Plating Organics: Hidden Defects

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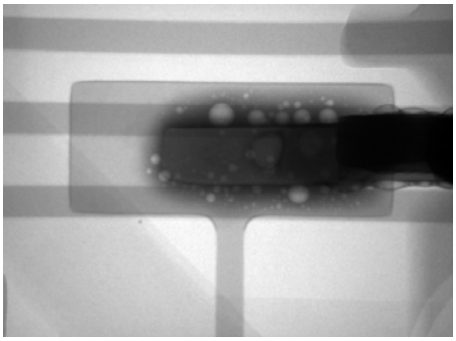

Figure 1. RTX Image of Socket Lead

Recently we received some hardware that exhibited failures at a specific multi-use socket. The socket originally came under scrutiny because of weak solder connections that were cracking during final integration resulting in electrical failure of the product. Real time x-ray analysis (RTX) performed on the connections confirmed the presence of significant voiding as illustrated in Figure 1. Upon studying the reflow profile used in the board assembly and after numerous teleconferences discussing factors related to the reflow, it was unclear as to the source of the voiding. We were assured that the humidity at the time of paste and reflow was maintained at or below 25-30%. Additionally, the process time had been minimized to ensure the flux in the paste did not dry out too soon. What was the root cause of the massive voiding? Why didn't other leaded devices exhibit similar voiding?

To further investigate the phenomenon, a socket that failed due to fractured solder connections was analyzed in our scanning electron microscope (SEM). Energy dispersive x-ray spectrometer (EDS) analysis of the lead indicated the fracture occurred very close to a Nickel (Ni) diffusion boundary layer since Ni was detected in the EDS spectrum. Cross sectional analysis of good connections indicated Ni plating was not present on the surface of the board, therefore the fracture location was confirmed as occurring at the lead interface. Also discovered was the appearance of voids in the upper portions of the socket leads as illustrated by Figure 2. The location of the voids was not consistent with voiding that would be initiated by binders in the solder determined to be caused by occluded organic impurities or contamination in the plating process of the leads.

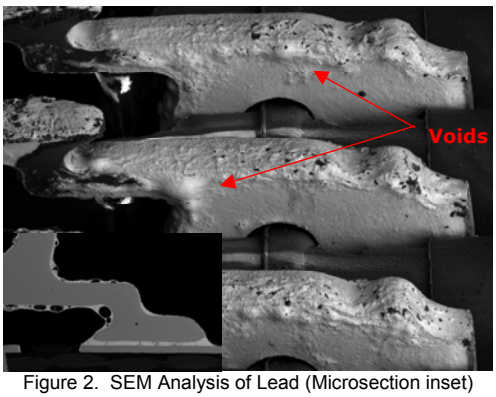

Figure 2. SEM Analysis of Lead (Microsection inset)

In implementing a corrective action to address the problem, the plating process must be understood. The plating material was measured as Tin (Sn) / Lead (Pb) in composition at a ratio of 93/7 respectively, common for Sn/Pb plating. While several types of solutions can be used to plate Sn/Pb, flouborate and organic sulfonate solutions are the most commercially accepted. Both processes require the use of organic additives to ensure a smooth, fine grain plating deposit and to

increase throwing power. Invariably, some of the organics are co-deposited onto the target surface during plating. These organics, if present in high enough concentrations, will outgas at reflow temperatures and cause the voiding that was discovered on this hardware.

Unfortunately, voids caused by plating organics are perhaps more detrimental to the mechanical integrity of a solder connection than voids caused by the binders in solder paste outgassing. In general, voids caused by the solder paste will be randomly distributed in the solder joint. Due to the nature of plating voids initiating from the plated lead surface, they normally remain very close to the lead surface upon reflow and solidification. All other factors remaining equal (intermetallic compound formation and grain structure), the strength of the solder connection is directly proportional to the attachment surface area.

As plating voids accumulate at the lead surface, the attachment surface area to the lead is reduced, thereby reducing the mechanical strength of the connection. Solder, by nature, is very weak compared to other engineering materials so, when plating voids reduce the attachment area, and applied mechanical or thermal stress is present, the risk of failure is higher than for normal solder paste voids.

Another critical factor is the screening process for determining whether leadframes are susceptible. Incoming visual inspection will not accurately diagnose the failure mechanism since the voids are not produced until the leadframe is heated. Cleanliness testing to identify organic contamination presence is also ineffective since the contamination is under the plating material and undetectable without altering the components. Therefore, some type of reflow simulation appears to be the best method for creating the phenomenon.

If reflow simulation is not possible, remember to look for telltale signs during visual inspection. Affected connections may appear cold due to their rough surface appearance. Furthermore RTX inspection of the in question may reveal voids on the lead that are well above the top of the solder paste. The location of these voids is a good indication that you have outgassing of contamination in the plating. While you would like to confirm this with 3D x-ray, it is not required. Take another look at Figure 1 at the right side of the lead as it extends up the socket. While it is subtle, voids are discernable in that 2D image that are well above the termination of the solder paste, leading to the conclusion that the voids present in the solder connection are most likely the cause of plating outgassing as well. Therefore, be suspicious of voids that do not occur uniformly across the circuit board and seem concentrated at a particular component. They may be the result of something outside of your manufacturing process.

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