Residue Effects of Weak Organic Acid (WOA) Flux Activators

Varying flux chemistries require different cleaning protocols and ionic contamination levels

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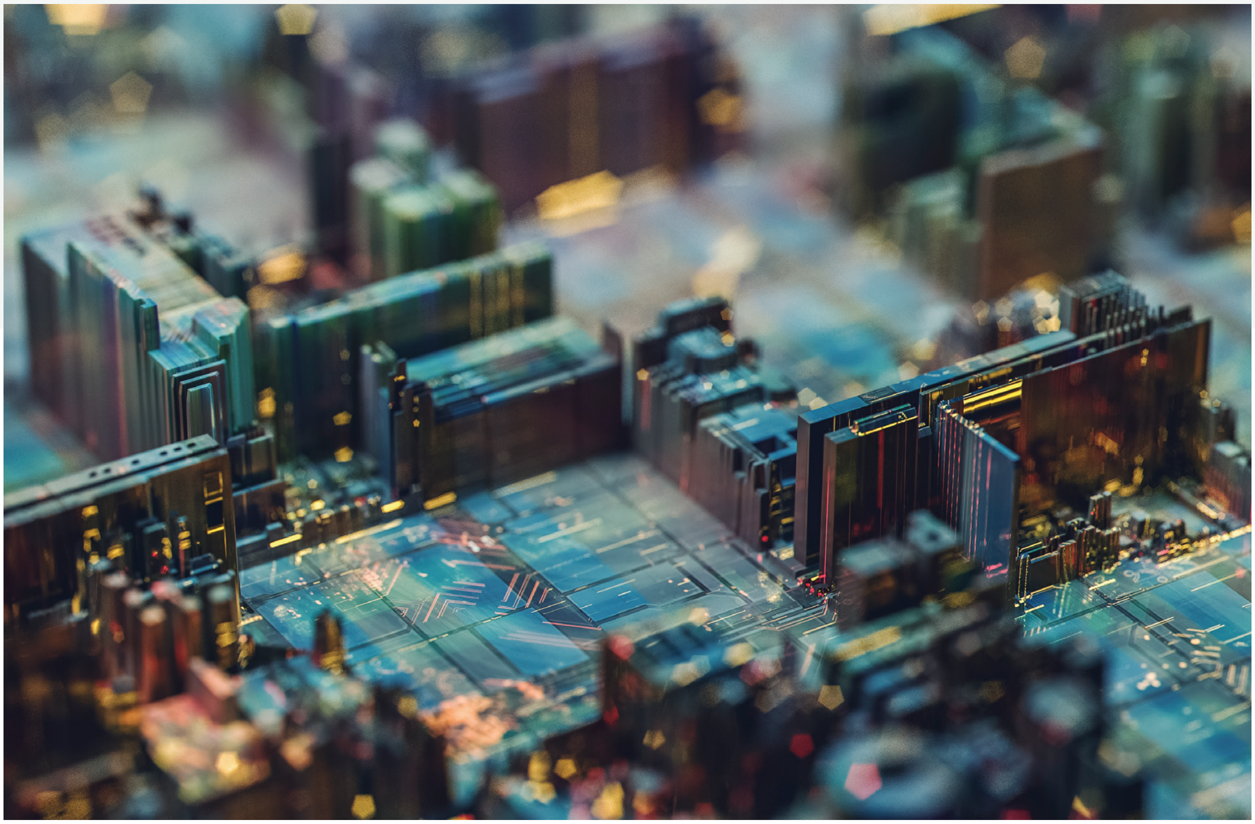

The purpose of flux is to clean surfaces that are going to be joined together, enhancing wetting by solder in the molten state. To accomplish this, the flux must be able to deoxidize metal surfaces at high temperatures without decomposing. Here is a listing of steps that flux goes through to accomplish this goal:

Solder paste is heated

↓

flux separates and flows to metal and beyond metal surfaces

↓

micro etches the surfaces and removes the oxides

↓

creates a barrier to prevent oxides from reforming

↓

metal goes to liquidous and wetting is achieved though capillary flow

↓

good metal-to-metal contact and binding

↓

now, what to do with the residues after good soldering has taken place?

These residues containing WOA flux activators fall into three categories:

1. Rosin solder paste with organic acid flux activators
2. Water soluble solder paste with organic acid flux activators
3. No Clean (low solids) solder paste with organic acid flux activators

1 Rosin solder paste with organic acid flux activators

These formulations are designed to be cleaned with solvents or saponified water cleaning.

Residues need to be reduced to less than 25 µg/in^2 of WOA for good electrical performance on the surface of an assembly when used in a class 2 or 3 operating environment. The residues left by rosin solder pastes with organic acid flux activators require cleaning with an aggressive solvent or saponified cleaning system to reduce the levels for good working conditions.

2 Water soluble solder paste with organic acid flux activators

This type of solder formulation is designed to be cleaned with water or a water and saponifier combination.

