leadfreesoldering Casebook

Newsletter from leadfreesoldering.com

Welcome to this edition of Leadfreesoldering Casebook for an update on the changes necessary for design and production departments in preparation for lead-free alloys.

Legislation

After 1 July 2006 component and assemblies that are imported into Europe must be lead-free, the producer is responsible, which means manufacturer or importer into the EU. If components or sub-assemblies are incorporated into other products the producer is again responsible. Lead free solder is defined as less that 0.1% by weight

If you are currently included under the legislation you are advised to implement a plan for change in manufacture as soon as possible or with your contract manufacturer.

Exemptions exist under WEEE and ROHS directives, but it is inevitable that things will change and selling products that are not lead-free may become more difficult in certain markets

It is not clear at present who or how the legislation will be enforced; this should be clearer following the next round of Government consultation

Japan has lead the way in implementing lead-free products and processes, with products on sale for over five years

Different solder alloys are available as are components and printed boards with lead-free finishes

Most material and equipment suppliers are aware of the issues and offer support as does the Department of Trade and Industry (DTI) through their web site at **www.dti.gov.uk/sustainability**

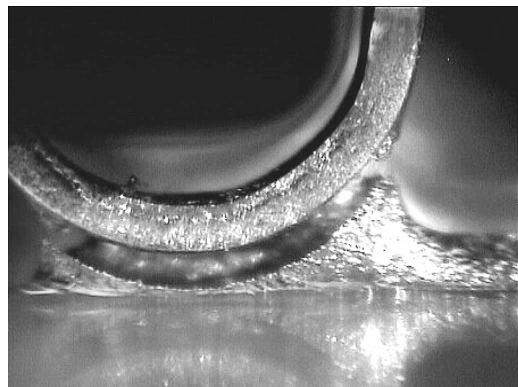
Components

Component selection is one of the first issues to address in your move to lead-free. It is often the step that takes the longest time to implement. The termination plating should be changed to have a lead-free finish; tin will probably be the most common choice even with concerns of tin whiskers. Using tin/lead terminations with lead-free solder should be avoided to meet the legislation requirements; it can also lead to process and reliability issues with secondary reflow.

The temperatures used during reflow will have a peak between 230-245°C for 30-60 seconds, however higher temperatures may be experienced. In the case of vapour phase fixed temperature will exist 230 or 240°C. Wave soldering will probably operate between 260-265°C and surface mount components will be exposed to these temperatures during contact times of between 4-6 seconds. Conventional component bodies will probably see an increase on the top side of the board of between 10-25°C.

Guidelines are currently being defined by IPC and JEDEC for component compatibility on future lead-free processes. There are basic guidelines already in existence, also draft standards and suppliers' documentation for your review. I often illustrate different component failures during my workshops to show that many components are not specified correctly.

A key issue is finding a method of testing leads and plating so that lead can be detected simply and quickly on the shop floor, a challenge for the future.



Printed Circuit Boards

The surface finish on the printed board must change from tin/lead which is still the most common finish in the industry, applied by solder levelling. Options are available like gold, silver, tin, copper OSP and of course lead-free solder levelled coatings.

There are advantages to having laminates which have a higher glass transition (Tg) temperatures Tg. However many people including the Japanese are using existing base materials rather than changing to higher priced laminates.

Concerns have been voiced over copper barrel plating failures and board delamination. Although this is a concern provided the board preparation and lamination is controlled delamination should not be an issue. PCB producers do monitor the ductility of copper and the plating thickness so cracking should be avoided.

Copper plating failures are normally associated with thin plating or poor ductility. Both are normally tested by the suppliers during manufacture on process quality audits. To date I have not evaluated copper plating failures on PCBs with lead-free introduction.

Stencil Printing

Solder paste printing should not be affected by a lead-free process. There will still be differences in the performance of one paste over another and the combination of paste and stencil type particularly on fine pitch. There will be an increase in paste price in the short term until demand increases.

I have seen differences in the expansion and contraction of the PCB laminate between first and second reflow, alignment issues have lead to a compromise. This has also been seen before with existing materials and may not be significant unless on ultra fine pitch on 0201 and 01005 chip assembly.

