Learning from the European RoHS experience

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Six months into the implementation of Europe's RoHS directive, countries and states planning their own legislation are advised to study the European experience for its affect on electronics reliability in safety critical applications, argues Graham Naisbitt

The EU has made a very poor job of implementing its RoHS lead-free soldering legislation. In an ironic example of how poor, it's known that the replacement alloys used for lead-free soldering leach noxious substances into ground water supply far more readily than lead.

In addition, one of the main mistakes the EU has not allowed sufficient time for the various international standards bodies - such as the International Electrotechnical Commission (IEC) and the US's Association Connecting Electronics Industries (more commonly known as 'IPC') - to revise their standards for lead-free. It will be at least 2008 before the introduction of the majority of revised standards because of the huge burden of work for the standards committees. This is despite these committees doing everything in their power to expedite the revised standards as efficiently as possible. Consequently, producers have minimal guidance on how best to implement the new procedures necessary for lead-free assembly.

Worse still, standards bodies have already discovered some serious technical misgivings about the long-term performance of lead-free, high tin alternatives such as SAC alloys (for example, Sn96.5Ag3.0Cu0.5).

What is known so far is that lead-free solders are certainly not a "drop in" solution for their lead forefathers. This presents a daunting prospect for many manufacturers, particularly those making high-reliability products used in safety critical applications where failure puts lives at risk. Countries planning their own RoHS-style legislation (such as China) can therefore learn much from the European experience and in doing so avoid replicating the mistakes caused by hurried introduction.

Tin threatens reliability

Independent studies -involving exhaustive test programs to evaluate the performance of lead-free alloys in high reliability systems - have revealed situations where lead-free alloys directly compromise electronic circuit reliability.

Many of these investigations suggest that a high percentage of tin in the alloy is the culprit. Tin whiskering is one issue; another is that tin disintegrates over time in low temperatures (below -15 C), due to a phenomenon known as "Tin Pest". This could seriously undermine reliability if a high tin-based, lead-free alloy were to be used in an avionics system where the electronics circuitry is (routinely) required to operate reliably down to -55 C.

A further problem that has come to the fore since the implementation of the European legislation is management of obsolete stock. For years, component suppliers have carried myriad component types to service customer commitments. Now, however, they have the perfect excuse to get rid of ageing, low volume (and therefore low margin) stock needed by the high-reliability manufacturers to service product in the field.

High reliability manufacturers suffer more than most because they tend to buy low volumes and therefore don't have enough commercial leverage with suppliers to force them to backtrack on such rationalisation programs. It's not an exaggeration to say that this policy will put some manufacturing operations out of business.

The heat is on

Even without question marks over reliability and supply chain challenges, changing to a lead-free alloy assembly process is not trivial. While alternatives are commercially available, they demand entirely new production processes.

Whereas previously the "glue" that held the components to the PCB was an alloy of tin/lead, it's now, typically, a ternary alloy of tin/silver/copper requiring a melt temperature of 219 C – far higher than the 183 C of eutectic tin/lead. Even with conventional alloys, in order to ensure soldering between components that are large and take up a lot of thermal energy compared to small discrete components, it's necessary to maintain a large temperature differential (Δt) of up to 50 C between the alloy melting point and the peak reflow oven temperature.

Maintaining this temperature difference using lead-free alloys pushes the process temperature close to 270 C (219 + 50 C) or higher. That's perilously close to the maximum rating of the majority of components and makes component manufacturers and distributors rather nervous.

Exposing the PCB these high temperatures causes expansion, "encouraging" absorption into the laminate; the consequent risk of phenomena such as delamination becomes higher, as do subsurface reactions of residual contamination from the chemicals used in the assembly process that can cause later electrochemical reactions and reliability problems.

Furthermore, there are questions about whether the higher soldering temperatures required for lead-free assembly rework and repair affect the long-term durability of an electronic assembly that has had components replaced and whether maintenance staff will know for sure if they are replacing lead or lead-free terminated components.

Faced with so many complex issues, many companies have simply ignored the EU's July 1, 2006 deadline and subscribed to the view that reliability issues outweigh the so-called environmental impact of tin/lead solders. This has left it too late for them to transition to – or even evaluate the process implications of – lead-free alloys. Such companies risk crippling fines and both embarrassing and commercially damaging publicity if they are caught shipping non-compliant products into the EU.

Instead of ignoring the problem, manufacturing companies need to carefully select the range of process materials needed to assemble the product and carry out further test work to verify to reasonable expectations that the product will prove reliable in the field.

If the Chinese (and others such as Californians) push through their own versions of RoHS without giving the standards setting bodies and the manufacturers sufficient time to adapt, then electronics manufacturers exporting into many of the world's most prosperous markets face a punishing and commercially high risk time adapting to lead-free. It's a challenge that may prove too much for some.

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