

## Advanced Packaging and Electronic Assembly Cleaning Fluid Innovation

**Mike Bixenman, Jason Chan, and T.C. Loy**

*KYZEN Corporation*

Bayan Lepas, 11900 Penang, Malaysia

### ABSTRACT

The miniaturization of modern electronics decreases conductor widths, which can create higher risk to insulation failure. As distances between conductors reduce, electronic hardware is more vulnerable to insulation failure, higher voltage gradients and easier to form a corrosion cell. Inter-conductor spacing influences the migration rate and is inversely related with conductor width. Acceleration factors create multiple stresses due to activation energy, temperature, humidity and voltage.

Removal of process residues is needed to reduce electrochemical migration. Cleaning electronic hardware is well known. The challenges with cleaning highly dense hardware are many. Low standoff gaps prevent flux outgassing and can underfill the bottom termination with active flux residue. Mixed metals can react with alkaline cleaning agents, which can result in galvanic corrosion. The time and energy needed to reach the residue and remove contamination under the component requires high pressure spray impingement and increased wash time. The purpose of this research is to present aqueous cleaning technology innovations to address the challenges of cleaning highly dense electronic hardware. Material compatibility on mixed metals, cleaning performance and bath life studies will be presented.

### INTRODUCTION

Highly dense interconnected assemblies are populated with greater than 40% bottom terminated components. The component pitch is

continuously reducing from 0.40 mm toward 0.20 mm. Stencil printing, inspection and placement equipment innovations have kept pace by accurately positioning these tiny components onto the assembly. Pad metallization, alloy compositions, wire bonding and heat dissipation requirements expose the board to different peak reflow temperatures. Additionally, different metals may be present on the assembly that could be impacted from mobilization of flux residues and by the cleaning process. These innovations increase cleaning difficulty due to low clearances under the component, potential interactions of the cleaning agent with exposed metals and harder to clean flux residues.

The move to lead-free solder has necessitated new solder alloys, flux compositions, higher soldering temperatures and soldering methods. Additionally, wire bonds are moving away from gold toward copper and aluminum. As assemblies evolve, smaller footprint with higher functionality is required. This necessitates new assembly equipment, alloy compositions, chemicals and soldering processes to build today's assemblies. Reliability concerns are more complex and invasive due to the sensitivity of the device, surface contamination, residues trapped under bottom terminations and conductor spacing.

Time-delayed effects from contamination will not show up until a product is put into service. The potential for failure is very real and the effects of failure can be costly when products are exposed to harsh environments. The consequences of failure range from product to

product. Numerous publications on this topic have found that many failures are a result of contamination. For products that must perform over time, effective cleaning methods are needed.

The job of the cleaning agent continues to become more demanding. Most assemblers that clean, build their boards with no-clean solder pastes. Low residue no-clean fluxes require oxygen barriers that repel moisture and encapsulate flux activators. The resin and polymeric structures are challenging to clean. Longer wash time is often needed to penetrate and remove residues under bottom terminated components. Exposed metals have different solubility potential as a function electrochemical forces and pH. Cleaning agents designed to meet today's challenges are complex and must be engineered to balance the many factors needed to clean today's electronic hardware.

## DESIGNING A WELL-BALANCED CLEANING AGENT

A well designed cleaning agent must be capable of removing process residues. The jobs of the flux engineered into solder pastes, paste fluxes and liquid fluxes are many.

- Remove oxide layer from pad and solder alloy
- Protect solderable surfaces during reflow
- Consume the flux just as the solder begins to melt
- Active at 130°C for SnPb and 150°C for SAC
- Remain active for 90 – 120 seconds
- Leave a benign residue
- A residue that repels (hydrophobic) moisture
- Provides excellent solderability
- Reduces other defects such as head-in-pillow, graping and bridging

Low residue no-clean fluxes are the dominate flux technology used for building highly reliable electronics. The resin, rosin and polymers used in these flux compositions along with the heat applied during the reflow process have a significant impact on the residue cleaning properties. Post soldering flux residues from some solder pastes are highly difficult to clean. Alkaline cleaning agents are required to remove these tougher to clean flux residues. New cleaning agent designs are needed that improve cleaning properties and material / metals compatibility.

Flux compositions are engineered with ingredients that have different solubility properties. The resin, rosin and polymers tend to be non-polar. Flux activators are polar. The functional additives comprise both polar and non-polar structures. Some residues are more hydrophilic and have a greater tendency to absorb moisture. The solubility parameters of the residue can be quantified using Hansen Solubility methods. Figure 1 is a Teas Diagram, which allows one to plot the residue based on the properties of Non-Polarity, Polarity and Hydrogen Bonding<sup>1</sup>.

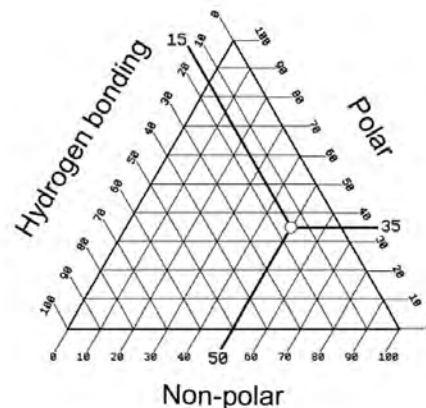


Figure 1: Teas Diagram

In theory, a cleaning agent with properties like the residue will clean more effectively<sup>2</sup>. Figure 2 provides an overview of a sampling of No-Clean solder paste residues. Since a flux is a multi-functional engineered formulation, the residue is not a single point on the graph. The flux is distributed in a larger area represented by the circles<sup>3</sup>.

