Contamination control in lead-free hand soldering

Can lead-free solder joints be completed using a soldering iron and tip that were previously used for tin/lead soldering? Contamination of one type of solder with another can have consequences on solder joint reliability. As many facilities transition to lead-free soldering, there will probably be a phase where both tin/lead and lead-free solders will be used at the same time. This will require that material controls are in place to prevent cross contamination of the solders.

Some facilities are considering, or implementing, the complete physical separation of one process (tin/lead) from the other (lead-free). This includes the hand soldering operation and the hand soldering equipment (irons, tips, etc.).

This paper will review an alternative to physical separation: the 'rinse' method of eliminating lead from a soldering iron tip. Results of laboratory analysis of solder samples from tin/lead soldering stations used for soldering lead-free solder joints will be revealed. The results will show whether it is possible to switch solder materials (by using the 'rinse' method) on the same soldering iron and tip without a risk of lead contamination of the solder joint.

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Keywords: Lead-Free, tin-lead, contamination, hand soldering.

Background

With the RoHS Directive implementation date approaching (July 2006), the big concern for many companies is compliance with the directive. For most companies the substance that will have the greatest impact on their transition to compliance with the RoHS Directive will be the lead in their tin/lead solders. It is very likely that some customers will continue to require the use of tin/lead solder either because their product is exempt from the RoHS Directive or their only customers are located in geographic areas that have no legislation restricting the use of lead in electronics. Contract manufacturers will have to ensure that their material controls are sufficient to produce both tin/lead products and lead-free products concurrently, without the possibility of cross-contamination. Some of the expenses to manufacture both products at once are unavoidable. A wave solder machine cannot be easily switched from tin/lead to lead-free without significant effort. Concurrent processing of both tin/lead and lead-free products would require that there be controls in place to prevent the processing of tin/lead assemblies in the lead-free wave solder machine, and processing of lead-free assemblies in the tin/lead wave solder machine. The big question is whether this same type of control is necessary for the hand soldering operation and, in particular, the soldering iron tips. If it is assumed that you will need to have two separate areas for hand soldering, the material expenses alone (soldering irons, tips, hand tools, desks, and microscopes) could be very great.

As an example, a company that employs 25 hand-soldering technicians and creates a physical separation between the two processes will not only have to find the additional floor space with all the facilities modifications, but will also have to procure 25 additional work stations and equipment. If it is assumed that the cost for purchasing a complete soldering workstation is approximately $4,500 (on the conservative side), then the cost for this effort would be approximately $112,500. Even after the completion of the separate work areas, additional controls are required to prevent the inadvertent introduction of the wrong solder to either one of these areas.

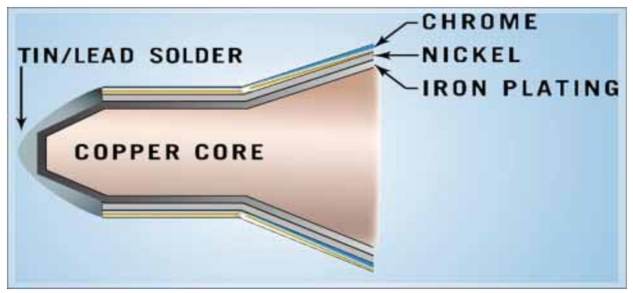

Figure 1. Cross-section illustration of a typical solder iron tip. Courtesy of OK International.

Soldering iron tips

The tin in both the tin/lead solder and the lead-free solder can and does form intermetallics with many other metals. It is this formation of tin intermetallics that allows the solder to 'stick' to the surface being soldered. Fortunately, lead very rarely forms intermetallics. What this means is that the tin of the solder is mixing with other metals, forming other alloys and intermetallics that may be difficult to remove. Lead, while remaining in solution, does not form intermetallics or other molecules, and this should allow the lead to be removed without resorting to a chemical or abrasive process.

Solder rinsing

Understanding the composition of soldering iron tips and some of the metallurgical characteristics of the tin and lead in solder aids in evaluating the potential for removing lead from a soldering iron tip. Since the lead does not form any intermetallics and since tin is very good at dissolving the lead, it should be possible to use the tin in the lead-free solder to dissolve

