



FromTheLab

By Bob Neves

Is Lead-Free Really Free?

The suspense is killing you isn't it? You've seen the projections that say lead-free is the (solder) wave of the future. You want to know the answer to this question, and you really don't want to have to read through my entire column to find it out. I'll be generous here and give it right here at the beginning. No! Lead-free is not free.

Now, that bold answer brings up a second, perhaps more important question. How much does "free" really cost? Is it like those late-night commercials where an item is free and all you have to pay for is shipping and handling? Or maybe it is like those free vacations, where all you have to do is sit and listen to a real estate presentation. To find out how much lead-free really costs, you will have to endure the rest of my column.

A lot of people have evaluated what it will cost to upgrade their equipment to produce lead-free assemblies, but very few have truly evaluated the impact on the PCB supply chain. There seems to be a general expectation that PCB cost and reliability will be unaffected by the move to lead free. Even the PCB manufacturers that have looked into lead-free have done little more than evaluate the direct implementation costs, such as the price of a new HASL machine that can do lead-free temperatures or how much the solder might cost (especially with tin prices on the rise).

Unfortunately, very few fabricators have truly evaluated the many hidden issues that will equate to real cost increases in PCB prices.

I am truly concerned whether you will be able to buy PCBs UL rated for lead-free soldering temperatures and times. If you take a look at the UL ratings for PCB Materials and Soldermasks, you will find that they are fundamentally based upon lead-based soldering temper-

atures and times. The most common rating for PCBs is 260°C for 10–20 seconds, and those ratings will not be acceptable for lead-free processing. The increased solder temperature and/or time required by lead-free processes will force the entire PCB manufacturing supply chain to re-evaluate and re-test their PCBs and materials to get them UL rated for the new lead-free soldering processes. Even though test labs like mine have geared up for an expected "rush" on UL approvals, this is still likely to be one of the big stumbling blocks to lead-free implementation.

I have seen very little work being done on the effect that the higher Lead Free soldering temperatures will have on Electrochemical Migration (ECM), Conductive Anodic Filaments (CAF) formation, and Surface Insulation Resistance (SIR). The decrease in reliability of the insulating system, caused by lead-free processing, will likely lead to a corresponding decrease in CAF resistance. The ECM and SIR resistance after lead-free solder processing will be determined by how effective the cleaning processes are. A lot more work needs to be done in these areas to assess the true effect that lead-free will have on these electrical reliability attributes.

Currently, most solderability tests that are done are of the "dip and look" variety—dip a few seconds on (or in) a solder pot and look to see if wetting occurred. Although this methodology can also be applied to "lead free," the solder, flux and temperatures used will be different. Many PCB shops are not prepared for this.

There are several other test techniques out there for determination of solderability, but the one that is gaining the most popularity is actually screening paste on the PCBs and running the product through a reflow oven. For example,

our lab has seen such an increase in this type of solderability testing that we now have a 10-zone reflow oven for actual solder process solderability testing.

Will a lead-free soldering process reduce via reliability? One thing I can tell you with certainty is that via reliability will be less with lead-free processing than with leaded solder processing. Why? The increase in soldering temperatures directly affects and degrades the organic materials that make up the insulating system in a PCB. As the insulation material begins to degenerate during the soldering process, the coefficient of thermal expansion of the material increases and places the vias under more stress (expansion), thereby decreasing the reliability of the vias. The question to ask is not will it reduce reliability, but how much less will it be and is that "acceptable?"

The assessment technique used to determine this relative reduction in via reliability will be critical in finding what is acceptable or not. Dual-chamber techniques have historically been "the way" to determine via reliability. Unfortunately, these are very costly and time consuming ways to assess via reliability. Our lab is currently employing another type of via reliability assessment, Highly Accelerated Thermal Shock (HATS) testing. HATS testing builds upon conventional dual-chamber techniques by using air as the heat transfer mechanism and using the same hot and cold temperature extremes. However, it reduces cycle time from 30–60 minutes down to a few minutes.

From all the projections I have seen and candid discussions I have taken part in, it is clear to me that "Lead-Be-Gone" is headed our way. OEMs seem bent on getting the lead out so for better or worse. It is on the horizon and fast approaching. We have to find a way to make it work now. **CT**

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