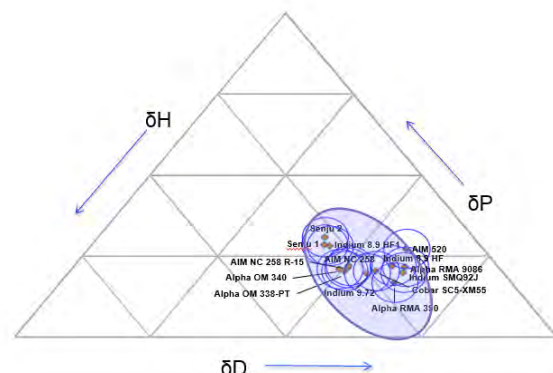


Figure 2: Teas Diagram for Selected Solder Pastes

Highly dense assemblies are populated with small components that have a narrow conductor spacing. Residue trapped under the component can bridge conductors. To meet a no-clean

standard, the residues must be benign (free of ionics) and repel moisture. As components miniaturize, solder material companies are using resin structures that polymerize during reflow. The residue takes on a plastic like structure. The challenge when designing a cleaning agent is to have a material that will dissolve polymeric resins in a short time period without materially attacking exposed metals, plastics, board laminates and part markings.

Today's fluxes more difficult clean due to:

- Polymeric resins used reduce oxidation of the alloys during soldering
- Hydrophobic residue that repels moisture
- Non-ionic residue post soldering
- Higher molecular weight resins, resins and polymers
- Polymerize when heated
- Residue can be equated to a soft plastic material
- Rubber like

Chemical and mechanical forces are needed to remove flux residues. Solvent blends by themselves do not completely remove these residues. The engineered cleaning composition requires the following properties:

- Solvents and activators targeted to polymeric like soils
- Both polar and non-polar solvents needed
  - Non-polar solvent to facilitate dissolution of resin and rosin polymeric soils
  - Polar activators to induce both Van der Waals and London Dispersive Forces
- Low surface tension to penetrate low standoff gaps
- Low foaming under pressure
- Broad material compatibility
  - Mixed metals
  - Plastics
  - Part marking
  - Board laminates
  - Bonding and stacking materials

Removal of process residues on the surface of the assembly are not a challenge to clean when using an effective cleaning agent. Residues trapped under bottom terminations are challenging to clean. Cleaning time is function of the time needed to dissolve the flux residue. Leadless components with standoff gaps less than 100µm requires longer wash time exposure

and strong impinging spray penetration (Figure 3)<sup>12</sup>.

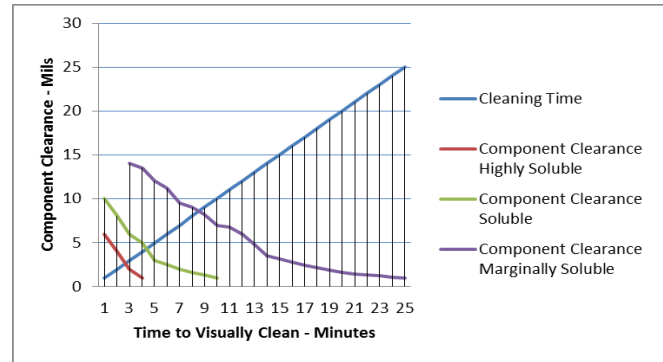


Figure 3: Time Clean under Leadless Components

### Exposed Metal Compatibility

Aqueous cleaning agent corrosion is the oxidation of a metal via an electrochemical reaction within water and its dissolved compounds<sup>4</sup>. Aqueous corrosion is dependent on the presence of water to act as an ion conducting electrolyte. Oxidation of a metal in an aqueous cleaning agent is dependent on electrical potential and pH<sup>5</sup>. The electrical potential of a metal represents the potential difference measured in volts between the metal and oxidation potential of the cleaning agent at its concentration, exposure time, temperature and pH.

If the exposed metals on an electronic assembly are contacted with a cleaning solution that reacts with a metal, metal ions will be lost from the metal into the aqueous cleaning solution, leaving electrons behind on the metal. This will continue to occur until the metal reaches its equilibrium potential and the system comes to equilibrium, with a saturated concentration of dissolved ions<sup>6</sup>. A cationic reaction may occur that uses up the electrons lost by the metal species. The cationic reaction acts as a sink for electrons liberated in the oxidation reaction of the metal. As corrosion occurs, the mass of metal is reduced due to the conversion of atoms to ions, which are subsequently lost (Figure 4).

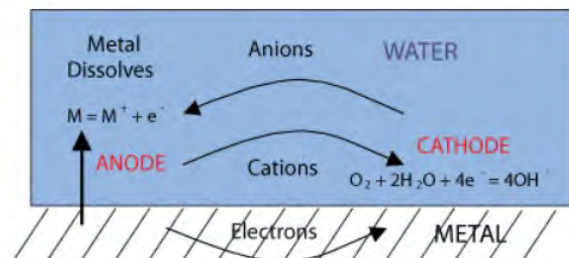
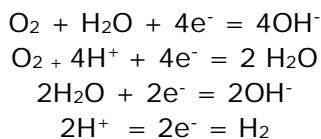


Figure 4: Aqueous Corrosion Oxidation / Reduction<sup>6</sup>

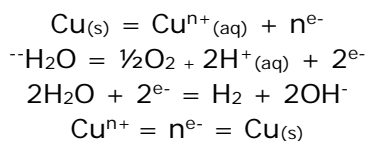
To summarize the corrosion reaction, the metal species are oxidized and lose electrons, forming metal cations when a cleaning agent attacks and oxidizes a metal. The corresponding reduction reaction consumes electrons at the cathode. Water becomes the electrolyte that facilitates ion mobilization. Metal ions dissolved in the water electrolyte result in corrosion.

