Reduced Oxide Soldering Activation (ROSA)

ROSA is a surface restoration technique that removes hard to reduce species like metal oxides or sulfides. At the time of its development, the focus was on solderability and compliance to environmental regulations. Industry trends and regulatory changes as a result of the Montreal Protocol were the driver for much of the concern over environmental compliance. The result was an increase in the development of no-clean and water soluble fluxes and the removal of halogenated cleaning chemistries. The practice of "just-in-time" manufacturing and practice of making life-time purchases of parts also influenced the concern over solderability since cycle times were critical, inventories were vulnerable to oxidation and historically no-clean chemistries provided different soldering results than rosin based activated fluxes.

One attempt at protecting bare copper was Organic Solderability Preservative (OSP). This process of covering bare copper with an organic compound was an unproven technology to protect PCBs. It has now found favor only recently as more reliable coatings have been developed and improvements in the coating process have taken place.*(1)* Re-tinning leads on components was done, but the process was time consuming, there was potential for damaging components, and some components were not suited for re-tinning.

The need for a way to restore component and PCB solderability prior to use was needed. The ROSA solderability restoration technique was developed in response to this need. The work, by an industry consortium involving the U.S. Army Research Laboratories, Rockwell Science Center, SEHO USA Inc., and the EMPF Center of Excellence resulted in a bench-top restoration unit (BART) and ROSA Application Module (RAM) prototype designs.

The conclusions of the project were the following:

- The ROSA process was successful at restoring bare PCBs given a wide range of surface oxide conditions or levels.
- The use of the BART cell for recovering both SMT and THT components was demonstrated in two commercial endeavors.
- A bench-top restoration unit (BART) and a ROSA module prototype unit were developed with four BART units and three ROSA units being deployed to four beta-sites. The EMPF was established as a ROSA restoration technology Center of Excellence able to support both commercial industry and DoD depot repair facilities.
- The system's closed loop design meant no chemicals were consumed. This fact and studies during the project indicated the ROSA technique was environmentally friendly and safe to use if SOPs were followed.
- The ROSA chemistry can damage some plastic parts requiring any ROSA treated materials to be cleaned.

The ROSA technique removes difficult to reduce species like metal oxides through a highly reducing and corrosive aqueous solution. The solution is not active in its uncharged state. Upon application of a potential, V+3 (Vanadium III) is reduced to V+2 (Vanadium II) which oxidizes at the component or board surface releasing electrons which reduce the metal oxide back to the metal. The following example with Sn (IV) oxide summarizes the half cell reactions which occur during the ROSA process:

$$4V^{+2} \longrightarrow 4\,V^{+3} + 4e^{-}$$

$$SnO_2 + 4H^{+} + 4e^{-} \longrightarrow Sn^{*} + 2H_2O$$

$$SnO_2 + 4V^{+2} + 4H^{+} \longrightarrow Sn^{*} + 4\,V^{+3} + 2H_2O \qquad \text{Net Reaction}$$

The second reaction involves regeneration of the vanadium:

$$4V^{+3} + 4e^{-} \longrightarrow 4\,V^{+2} \qquad \text{(at the cathode)}$$

$$2H_2O \longrightarrow 4H^{+} + O_2 + 4e^{-} \qquad \text{(at the anode)}$$

$$4V^{+3} + 2H_2O \longrightarrow 4\,V^{+3} + 4H^{+} + O_2 \qquad \text{Net Reaction}$$

$$SnO_2 \longrightarrow Sn^{*} + O_2 \qquad \text{Overall Reaction}$$

The cell, shown in Figure 7-1, is separated by a semi permeable membrane allowing transfer of protons but hindering the transfer of the V+2 and V+3 species where they would be further oxidized to higher valent species. Figure 7-2 is an example of the improved wetting obtained after the ROSA process.