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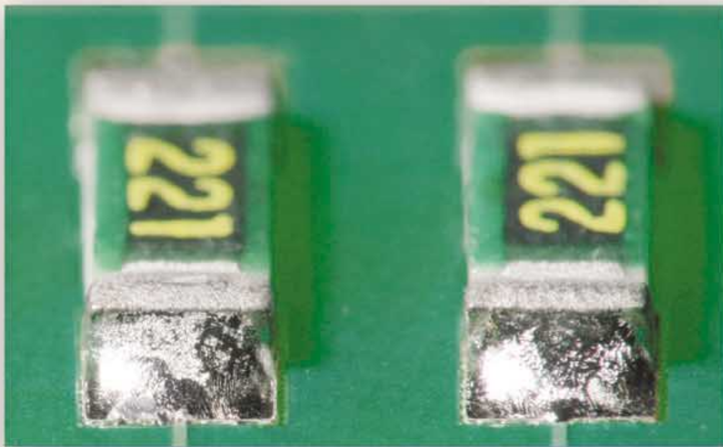

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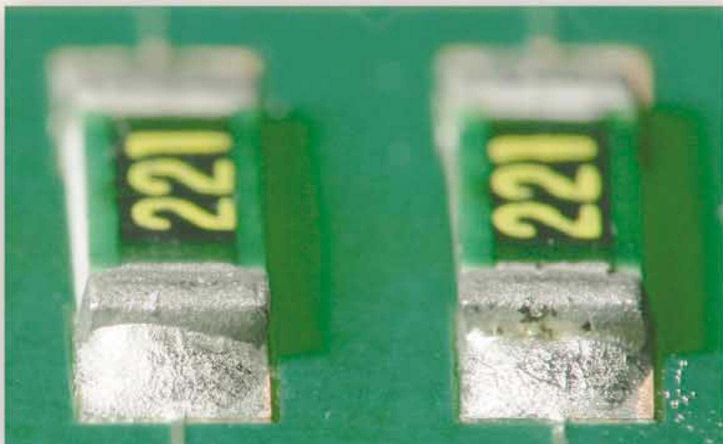

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the lead on the tip and then remove it by wiping the tip. The concept is similar to using hot water to rinse soap from a car after a car wash. The soap does not form a molecular bond with the surface of the car and the water is very good at dissolving the soap. This allows the water to rinse the soap off the car. In the case of soldering iron tips, this process is used to attempt to 'rinse' the lead off the hot soldering iron tip using molten lead-free solder. The big question is how effective this process would be at removing the lead from the soldering iron tip.

The evaluation

The evaluation began for collection 1 by using a soldering iron tip that was tinned with tin/lead solder. The tin/lead solder on the tip was then wiped off using a moist sponge. The clean tip then had lead-free solder added to the tip. The quantity was the maximum amount that could be added without having any of the solder drip off the tip. The lead-free solder that was on the tip was then knocked off the tip onto a clean non-wettable surface for collection. This entire process was completed many times, until a large enough sample was collected for analysis. This process would simulate the lead content of the solder in a solder joint if the tip was only wiped to remove the tin/lead solder and then lead-free solder was flowed into the connection. The sample was analyzed using inductively coupled plasma atomic emission spectrometry (ICP-AES). The lead-free solder used in the test was analyzed using the same method and the percentage of lead was found to be 0.079%. The solder sample from the soldering iron tip was analyzed and the percentage of lead was found to be 0.91% *(see Figure 2)*. This demonstrates that a simple wipe (without a rinse) was capable of reducing the lead content of the solder on the tip from 37% to less than 1%. While this is an impressive reduction, the amount of lead in the solder sample from the tip was much greater than the amount of lead in the as supplied lead-free solder. Not only was the percentage greater than the as supplied lead-free solder by at least a factor of ten, but the percentage far exceeded the 0.1% allowed by the RoHS Directive. The data revealed that wiping the soldering iron tip on a moist sponge is not an adequate method of removing residual lead from the tip. This process also indicated that the tin in the lead-free solder was very good at dissolving most of the remaining lead that was on the tip.

With the results from the collection 1 completed, the next step was to see what the effects were of an additional application of lead-free solder to the tip (a rinse after a wipe). For collection 2, the soldering iron tip was tinned with tin/lead solder. The tin/lead solder on the tip was then wiped off using a moist sponge. The clean tip then had lead-free solder added to the tip. The quantity was the maximum amount that could be added without having any of the solder drip off the tip. The lead-free solder that was on the tip was then knocked off the tip and discarded. At this point more lead-free solder was added to the tip. The lead-free solder that was on the tip was then knocked off the tip onto a clean non-wettable surface for collection. This process would simulate not only a tip wipe, but an additional rinse with lead-free solder before making a solder connection. The sample that was collected was then analyzed and revealed a significant reduction in the percentage of lead (0.34%) *(see Figure 3)*. While the effects of this single rinse was dramatic, the reduction was

