A Unique Process That Eliminates Solder Dross

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Dross generation has always been a costly issue for the electronics assembly industry. At least half, and in many cases, more than half of the metal (solder) purchased for electronic manufacture is wasted as it becomes tied up in dross. With the advent of lead free solders the moderate economic pain of dross generation becomes acute. A new process recently introduced to the industry cures virtually all problems caused by dross.

This paper will show the true cost of dross, including metal replacement, loss of efficiency, and safety as well as environmental issues clearly demonstrate a need for a solution to this problem. In addition to dross elimination the process has been shown in the lab to reduce temperatures for wave and selective soldering and to improve wetting. Collaborating beta test as well as lab test data will be presented along with initial actual production results.

In addition to answering the technical questions, why and how the "economics of dross" will be examined and a specific and significant cost savings scenario will be presented.

Dross
Dross is the formation of an insoluble solder oxide when the molten alloy is exposed to oxygen. It can cause leads to bridge, causing poor joints and voiding. Dross causes expensive rework and represents wasted solder that does not go on the finished assembly but still must be bought and therefore becomes part of the cost of the assembly. Dross is truly a non-value-added cost.

Molten Solder Surfactant (MS2™)
MS2™, a Molten Solder Surfactant, is a material that eliminates dross from all molten solder alloys. There are formulations optimized for both leaded and lead-free alloys. Any and all solder alloys respond to the dross elimination properties of this material. It reduces virtually all costs associated with dross related hazardous waste and greatly reduces the amount of hazardous waste generated. When using the material, there is no need for manual or mechanical dross removal. This new process reduces solder purchases by 40% to 75% based on production volumes. It does not mix with the clean metal and only reacts with dross and it does so without generating fumes or odor.

Explanation of the mode of action
When the active additive contacts a molten solder bath it performs two functions. First, it forms an oxygen barrier over the surface of the molten metal. This oxygen barrier is achieved both by the bulk material spreading across the molten metal and by a monolayer film of the active ingredient that covers areas that appear free of the bulk material. This barrier prevents further oxidation of the metals in the bath from occurring on the top of the solder pot's reservoir.

Secondly, the active ingredients in the material complexes with metal oxides in the solder bath and render them soluble in the bulk material. Oxides in the dross that is on the solder pot surface are sequestered in the initial treatment of the material onto the pot and any small amounts of oxide that form on the flowing wave are also reacted when contacting the active ingredient. The resulting organometallic complex that is formed between a metal oxide particle and the active ingredient remains suspended in the bulk material and is sequestered from the bulk metal. This spent material builds up with time and use until it is removed in a periodic cleaning cycle.

The active ingredient does not react with metal in its native, chemically reduced, state. When metal oxides are sequestered by the material in solder pot dross, the interconnected metal oxide matrix in the dross is opened and any valuable clean metal that is caught up in the dross matrix is dispersed back into the solder bath and remains unaffected by the material. This new material is unique in its dual role as a heat stable oxygen barrier and as an oxide scavenger. This material works with no discernible smoke or odor. The starting material is non-toxic and non-irritating and the resulting spent organometallic waste presents no inhalation or contact hazard.

No change in process fluxes or process parameters are necessitated by the use of the material. Whatever flux or alloy was in use prior can still be used.

The graphics below show a lead free solder pot in normal operation without (Left) and with the new material (Right).

Note the normal build up of dross in the pot on the left. The pot on the right is running the material. There is no dross being generated. The picture below is a static solder pot (wave not running) using the material. This shows an additional view of a dross free operation.

The Economics of Dross
While using this new material there have been observations by testing labs and users that may indicate cleaner, brighter solder joints and improved wetting. This makes sense as the solder bath itself is clean and running in a steady state mode when using it however we have as yet been unable to quantify these observations and therefore offer the significant cost reduction due to dross elimination as the key reason for the use of this product.

Case Study
Following is “The Economics of Dross” using data gathered from an actual assembly operation.

In a typical wave solder machine, dross generated after one hour of production is 2.7 lbs. Up to 70% of solder added can be due to the need to replace metal tied up in dross. Solder purchased per month: 4400 Lbs @ $9/ lb which equals $39,600 (total for four (4) wave solder machines). This typical facility generates 1760 lbs of dross per month which they sell to a scrap broker for $5632. Their net cost for solder is therefore ($39,600 minus $5,632) or $33,968.