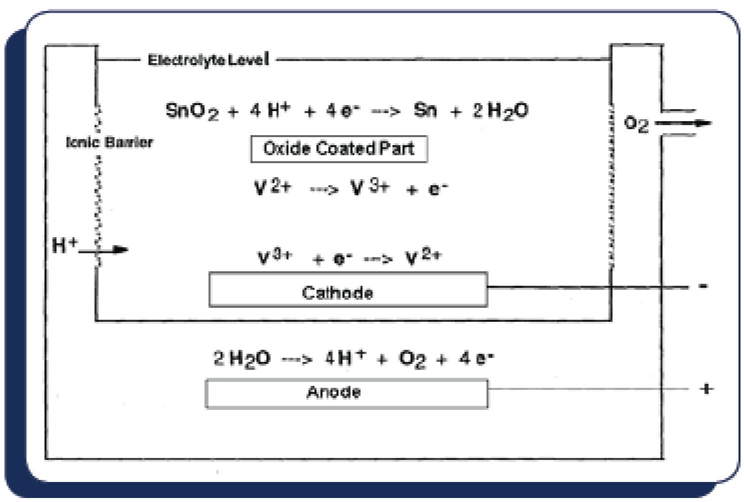


Figure 7-1: Block diagram of ROSA process

The economies of scale of large production runs have defined the concept of the disposable part, thus eliminating the need to restore components or PCBs. The Pb-free trend has created a new potential market for the ROSA technique for a number of reasons. In the case of high Sn, Pb-free solders like SAC 305, the surface tension is greater than the standard eutectic Sn63/Pb37 [548 mN/m vs. 481 mN/m respectively(2),(3)], indicating this Pb-free solder type would wet less. Another trait of many of the Pb-free alloys is their tendency to readily tarnish because tin is often the major component and oxides of tin are more stable than those of lead (i.e. lower heat of formation SnO -69 cal/mol, SnO_2 -143cal/mol, PbO -53cal/mol, PbO_2 -67cal /mol).4 These two characteristics of Pb-free solders present a challenge when it comes to solderability.

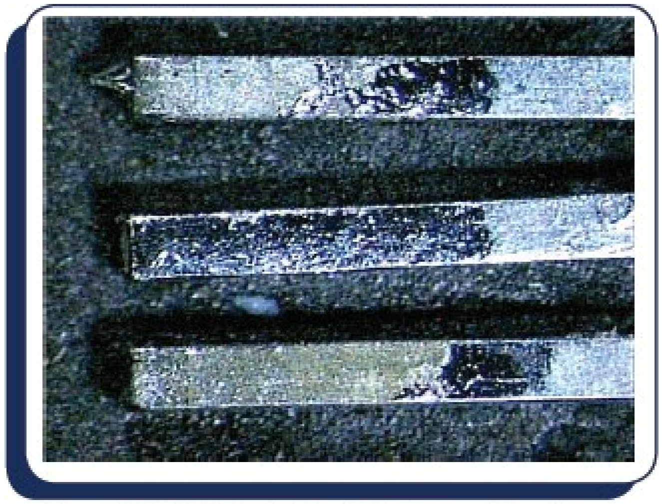
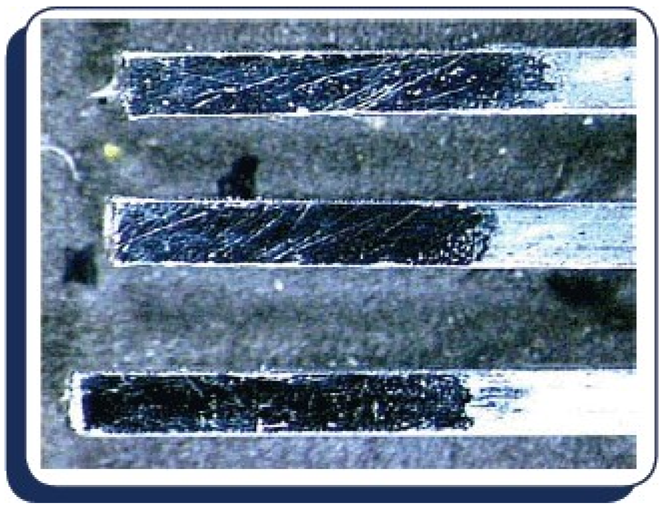


Figure 7-2 Dip & Look solderability testing of transformer leads without ROSA treatment (top) and after ROSA treatment (bottom)



Some companies have gone completely Pb-free, others are maintaining both Pb and Pb-free lines. The companies who are contractually committed to the use of Pb or are in markets where such restrictions do not apply (i.e. military), are dealing with difficulties in locating sources of Pb plated components and boards. These companies are now relying on aging inventories in order to maintain raw material streams. The potential need to recover such inventories is high. In the case of components, re-tinning can be time consuming and not cost effective.

The EMPF is currently working with a number of DoD depots as these potential ROSA customers could benefit from this component and board restoration technique along with those commercial customers who have transitioned over to Pb-free and found solderability problems.

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1 http://www.electrochemicals.com/carhunta.html#osp
2 http://www.emsnow.com/cnt/files/White20%Papers/henkel_case_study2.pdf
3 http://www.codata.org/04conf/papers/Moser-paper.pdf

4 CRC Handbook of Chemistry and Physics, 65th Edition 1984-1985