that need to be soldered in position what are the temperature specifications of connectors and connector housings on the topside of the board. In some cases the plastic used to form the parts does meet specification but still the pin and sockets can move in the plastic leading to misalignment.

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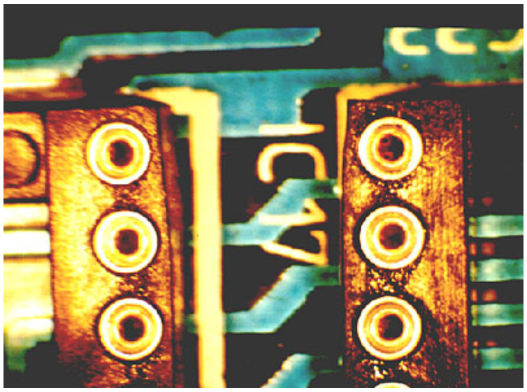
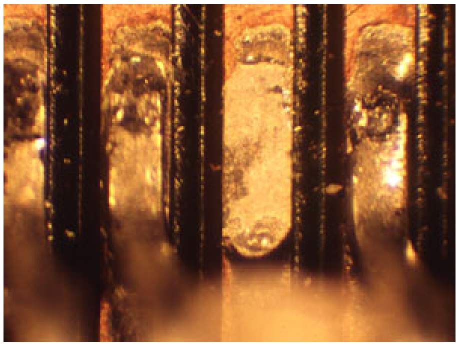


Example of an IC socket on topside of the board distorted by the topside board temperature during wave soldering

Concerns have been shown on the use of tin/lead terminations in combination with lead-free solder alloys. The issue is related to initial lead contamination at the interface of the joint leading to a lowering of the temperature of the alloy at the intermetallic interface. This can cause a premature weakening or failure of the joint during production and during temperature cycling. Lead contamination at the interface of surface mount joints can increase the possibility of the termination lifting during wave soldering. If solder joints reach a temperature over 160 degC below leads on the topside of the board lifting can occur. This is more likely on large reflow components as the board warps the component and board flex against each other applying force on the pins. It's a similar problem which has happened in the past with any large component on the topside of the board with tin/lead referred to a secondary reflow and most dramatically seen on large BGAs. If the solder does go into a semi-liquid state and component terminations lift it is normally associated with too higher preheat, wave solder temperature, too long a contact time or seen in fully inerted wave soldering systems where the enclosed chamber temperature affects the process.



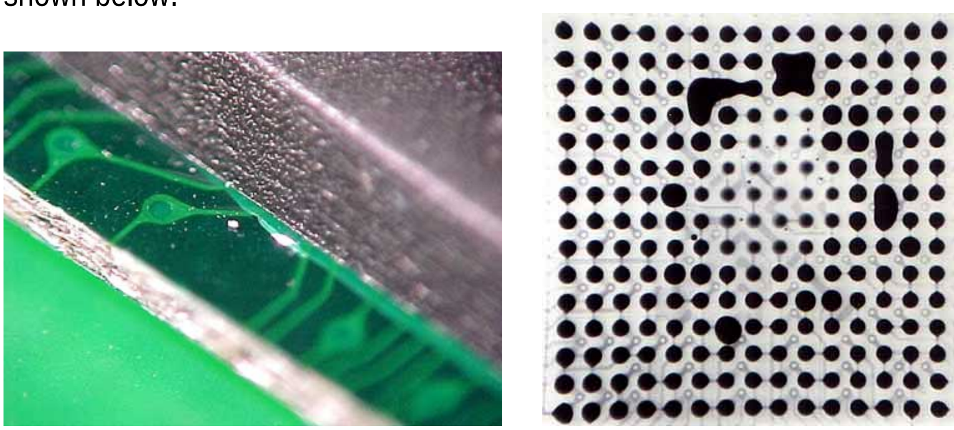
Example of lifted/intermittent leads on QFP after wave soldering

Any lead in the plated finish will render the joint not lead-free and in the case of wave soldering slowly contaminate the solder bath. The bath contains between 300 - 400kg of solder which will cost between £9-12 per kg depending on the alloy choice. This is approximately three times the price of tin/lead bar. Though hole parts still account for a significant number of terminations soldered in our industry and will continue to do so.