A metal that is attacked by the cleaning solution loses some of the metal electrons through a half cell electrochemical oxidation. The aqueous cleaning agent solution where metal electrons are gained is the reduction electrochemical half cell.

Reduction reactions occur at the cathode and involve the consumption of electrons<sup>6</sup>. In corrosion, these normally correspond to reduction of oxygen or evolution of hydrogen, such as:



Oxidation reactions occur at the anode and involve the production of electrons<sup>6</sup>. For the corrosion of metals, these reactions normally correspond to the metal dissolution of oxide formation reactions, such as:



In addition to causing corrosion, oxidation may result in the formation of a passive oxide. The passive oxide produced may protect the metal beneath from further corrosion

### The Nernst Equation

The Nernst equation links the equilibrium potential of an electrode,  $E_e$ , to its standard potential  $E^0$ , and the concentrations or pressures of the reacting components at a given temperature<sup>6</sup>. It describes the value of  $E_e$  for a given reaction as a function of the concentrations (or pressures) of all participating chemical species.

The Nernst equation for an electrode is written as:

$$E_e = E^0 - 2.303RT/zF \log [\text{reduced}]/[\text{oxidized}]$$

$$E_e = E^0 - RT/zF \ln [\text{reduced}]/[\text{oxidized}]$$

$R$  is the universal gas constant ( $8.3145 \text{ JK}^{-1} \text{ mol}^{-1}$ )

$T$  is the absolute temperature

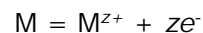
$z$  is the number of moles of electrons involved in the reaction as written

$F$  is the Faraday constant ( $96.485 \text{ C per mole of electrons}$ )

The notation [reduced] represents the product of the concentrations (reaction of the cleaning agent with metal) of all the species that appear on the reduced side of the electrode reaction, raised to the power of their stoichiometric coefficients. The notation [oxidized] represents the same for the oxidized side of the electrode reaction.

### Pourbaix Diagram

A Pourbaix diagram plots the equilibrium potential ( $E_e$ ) between a metal and its various oxidized species as a function of  $\text{pH}$ <sup>6, 7</sup>. The extent of half-cell reactions of a metal depend on various factors, including the potential,  $E$ ,  $\text{pH}$  and the concentration of the oxidized species,  $\text{M}^{z+}$ . The Pourbaix diagram can be thought of as analogous to a phase diagram of an alloy, which plots the lines of equilibrium between different phases as temperature and composition.



To plot a Pourbaix diagram, the Nernst equations are used. As the Nernst equation is derived entirely from thermodynamics, the Pourbaix diagram can be used to determine which metal species is thermodynamically stable at a given  $E$  and  $\text{pH}$ . It gives no information about the *kinetics* of the corrosion process.

When a cleaning agent reacts (dissolution) with an exposed metal, a  $\text{pH}$  gradient is produced with *hydroxonium ions* at the anode and *hydroxide ions* at the cathode. Figure 5 is a schematic of the reaction<sup>8</sup>.



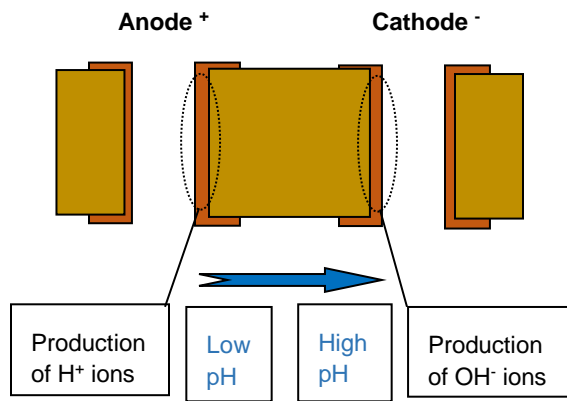


Figure 5: Reduction / Oxidation of an Exposed Metal

In Figure 6, the Pourbaix diagram example provides insight into copper solubility as a function of pH and the electrical potential applied. Copper is stable when exposed to a cleaning agent when the equilibrium potential is negative across the pH spectrum and is passive when exposed to a mildly alkaline cleaning agent with at a pH range of 8-10.5 when the equilibrium potential is positive (Figure 6)<sup>8</sup>.

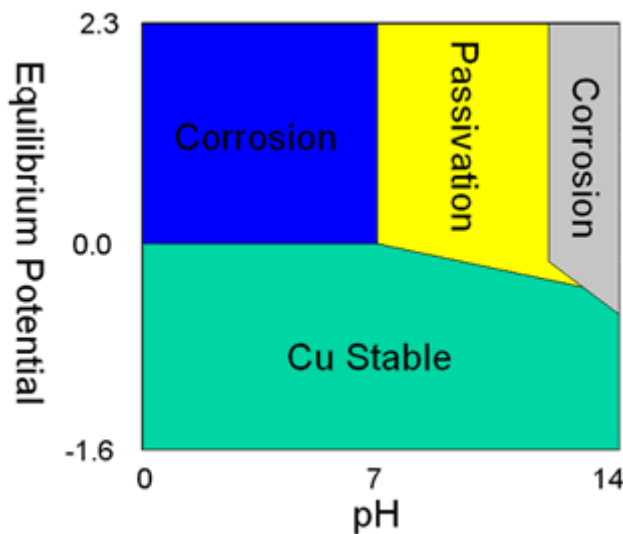


Figure 6: Copper Pourbaix Diagram

To summarize, a specific metal alloy has corrosive, stable and passive regions based on pH and equilibrium potential. Different metals are soluble in an aqueous medium as a function of the electrochemical potential and pH (Figure 7)<sup>9</sup>. A safe pH range for the metals commonly used on electronic circuitry is pH 7.5 – pH 9.5.