Photo 1 – Electrochemcial migration occurring due to high levels of water soluble flux residues left on the board

These residues are designed to remove the thicker layer of metal oxide, and are very aggressive residues at oxide removal. What the flux is actually doing at this point is absorbing oxygen and preventing oxides, or tarnish, from developing. Preventing oxides from forming is important because they will inhibit the solder from flowing, or cause it to flow where it is undesired. The flux activators in sufficient concentrations when left uncleaned and exposed to moisture will cause electrochemical migration failures (as seen circled in photo 1). Flux that is trapped in a via or hole and sealed from moisture can see levels of up to 150 µg/in^2 with little detrimental effect at ambient room temperature conditions. Residues trapped in voids of solder and vias have shown good performance for more than ten years of operating life, even with a voltage differential. Typical flux residues on the surface of an assembly exposed to moisture need to be reduced to less than 25 µg/in^2 of WOAs for good electrical performance on the surface of an assembly when used in a class 2 or 3 (medical or high reliability military are examples of a class 3 reliability classification) end product operating environment. Levels of WOAs from a water soluble flux residue not exposed to moisture (levels 60 to 150) will typically see failures in approximately 30 months with elevated operating temperatures above 40°C. Levels greater than 150 µg/in^2 will see failures typically in 18 months or less while operating at elevated temperatures above 40°C. This is due to the softening of the rosin, resin from the solderpaste which allows the activators to be more mobile.

3 No Clean (low solids) solder paste with organic acid flux activators

No Clean solder flux residues are designed to be heat activated and left on the surface of the assembly as insulating and protective residues.

The activator will also remove the oxide and bind the oxygen. The flux is designed to spread over the surface during the preheating section of the soldering reflow process, removing oxides and preventing any additional oxide formation thus promoting good wetting of the molten solder. Weak organic acids such as adipic or succinic acid, serve as activator compounds in many fluxes, especially no-clean fluxes. WOAs are typically benign materials and are therefore not a threat to long-term reliability. In order to avoid formulation disclosure difficulties with flux manufacturers, we group all detected weak organic acid species together and refer to them collectively as WOAs such as the succinic, adipic, glutaric and malic acids.

WOA amounts greater than 150 µg/in^2 present a significant reliability threat for finished assemblies on surfaces exposed to moisture. An excessive amount of flux can produce the situation in which the thermal energy of preheat is spent driving off the solvent, thereby not allowing the flux to reach its full activation temperature. Unreacted flux residues readily absorb moisture. This will promote the formation of a corrosion cell and the opportunity for current leakage failures. These leakage failures will perform the same as electromigration failures, but without any visible evidence on the surface of the part. Levels of less than 150 µg/in^2 of WOA have shown 14+ years of good product performance for these no clean fluxes (low solids) for all environments. The first use of these fluxes was in the early 1991 time frame by automotive manufactures. These no-clean processes are still operating the same today for HVAC and audio assemblies with levels <150 µg/in^2 (typically between 100 and 135 ug/in^2). These flux residues are designed to be clear and not easily seen after reflow, but the residues are present. Even with contamination levels above 150 µg/in^2, the residues may not be easily visible. Photo 2 shows no clean fluxes at 179 µg/in^2 of WOAs creating leakage pathways in high humidity conditions, but no residue is easily seen between pads on the resistor.

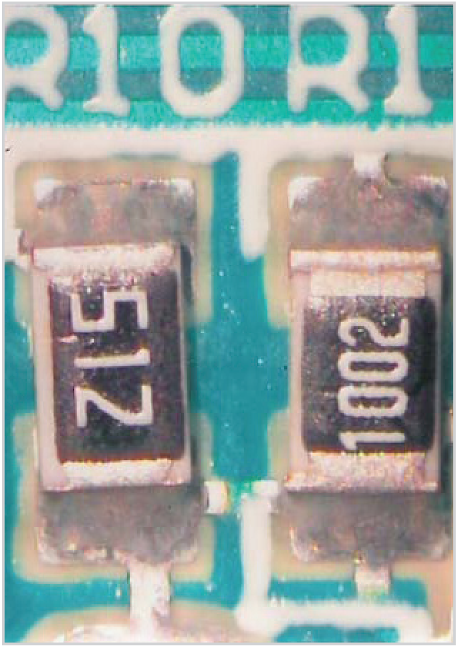

Photo 2 – High level of WOA flux residue (179 µg/in^2) is creating a leakage pathway, but is invisible to the eye.

Corrosion Cell Mechanics

If these elements are present at sufficient quantities a corrosion cell is created.

1. **Voltage differential**
2. **Fluid media** (typically moisture, but there are exceptions)
3. **Corrosive or conductive** media able to absorb moisture and be solublized

Process control revolves around minimizing corrosive and conductive media, either by rendering the media constituents benign or removing them and/or both.