Electrolytic capacitors are probably one of the most susceptible parts to damage. Overheating the electrolyte inside the component can lead to expansion of the body and pressure on end caps or pressure relief areas. This can cause package deformation or in the worst case, complete destruction on reflow parts. Although not specifically related to lead-free processes there have been reports of through hole capacitors with questionable origins having the same problems due to unstable electrolytes.

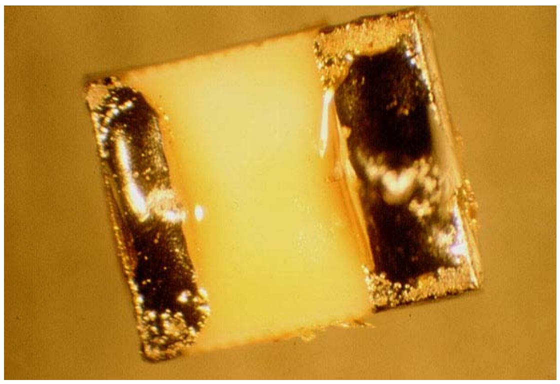
Example of damage during an National Physical laboratory (NPL) Lead-free project. The case and the base are significantly distorted during simulated reflow. A report is available at www.npl.co.uk/ei

Some people have experienced problems with LEDs where moisture can cause the optical lens to mist reducing the output of the component. Some issues have also be seen with material expansion and cracking of the parts leading to bond wire movement, again this is due to moisture in the body, however this is more of an issue with TSOP, QFP and PBGA devices as shown below.



Plastic Ball Grid Array PBGA cracking and the effect on the solder balls under the PBGA being featured in the Cookson Lead-Free European Workshop

If we step back a few years when companies first introduced surface mount, leaching of component terminations was an issue. This was overcome by plating nickel as a barrier layer on to the silver/palladium paste end caps. Nickel has a much lower dissolution rate during soldering so leaching was virtually eliminated as a problem in the industry. One additional benefit that the barrier plating provides is a longer solderability life. Some suppliers did not implement the use of nickel over plating or the plating was so thin, these companies have seen problems of termination loss at elevated temperatures. More recently this problem has led to joint failures in the field for one user. We will have to look again on the thickness of the nickel plating, plus the other barrier plating thicknesses used on zinc, iron and even copper lead frames to reduce intermetallic thicknesses forming during soldering and high temperature storage.



Example of component termination leaching on capacitor terminations

All components will have a solderability life and care needs to be taken on over stocking. Solderability of components may also be apparent with lead-free alloys, as most people have experienced the reduced wetting which seems to be apparent with lead-free alloys. Using a simple shop floor component solderability test with lead-free pastes and a glass slide wetting can be assessed. If problems are highlighted on the production test they can be verified by laboratory testing. In most cases a simple test gives a yes or no answer. A copy of this test procedure can be downloaded from www.leadfreesoldering.com

Obviously there is a transition stage where tin/lead components are still being used or lead-free component terminations need to be soldered with tin/lead solder pastes. The key process change in any company will be the components and confirming component compatibility. It is probably the biggest issue to tackle the problem now while new designs are being considered. This should eliminate any reliability issues when lead-free alloys are used in production. It is also good practice during design to look at component used on products that are considered exempt from the lead free ban. It is a little foolhardy to just dismiss the lead issue entirely, although some products are exempt from legislation the industry will continue to change around you, making change inevitable.

Bob Willis is a process engineer providing lead-free engineering support in conventional and surface mount assembly processes. He has set-up production lines and also provides reflow soldering seminars and workshops worldwide. He is often called to advice suppliers and customers on process issues and is able to undertake process improvement projects on site. He has one of the largest collection of training videos, interactive CD-ROMs and training material in the industry.

Bob will be presenting three workshops at SMTA International in 2005, Master Classes at APEX 2005 in California and at SMT Nuremberg in Germany. Bob is also supporting NPL with their European Lead-Free Master Classes. Bob has produced lead free training CDs for NPL, Soldertec, Global SMT magazine as well has his own products. For further information go to on www.leadfreesoldering.com

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