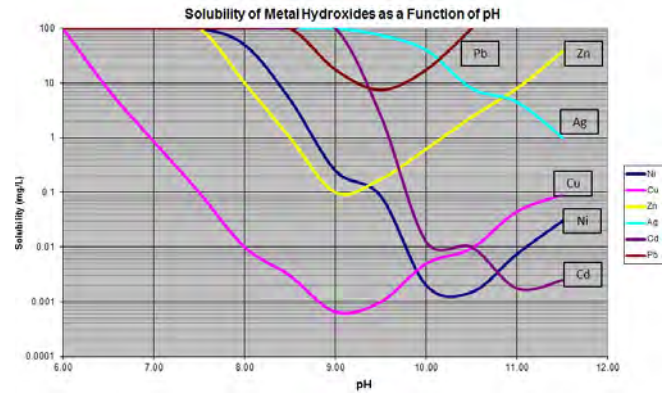


Figure 7: Solubility versus pH

### Corrosion Inhibition

Nearly all metals, with the exception of Au and Pt, corrode in an oxidizing environment. The corrosion reaction of a metal with a cleaning agent is electrochemical with the transfer of charged ions from the cleaning agent (electrolyte) across the surface of the metal<sup>11</sup>. The reaction only occurs at the surface of the metal<sup>10</sup>.

Metallic corrosion, resonating from surface reactions, can be controlled by compounds known as corrosion inhibitors that adsorb on the reacting metal surface<sup>12</sup>. The term adsorption refers to molecules attached directly to the surface, normally one molecular layer thick without penetrating into the metal itself. Corrosion inhibitors function in the following ways:

1. Anodotic / Cathodic Inhibitors - Restrict the rate of the anodic or cathodic process by blocking active site on the metal surface<sup>12</sup>
2. Passivation - Increase the potential of the metal surface so that the metal enters the passivation region where a natural oxide film forms<sup>12</sup>
3. Adsorption Inhibitors - The formation of a thin layer on the surface that protects the underlying metal from reacting with the cleaning solution<sup>12</sup>

Chemical inhibitors can be engineered into the cleaning agent to protect the metals from corroding during the wash process. Chemical inhibitors work by removing electrons from the metal, thereby pushing the potential into a positive region with an oxide film spontaneously forming<sup>[10]</sup>. Corrosion inhibitors render a passive surface resulting in a very low metallic corrosion rate.

Corrosion inhibitors have been successfully used within aqueous electronic cleaners. Aqueous engineered cleaning agents enable the ability to formulate the materials necessary to perform a wide range of functions during the cleaning process. Those operations include a material that is attractive to the residue, superior wetting, low foaming, metallic corrosion resistance and long bath life. High performing aqueous cleaning agents require a slightly alkaline pH. These slightly alkaline cleaning agents have been found to be superior cleaners for cleaning electronic post soldering flux residues.

Engineering corrosion inhibitors into the cleaning agent provides significant benefits. Electronic cleaning solutions must work on polymeric soils quickly. The polymeric flux residues form a covalent bond that encapsulates flux activators. To clean at a rapid rate, the cleaning agent must form both attractive forces with the resin, rosin or polymer structure. Additionally, reflow temperatures can further harden flux residues making them harder to clean. Mildly alkaline cleaning agents have been found to improve cleaning performance.

## EXPERIMENTAL

To clean many of the no-clean solder paste flux residues, an engineered cleaning agent with functional properties is needed. The best case cleaning agent is a material that exhibits the following properties:

- Aqueous engineered cleaning agent
- In use concentration range of 5-15%
- Effective at cleaning > 95% of solder pastes used within industry
- Low foaming
- Long bath life
- pH range between 7.5-9.75
- Corrosion inhibition technology engineered into the cleaning agent to protect exposed metals during processing
- Environmentally and user friendly

An advanced electronic hardware cleaning agent was designed focused on these properties. Four properties will be tested:

1. Cleaning Efficacy on difficult to clean solder paste flux residues
2. Bath life as a function of pH
3. Metal compatibility

## 4. Surface Insulation Resistance under BTCs

### Cleaning Efficiency on No-Clean Flux Residues

Twenty three industry commercial lead-free solder pastes were used to build test vehicles. The test vehicles were not populated with components. The boards were cleaned in the Aqueous Technologies Trident batch aqueous cleaning machine. The process parameters were as follows:

#### Process Parameters

- Aqueous Technologies Trident Cleaning Machine
- Aqueous cleaning agent at 15% Concentration / 85% DI Water
- 65°C
- 15 minutes

#### Response Variables

- Percent Clean on scale of 0-100%
- Solder Joint appearance on scale of
  - 1 = Black – heavy attack
  - 2 = Dark grey – significant attack
  - 3 = Grey – mild attack
  - 4 = Matted – slight attack
  - 5 = No attack

Electronic assembly Aqueous Defluxing cleaning agents tested.

- Aqueous 1.0 @ pH 10.3
- Aqueous 2.0 @ pH 10.0
- Aqueous 3.0 @ pH 9.0
- Aqueous 4.0 @ pH 10.1
- Aqueous 5.0 @ pH 8.8
- Aqueous 6.0 @ pH 9.5
- Aqueous 7.0 @ pH 7.5
- Best Case Aqueous 8.0 @ pH 9.75

The best case aqueous cleaning agent (Aqueous 8.0) provided the highest mean cleanliness scores for all the solder pastes flux residues studied. The polymeric flux residues were all cleanable in the engineered formulation (Figure 8). There was no material attack to solder alloys.