When using this material they would only have to purchase (4,400 lbs minus the 1760 lbs that is wasted as dross) or a 40% reduction for new purchases of 2,640 lbs for gross savings of $39,600 minus $23,760 for a net monthly savings of $15,840. Add in the cost of the material which is approximately 50% of the savings and the company saves about $8000 per month or $96,000 per year ($24,000 annual savings per machine).

Cost factors; in addition to the cost to replace solder lost to dross you must consider:

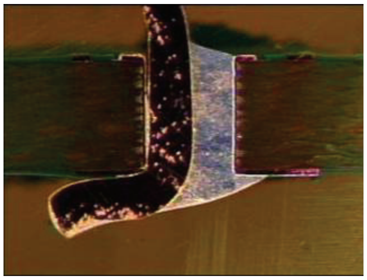
- Down time to clean dross from the unit
- Down time to calibrate wave or fountain due to dross clogs
- Labor costs to remove dross
- Safety issues caused by scooping hot dross from the unit
- Cost of dross related rework on the assembly
- Cost of storage and shipment of dross to the scrap broker

The quantified savings from the above list will vary from installation to installation and is, therefore, not in the above somewhat conservative calculation; however, there is true additional value above and beyond the calculated cost of dross replacement.

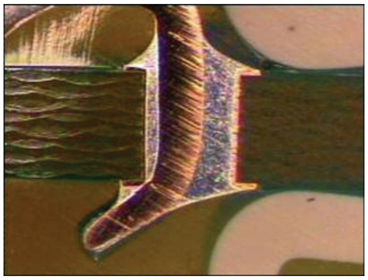
Reliability
Significant reliability testing has been undertaken at various test labs such as Engent Labs, Foresite, STI, and the University of Toronto as well as at beta and production sites. There have been no issues with reliability or contamination. All tests conducted to date for SIR electrical performance and ion chromatography testing have passed with levels well above the limits of 1E8 ohms of resistance which is the SIR criteria of J-STD-001C, Appendix B. Solder wetting tests show good solder wetting with joints meeting or exceeding IPC 610C class 3. No apparent change in grain structure has been found between the boards processed with and without the dross elimination material.

It should be noted that the first installation of this product has been running for over eight months. During this period of time they have not reported any negative effects and have not generated dross.

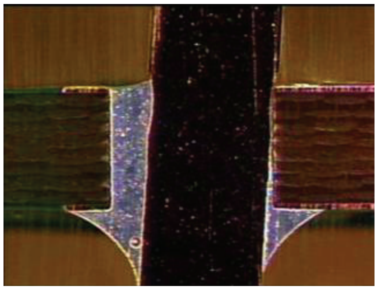
Examples, cross sections from a test run at a large OEM



No Material (L)



With Material(R)



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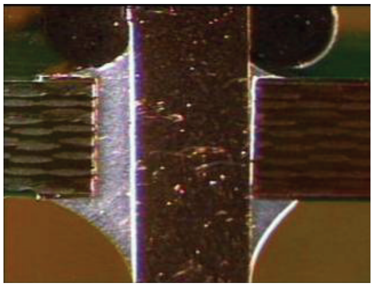

With Material (R)

The graphics above are samples taken from a control run at a recent installation. The pictures on the left depict cross sections from boards soldered before the new process was initiated. The ones on the right depict cross sections taken from boards processed in the same solder pot using the material.

In Conclusion:

- All testing to date shows that this new material produces no detrimental effects to the solder joint
    - Initial production installations confirm this
    - The reliability data shown here is but a small fraction of the information collected over many months of testing and production
    - We are not aware of any negative effects on the solder joint, the solder mask or the PWB base material or components.

- This material provides very significant cost savings
- There are observations that solder joints produced using this material are of higher quality, however this has not been quantified
- There have been no observations that solder joints produced using the material are of lower quality or reliability

It appears that the use of a Molten Solder Surfactant provides a means to mitigate at least part of the increased costs associated with lead free soldering while standard leaded soldering also benefits from the use of this material. This process represents an example of a rare juncture of technology becoming available in conjunction with a need being driven by global competitive pressures along with legislated changes in the electronic manufacturing process.

Dedication:
This paper is dedicated to Ron Daniels, a valued team member who had the vision to believe in MS2 before anything was proven. He is missed.