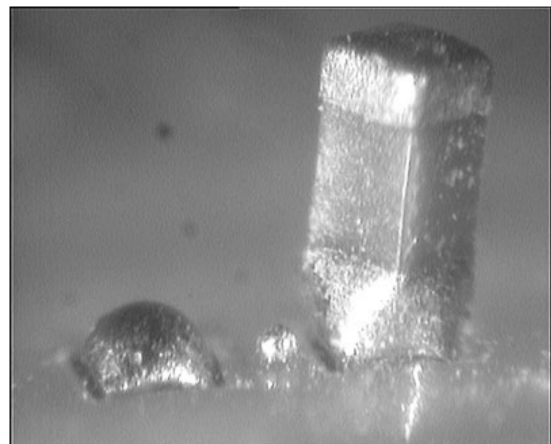
Control of the paste types and the separation of waste should be considered along with re-education of staff on alloy types and the issues of using incorrect materials. Anyone using paste should know the difference in the alloy and periodic symbols and know not to mix paste or forget to clean the printer/stencil thoroughly if different alloys are going to be used.

Component Placement

Component placement should not be effected by lead-free introduction. Any increase in board warpage or expansion and contraction during initial reflow could cause some alignment issues. Care needs to be taken on components, using only lead-free terminations and not mixing component stocks which may be a challenge for the contract assembly industry.

During the transition phase there is likely to be a lot of tin/lead and lead-free parts with suppliers and distributors. Also the stock holdings in contract assembly companies needs to be purged to avoid confusion on what is and is not lead-free.

Changing from tin/lead solder levelled boards we have needed to recalibrate the camera alignment system for copper, gold, tin or silver printed board finishes on older machines.



Reflow Soldering

In most cases the reflow soldering temperatures will rise between by 20-30°C and most high end professional ovens will be able to cope. Where the differential temperatures (Delta T) across products is existingly 20-30°C problems may occur and new equipment may be necessary, hence the increase in suppliers offering vapour phase.

As the reflow temperature increases cooling becomes even more important. Ovens must be able to cool more effectively at the throughput speeds required in production. Better cooling will benefit solder joint structure, solderability of PCB finishes, handling during exit from the oven and may benefit through hole fillet lifting.

The surface or the skin temperature of the oven needs to be examined for any health and safety implications. Increased temperatures will have some impact on maintenance schedules on chain drives, cooling systems and conveyor width adjustments. Improvements in atmosphere management are appearing all the time to reduce nitrogen consumption and reduce flux residue build up. Nitrogen has been demonstrated to be beneficial to lead-free reflow but its additional cost needs to be factored into product costs.

Engineers will have to look more deeply into profiling board assemblies. Generally with convection this has been taken for granted, so with lead-free you must think again. Even using the best profiling equipment it still takes time to get the best profiles in manufacture. There will be an increasing interest in vapour phase soldering due to its fixed peak temperature of 230 or 240°C. Many engineers will feel that VPS is a good option when upgrading equipment.

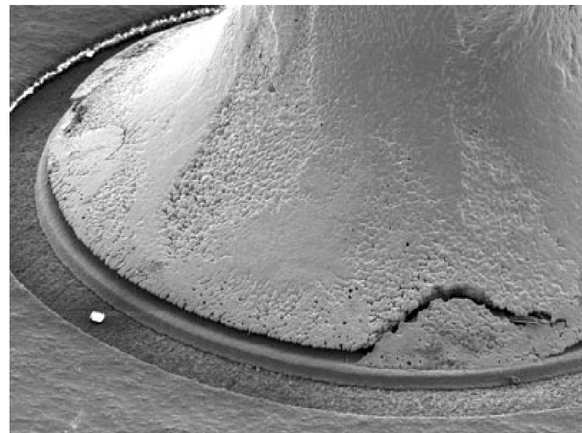
Wave Soldering

Wave soldering is probably the process most affected by a change to lead-free alloys. In most cases the fluxing and preheat systems will not change but parameters may. With the poor drainage of lead-free solders, changes in the type of flux may be beneficial, replacing alcohol with water based materials. My experience is inline with most engineers that solder shorts and bridging does increase with lead-free. In the case of water based fluxes there will be an increasing interest in convection preheaters, certainly my results find this is true but be careful with alcohol flux and convection.

The cost of operating the process will increase with more power consumption and the alloy price will increase typically from £3 to £9 per kilo. The value of the dross will also increase in value and recovery will be a focus for many.

The solder bath module will probably need to change with all stainless steel parts in contact with the wave. This is due to the reported erosion that has been noted with the high tin content solders. Some suppliers are taking the opportunity to make changes to wave design to optimise the soldering performance. Reducing temperature drop between waves and reducing the contact time benefits the amount of copper removed from the PCB and component terminations.

Monitoring of the solder alloy and its contamination levels will need to change. The type of contamination and its potential impact on fillet lifting, liquidus temperatures and drainage need to be understood. Copper will build up quickly in the bath and the potential for lead contamination is high particularly during the transition from a tin/lead world. Temperature increase in the wave will be between 15-20°C and the preheat between 10-20°C. Cooling after the wave or topside cooling may become a feature on some machines, it has already appeared in Japan using ambient and nitrogen atmospheres. Again profiling must be considered to stop topside reflow of surface mount components.