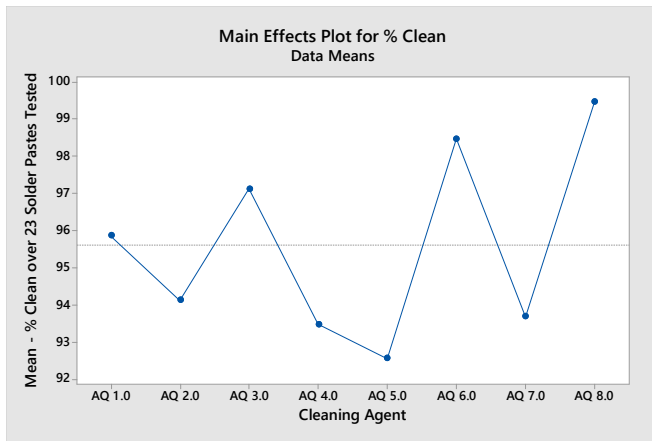


Figure 8: Mean Cleaning Performance

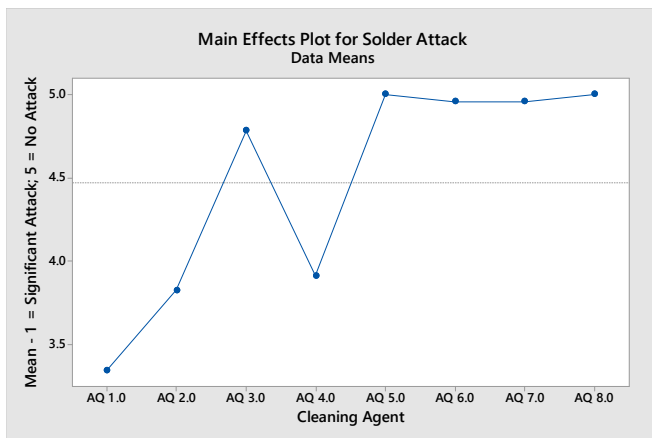


Figure 9: Cleaning Agent Interaction with Solder Alloy

### Bath Life

One of the challenges when cleaning with aqueous cleaning agents is the ability to control the wash bath. This complex requirement is compounded by the hundreds of flux and solder paste types available. Each material can affect bath life and monitoring. Common reasons for losses in cleaning efficacy can include foaming, redeposition of flux back onto the assembly, drop in pH, shift in active ingredients and soil reaction with the cleaning solution.

Solving the equation with multiple unknowns can be achieved using the following test methods:

- pH
- Concentration measurement
- Non-volatile residue
- Free / Total alkalinity
- Analytical instrumentation

Modern cleaning agents are formulated to dissolve residues and “hold” them in solution for long bath life. Not all fluxes, tapes, and masking materials are created equally. Each can behave differently. Every cleaning process has a critical saturation point where the dissolved soils begin to affect performance.

The dynamics of the aqueous cleaning process can be influenced by the cleaning tool. Spray-in-air tools create a highly humid condition within the air space of the machine. Air flows must be balanced. Losses take place from carry out from the cleaning section to the rinse section and exhaust. Water has a higher volatility and will be lost at a faster rate than will the ingredients within the cleaning agent.

The dynamics of the aqueous process can be beneficial for achieving long bath life. When the wash tank is controlled, monitored and replenished with water and cleaning agent at the designed concentration range, the system can run at a steady state. Replenishment of cleaning agents losses due to drag-out and exhaust losses moves small levels of contamination out of the wash tank and the addition of new cleaning agent to the wash tank can keep concentrations levels below critical soil load levels (Figure 10).

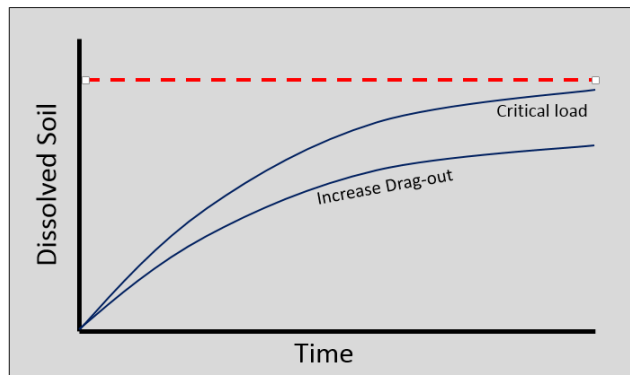


Figure 10: Bath Life Dynamics

The cleaning agent interacts with and in some cases, reacts with the flux residue. Most fluxes are slightly acidic. If the wash composition drops below a pH of 7, the residue can start to flocculate and drop out of solution. When this occurs, two issues arise: (1). Residues can be redeposited onto the surface of the assembly and (2). Cleaning agent performance drops. To stabilize and improve loading potential, the formation of a buffer can be engineered into the cleaning composition. A buffered cleaning solution improves wash bath stability, increases loading potential and prevents rapid pH drops as a function of loading.

To illustrate, a lead-free flux was used to test the equivalence points of the defluxing cleaning agents used in this study (Figure 11). The titration procedure can be used to test the strength of the cleaning agent buffer and pH as a function of flux loading. The pH values measured can slightly vary based on temperature and concentration.