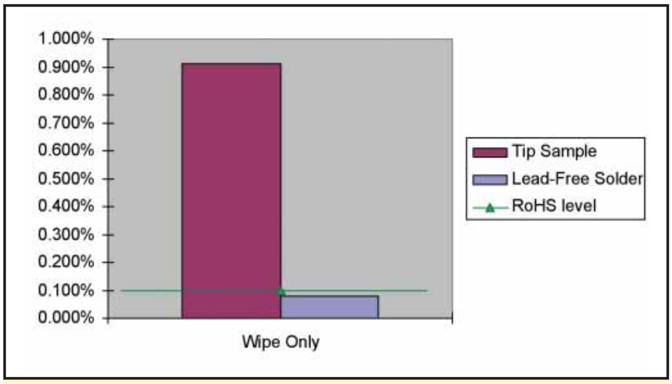

Figure 2.

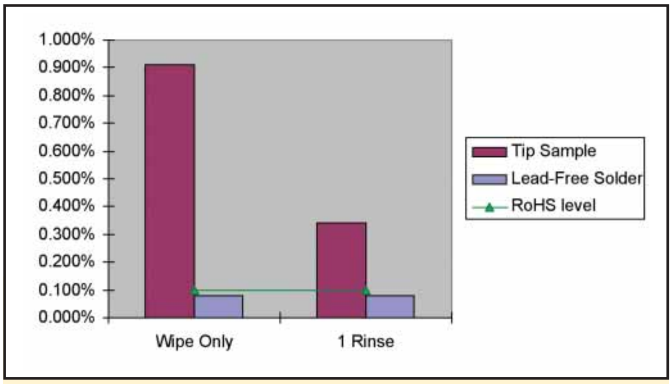

Figure 3.

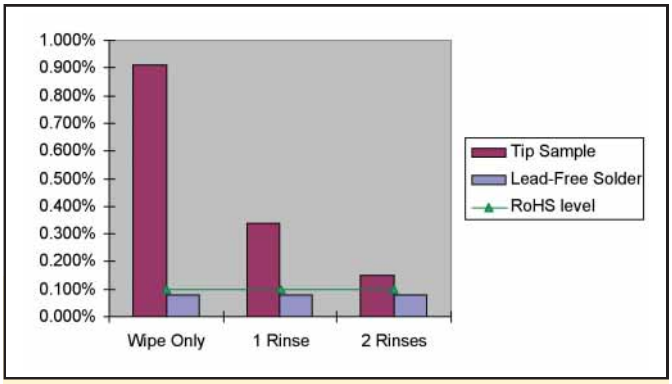

Figure 4.

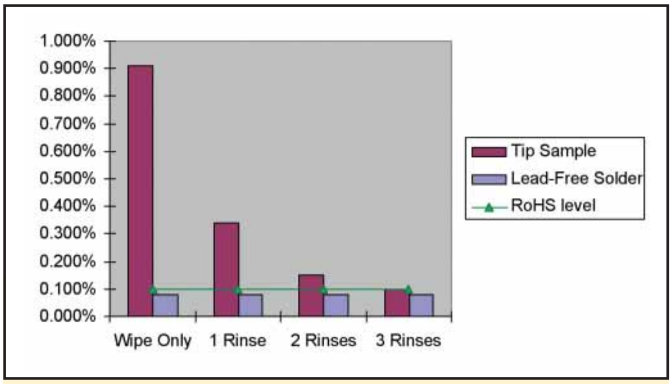

Figure 5.

still not great enough to pass the RoHS requirements of 0.1%.

For collection 3, the entire previous process was repeated again, but this time included two rinses of the tip before sample collection. The results of this analysis revealed another large reduction of the lead content to 0.15% *(see Figure 4)*. The double rinse reduced the lead content by over half, however, this was still too much to pass the requirements for a lead-free process.

A third rinse was included for the collection 4, and resulted in success. The lead content was now at 0.10% *(see Figure 5)*. This level of lead would pass the RoHS requirements. Since the original lead-free solder sample was analyzed and had a lead content of 0.079%, the third rinse reduced the lead levels very close to the original lead-free solder sample (within 0.021%).

Conclusion

It is obvious from the results of the analysis that 'rinsing' the soldering iron tip with lead-free solder will gradually reduce the lead contamination from previous processes until the lead levels reach equilibrium with the original lead-free solder lead levels. Although this means that a soldering iron can be used for both tin/lead and lead-free soldering, it does not mean that control of materials or processes will be any easier. Whether a separate area is set up for lead-free processing or both tin/lead and lead-free soldering is done at the same workstation, it will be essential that both administrative and engineering controls are in place and that the employees have received thorough training.

References

[1] Joe Curcio, OK International, "Pb-Free Process Control", Nepcon Shanghai, April 2005.

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