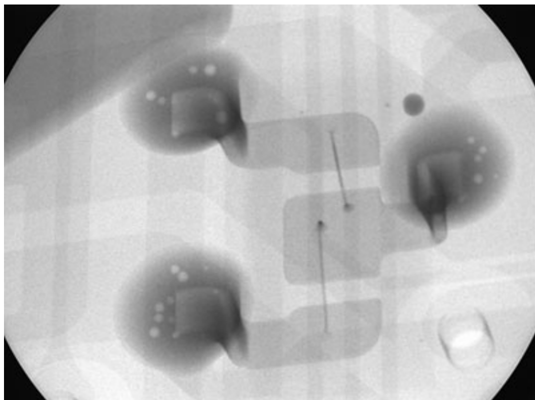
Inspection

Currently most companies use the IPC inspection criteria for tin/lead joints. It is suggested that the basic criteria should not change for lead-free. The criteria on joints wetting height, hole fill, should remain the same but with minor modification to the area of solder coverage on pads. When training staff on inspection I find that many people don't think there is a significant difference in the joint appearance. Example solder joints should be included showing acceptable solder joints for the different lead/free alloys and will prove relatively easy to introduce without complete retraining of the industry.

There should be an increasing use of in-process checks and monitoring. The use of process and defect monitoring will become more common to benchmark the differences in process yield and compare yields across the industry. This type of information has been provided by the SMART Group for the last two years along with inspection criteria and training CDs.

X-Ray Inspection

There is no evidence that lead-free solder alloys present a problem to x-ray inspection. To date experience has been gained with each of the common alloys on each of the different lead-free solder finishes with good joint and defect clarity. We have produced some inspection examples with lead-free joints, I don't think you can tell the difference in alloys. I have personally examined most surface mount, area array and through hole termination's using real time x-ray with no real problems.



Rework

With the increase in temperatures for lead-free, components requiring rework need to assessed. Many parts are sensitive to moisture ingress which can lead to body cracks. This in turn causes bond wire separation, it's a common area we do failure analysis on for customers. Area array devices are most prone to damage but plastic QFPs can also suffer from what is called "popcorning". During training sessions I often see examples of damage, it's often beneficial to show staff what can happen in the real world.

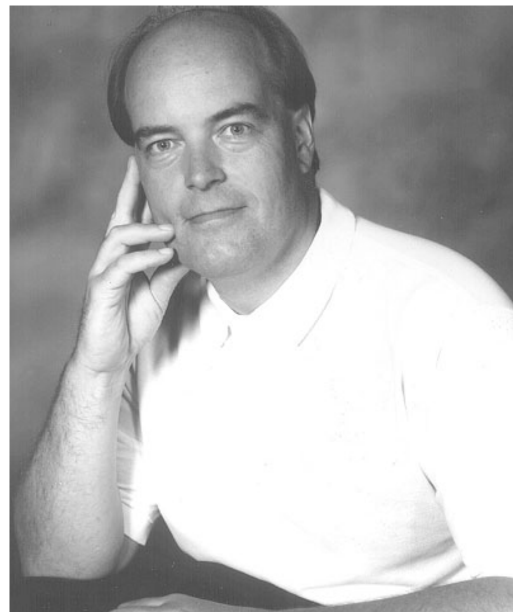
To avoid cracking care needs to be taken during storage of new parts and the possible baking of the assembly prior to rework. The reason is to avoid damage of the parts being remove, adjacent parts or the printed circuit board delaminating.

Hand Soldering and De-soldering

With typical tip temperatures of between 700-800oF hand soldering and de-soldering has been successfully achieve on plated through hole boards. Multilayer boards will probably require slightly higher temperatures but this will depend on the soldering iron efficiency. Profiling joints during soldering and de-soldering do show difference in time to make joints.

Probably the main issue will be the care of soldering, de-soldering iron tips. During the introduction of no clean there were a lot of issues with poor wetting of tips due to oxide formation. This was mainly due to poor tinning and leaving the soldering iron on when not in use. Lead-free will suffer in the same way, there have also been reported problems of tip corrosion of the copper core. Further work need to be done to confirm the plating types and thickness to optimise the life of tips. However if correct operation and storage procedures are used many of the problems can be avoided.

Cored solder wire will have a slightly higher prices and there may be limits on wire diameter for some alloys. As some lead-free alloys are less ductile producing small section wires can be more difficult.



For further information on how Bob Willis can assist you and your customers introduce lead-free go to **www.leadfreesoldering.com**