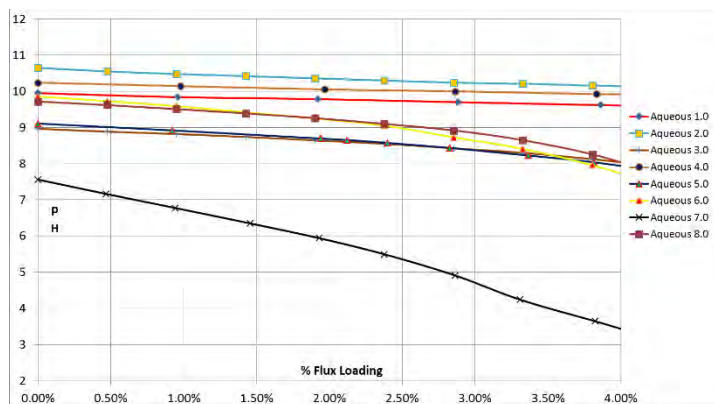


Figure 11: Flux Loading as Function of pH

### Material Compatibility

Miniaturized bottom terminated components with tight pitch and standoff gaps creates the need for longer wash time and high impingement spray systems. Cleaning agent compatibility with circuit board laminates, surface finishes,



components, metal alloys, adhesive bond strength, part markings, plastics and the configuration of materials in the assembly has become high priority. Other factors must also be considered, such as the chemical characteristics of the cleaning material, cleaning temperature, impingement energy, and exposure time to the cleaning process, including rework cycles.

For this study, a copper die was selected to test cleaning agent interactions. Unlike the traditional bumping process, the copper pillar design exposes a number of reactive metals to the cleaning process. Many of these metals can potentially react and dissolve when exposed to aggressive cleaning agents. Corrosion inhibitors can reduce, and in some cases, prevent this interaction. The challenge is designing cleaning agents that are effective at cleaning and inhibiting the different exposed metals that the cleaning agent comes in contact with. If longer cleaning time is needed, the risk of metal interaction is greater.

The following test was used to evaluate chemical compatibility of the cleaning agents evaluated within this study.

- Cleaning Agent Concentration ~ 15%
- Exposure Time ~ 20 minutes
- Temperature ~ 65°C

Figure 12 provides an overview of the test vehicle. The metals exposed to the cleaning agent are Al, Cu, Ni, and SAC alloys. The Al pad is outlined with silicon nitride.

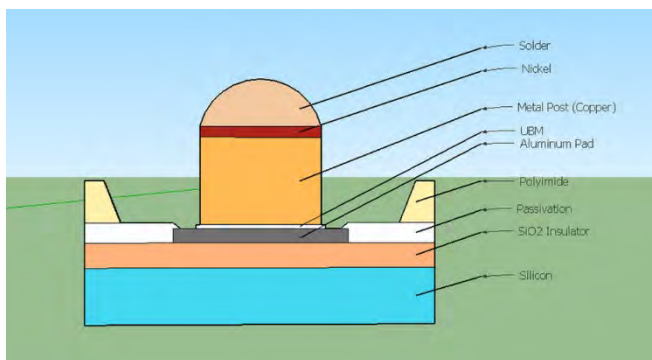


Figure 12: Copper Pillar Test Vehicle

Before and after test images were taken of the die exposed to the cleaning agents used for this study. From the images tested, the alloy interaction from the cleaning was scored using the following:

- N = No Attack
- L = Minor Attack

- M = Medium Attack
- H = Heavy Attack

Cleaning Agent	SAC	Copper	Al	Ni
Control	N	N	N	N
AQ 1.0	L	M	M	N
AQ 2.0	N	L	L	N
AQ 3.0	N	N	L	N
AQ 4.0	N	M	N	N
AQ 5.0	N	L	L	N
AQ 6.0	N	N	N	N
AQ 7.0	N	L	N	N
AQ 8.0	N	N	N	N

Table 1: Alloy Interactions with Exposed Metals

Each cleaning agents tested, the level of metal attack is based on pH, electrochemical potential and corrosion inhibition. The cleaning agent that provided the best performance was Aqueous 8.0. This cleaning agent was engineered for cleaning performance, long bath life and metal compatibility. Developing a cleaning agent that addresses many of the cleaning factors provides the end-user with a process window for cleaning today's electronic hardware.

