A Unique Process that Totally Eliminates Solder Dross While Potentially Providing Improved Quality, all while Significantly Reducing Costs

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Dross generation has always been a costly issue for the EMS 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, safety and environmental issues and demonstrate a solution for this problem. In addition to dross elimination the process has been shown to reduce temperatures necessary for wave and selective soldering at some locations 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 including specific case studies.

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, replacement 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™ 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 MS2 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 MS2 mode of action

When MS2 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 MS2 spreading across the molten metal and by a monolayer film of MS2 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 MS2 complexes with metal oxides in the solder bath and render them soluble in the bulk MS2. Oxides in the dross that is on the solder pot surface are sequestered in the initial treatment of MS2 onto the pot and any small amounts of oxide that form on the flowing wave are also reacted when contacting MS2. The resulting organometallic complex that is formed between a metal oxide particle and the MS2 remains suspended in the bulk MS2 and is sequestered from the bulk metal. This spent MS2 builds up with time and use until it is removed in a weekly cleaning cycle.

MS2 does not react with metal in its native, chemically reduced, state. When metal oxides are sequestered by MS2 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 MS2. MS2 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 MS2 organometallic waste presents no inhalation or contact hazard.

No change in process fluxes or process parameters are necessitated by the use of MS2. What ever flux or alloy was in use prior

The graphics below show a lead free solder pot in normal operation without MS2 (L) and with MS2 (R).

Note the normal build up of dross in the pot on the left. The pot on the right is running MS2, There is no dross being generated. The picture below is a static solder pot (wave not running) using MS2. This shows an additional view of a dross free operation.

The Economics of Dross

While using MS2 there have been observations by testing labs and customers 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 MS2 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 MS2.

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 facility generates 1760 Lbs of dross per month which they sell to a reclaimer for $5632. Their net cost for solder is therefore ($39,600 minus $5,632) or $33,968.

When using this material they only have to purchase (4,400 lbs minus the 1760 lbs that is wasted as dross) or a VERY CONSERVITAVE 40% reduction for new purchases of 2,640 lbs for gross savings of $39,600 minus what they were getting for dross which is $5632 minus $23,760 for a gross monthly savings of $10,208 in solder purchases.

The material is not free therefore add in the cost of the material which in this case is approximately 50% of the savings and the company saves about $5,000 per month or $60,000 per year ($15,000 annual savings per machine). Assume 10 machines running 16 hours per day (2 shifts), 80 hours a week the net savings at this facility is $300,000 in Solder Purchases Alone.

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 reclaim center
- Reduction in solder related defects
- Increased throughput
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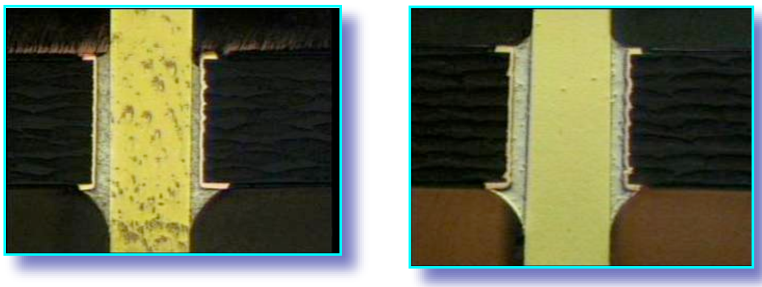
The quantified savings from the above list will vary from installation to installation and is therefore not in the above somewhat conservative calculation however there is significant additional value above and beyond the calculated cost of dross replacement.

Reliability

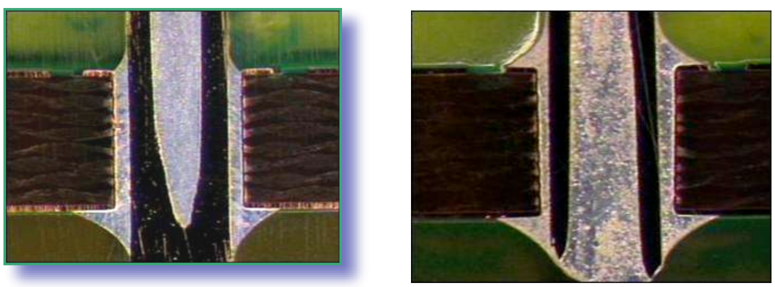
Significant reliability testing has been undertaken at various test labs such as Engent Labs, Foresite, STI, and the University of Toronto as well as at beta and production test sites. There have been no issues. All tests for SIR electrical performance and ion chromatography testing to date have passed 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 for the boards processed with and without MS2.

It should be noted that the first installation has been running MS2 for over ten 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 MS2 (L) With MS2 (R)



No MS2 (L) With MS2 (R)

The graphics above are samples taken from a control run at a recent MS2 installation. The pictures on the left depict cross sections from boards soldered before the MS2 process was initiated. The ones on the right depict cross sections taken from boards processes in the same solder pot using MS2.

In Conclusion:

- All testing to date shows that MS2™ 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.
- MS2 provides very significant cost savings
- New statistically valid data shows significant reduction in solder related defects
- New data shows increased line speed possible
- There are observations that solder joints produced using MS2™ are of higher quality. This has not been proven or quantified
- In no case have there been observations that solder joints produced using MS2 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. Standard leaded soldering also benefits from the use of MS2.

The P. Kay Metal MS2™ process represents an example of a rare juncture of technology becoming available and need with the need being driven by global competitive pressures and by legislated material changes in the global electronic manufacturing process.