Control

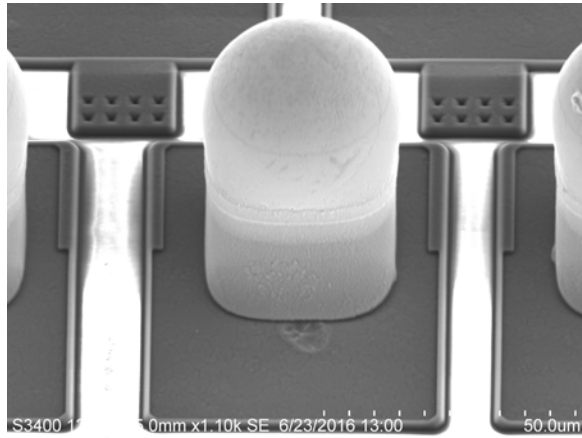


Figure 13: Copper Pillar Before Testing

Aqueous 3.0

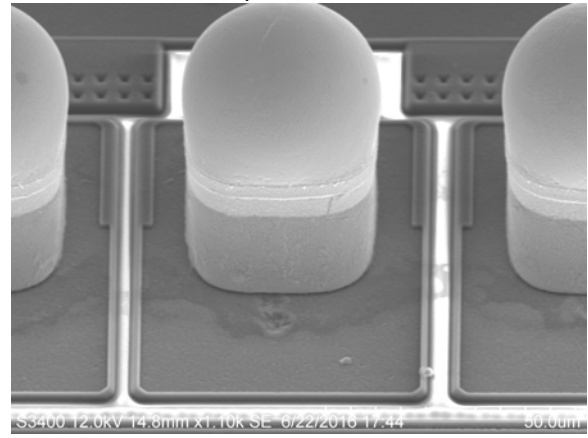


Figure 16: AQ 3.0 after Testing

Aqueous 1.0

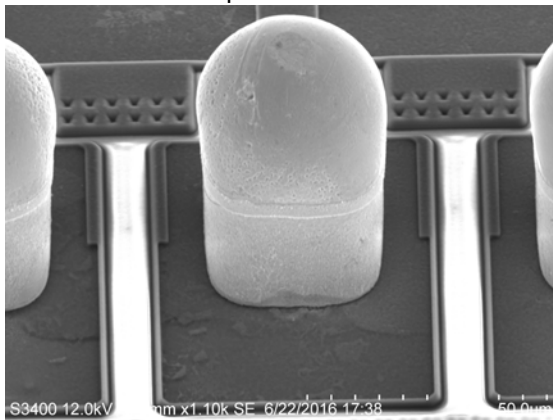


Figure 14: AQ 1.0 after Testing

Aqueous 4.0

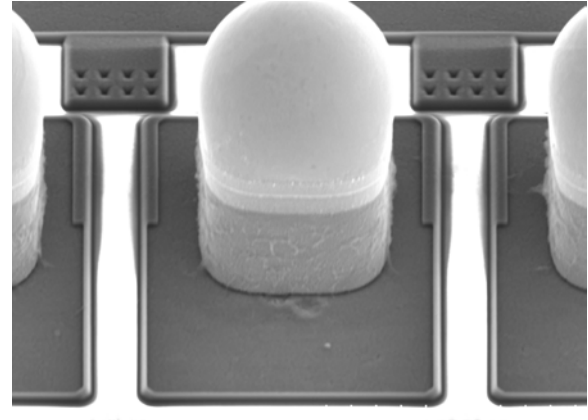


Figure 17: Aqueous 4.0 after Testing

Aqueous 2.0

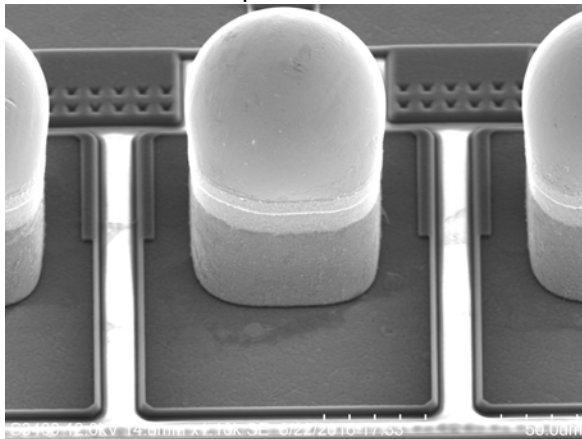


Figure 15: AQ 2.0 after Testing

Aqueous 5.0

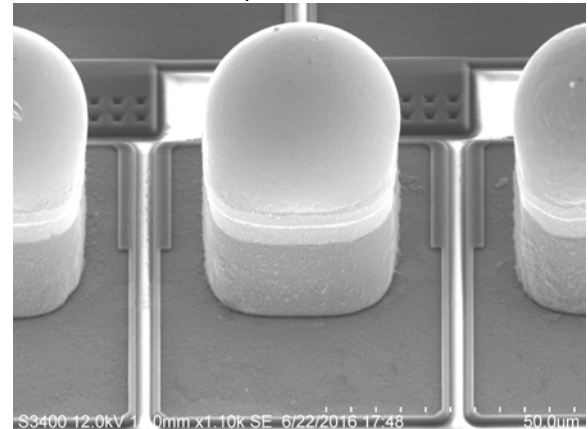


Figure 18: Aqueous 5.0 after Testing

Aqueous 6.0

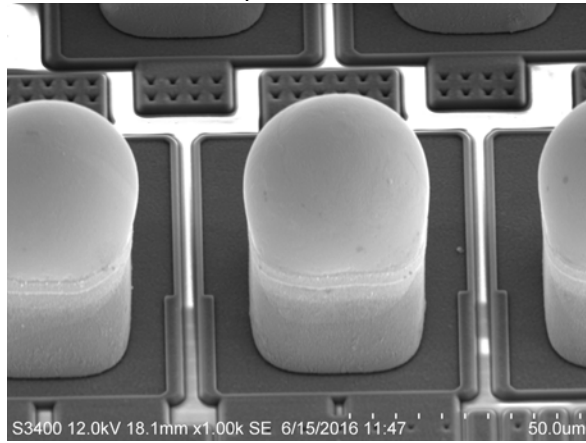


Figure 17: AQ 6.0 after Testing

Aqueous 7.0

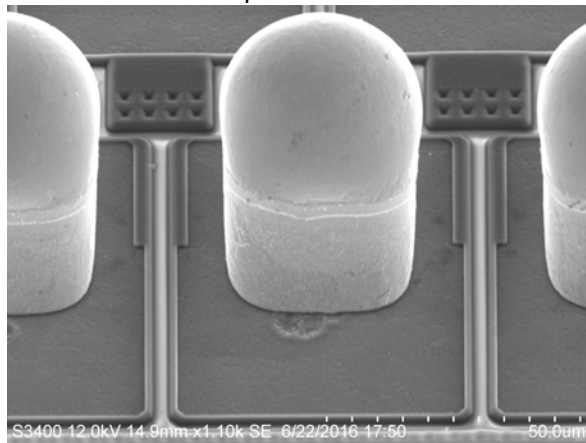


Figure 18: AQ 7.0 after Testing

Aqueous 8.0

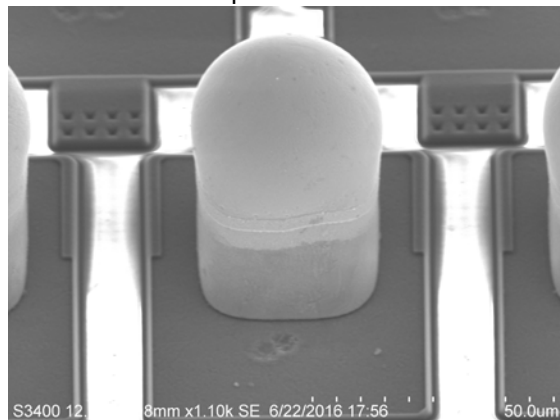


Figure 19: AQ 8.0 after Testing

AQ 8.0 provided the best overall performance for cleaning flux residues from numerous solder pastes, material compatibility, and corrosion inhibition.

#### Surface Insulation Resistance under BTCs

The test board designed for this study has sensors placed under the components bottom

termination. The component types selected are  $\mu$ BGAs, QFNs and Chip Cap resistors. Four solder pastes with different activator systems will be studied. Surface Insulation Resistance and Ionic contaminants of the residues trapped under the component termination will be measured. The DOE matrix calls for a subset of the boards to not be cleaned, a subset cleaned at process conditions where residues are still present under the bottom termination and a subset to be totally cleaned. AQ 8.0 was the cleaning agent used for processing these test boards.

The SIR readings data reported for each device show that the BGA and Passives show less of a response change when compared to the QFN devices. Cleaning effect is tabulated using the following color scheme:

- Green: Fully Cleaned
- Blue: Residues still under bottom termination
- Black: Residue not cleaned post soldering

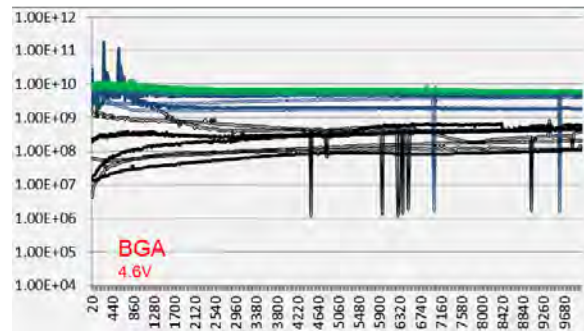


Figure 20: BGA SIR Data

BGA's fully cleaned with AQ 8.0 showed not sign of leakage potential. When processed at a throughput rate where some residue was present under the component, there was some leakage but the board recovered. For parts not cleaned, resistivity values were lower with many values under  $1.00E + 08$ .

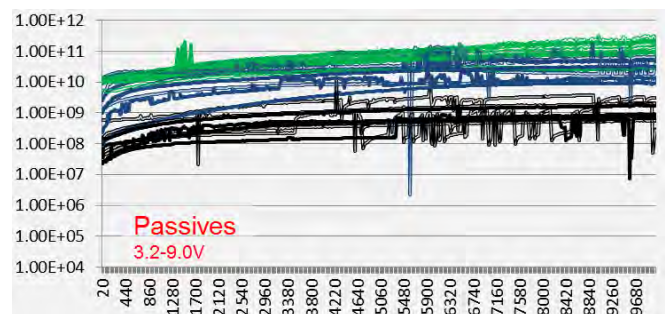


Figure 21: Passive SIR Data



Passive's fully cleaned with AQ 8.0 showed not sign of leakage potential. When processed at a throughput rate where some residue was present under the component, there was some leakage but the board recovered. For parts not cleaned, resistivity values were lower with some values under  $1.00E + 08$ .

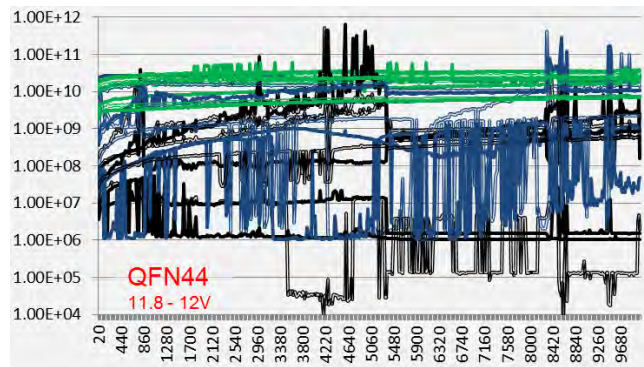


Figure 22: QFN44 SIR Data

QFNs show a significant amount of variability over BGA and passives. The complexity of residues under QFNs is due to the large ground lug, low standoff, trapped residue, flux outgassing and field strength. The data indicates the importance of total cleaning. When the part was totally cleaned with AQ 8.0, there was no sign of leakage currents. When processed at a throughput rate where some residue was present under the component, there was significant leakage. The data shows potential risks to oth partial cleaning and no cleaning under QFN components.

## CONCLUSIONS

Engineering the next generation cleaning agent is not an easy task. The cleaning agent must clean process soils, not attack metals and other assembly materials, work over an extended time period, match up with the cleaning tool, environmentally friendly, user safe and cost effective. Numerous factors can impact the cleaning process such as planar board surfaces, solder alloys, flux composition differences and exposed metals. Longer wash times, higher impingement energy and stronger cleaning agents are needed to achieve cleanliness levels.

Decreased conductor widths increase the electric field, which means that lower levels of ionic residues can be problematic. Humid environments creates a condition for ion residues to mobilize and develop leakage currents. The job of the cleaning agent is to

remove process residues and free the assmby of ionic contaminants.

Aqueous cleaning agents lend themselves to being engineered to the soils being cleaned, metal compatibility, equipment types and environmental limitations. Engineering the cleaning material to the application is key. Limiting factors include bath life, evaporative loss effects, controlling the cleaning agent and material compatibility.

Next generation cleaning agents clean polymeric soils. They work on a both polar and non-polar soils. They provide low surface tension, low foaming, entended bath life, environmental and worker safe and provide improved material compatibility. Corrosion inhibitors can render the cleaning agent passive to exposed metals.

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