empfasis

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The EMPF is a U.S. Navy-sponsored National Electronics Manufacturing Center of Excellence focused on the development, application, and transfer of new electronics manufacturing technology by partnering with industry, academia, and government center and laboratories in the U.S.

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In This Issue

Affordable Switches for Pulsed Power Systems

Several next generation military weapons systems rely on pulsed power systems. Early research efforts in this area were directed towards inertial confinement in nuclear fusion reactors. More recently, these systems have been applied to advanced military hardware including high power microwave or high power laser directed energy weapons, as well as electromagnetic launchers. In simple terms, a pulsed power system uses energy stored in a bank of capacitors that is discharged as brief pulses. Through the use of a pulse forming network, these pulses may be compressed and made shorter to increase the power density and the power in each pulse. One of the key components of a pulsed power system is the switch used to discharge the capacitor bank. This switch must be capable of operating in a high voltage environment and switching very high currents, with a very fast switching speed or rise time. Traditionally, gas discharge or vacuum switches are used in these systems.

Figure 1-1: Example of a light activated solid state switch illuminated with visible light.

However, solid state switches are expected to provide substantial reliability improvements in a more compact package.

OptiSwitch Technology Corporation (OTC) has demonstrated solid state switches that meet the basic requirements for military pulsed power systems. Traditional solid state switches are triggered (i.e. "switched") by the application of a gate voltage. In a conventional electrically gated device, the current initially flows around the gate area and current diffusion away from this activation point is required to support large currents. The diffusion process is slow, especially for high voltage devices, which limits the rate of current rise. In contrast, OTC uses a solid state switch that is triggered by an intense laser light pulse. The rate of light propagation through the bulk silicon device and the creation of carriers is much faster, compared to the traditional electrically gated solid state switch. This accounts for switching speeds that can be 100x greater than what is encountered in gate turn off (GTO) devices. A large area switch can be turned on by an optical pulse width of nanoseconds to microseconds. This triggering technology allows these switches to fulfill the needs of military pulse power systems. The use of an optical trigger also makes these switches more readily adaptable to a high voltage environment. Figure 1-1 shows an example of a light activated solid state switch.

The EMPF and OptiSwitch Technology Corp. are currently working together under a US Navy ManTech program to establish a manufacturing line for light activated semiconductor switches that will meet DoD production requirements and

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Affordable Switches for Pulsed Power Systems

(Continued from page 1)

achieve significant cost reductions. This program will optimize the yield of individual fabrication processes and develop testing procedures to remove defective devices before a significant amount of value has been added by the manufacturing process.

Unlike the more common CMOS integrated circuits, high power solid state switches require long minority carrier lifetimes. In fact, the performance increases achieved during this program have been directly correlated with greater and more uniform carrier lifetimes. Contamination is a common source of minority carrier lifetime degradation. In particular, iron is a common contaminant that must be eliminated. Under the ManTech program, a thyristor fabrication line was developed for the manufacturing of light activated semiconductor switches. Special attention was paid to the elimination or reduction of known contamination sources. This line produced wafers with greatly reduced contamination levels, compared to those manufactured elsewhere. Carrier lifetimes increased, as well as the high power performance of the device. Device yields from the new manufacturing line have substantially increased, which is expected to lead to significant cost reductions for the overall component.

Since these switches are designed for operation at high voltages, the devices require a significant amount of grinding and passivation coating. Processes have been developed to grind wafers accurately that are compatible with automated production equipment. The coating process has been optimized to produce switches that can withstand 20 kV with a high yield. Under the ManTech program, a hermetic package will be developed so that light activated switches are available in a presspak design configuration.

Through semiconductor process simulation software, the device defects were reduced and the performance optimized. The elimination of a particularly malicious process induced defect allowed the optical trigger pulses to be reduced by more than an order of magnitude with no loss in switch performance. This will allow the laser driver power supply to be considerably reduced, leading to an overall cost reduction of a light activated semiconductor switch.

For solid state switches, the number of cycles[1] to failure (N_F) can be conservatively related to the temperature excursion (ΔT) for each current pulse through the equation:

$$N_F = (300/\Delta T)^9 \qquad (1)$$

where ΔT is measured in °C.

In pulsed power systems, a discharge pulse duration is often in the range from 10^{-6} to 10^{-3} sec. In this pulse duration range, the heating of the switch is adiabatic, so one can estimate ΔT from the following equation:

$$\Delta T = \frac{R_{on} * \text{Action}}{c * \text{m}} \qquad (2)$$

R_{on} = "on state" switch resistance
c = specific heat of switch (silicon),
m = mass of switch.

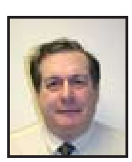
$$\text{Action} = \int_0^T I^2(t)\, dt$$

The equation above tells us that switch reliability will be improved by optimizing the semiconductor processing to give the lowest "on-state" resistance for the switch. This equation also allows the designer to estimate the reliability of the switch based on the "on-state" resistance and the action of the switch. OTC has demonstrated light activated semiconductor switches having actions in excess of 1×10^6 A^2-sec. A switch designed for greater than 200,000 cycles requires $\Delta T < 75$ °C.

In summary, a US Navy ManTech program is currently underway that will develop a manufacturing line for light activated solid state switches that meet the requirements for pulsed power systems needed for advanced weapons systems. This manufacturing system relies on a semiconductor wafer fabrication line that is optimized for these devices. Through process optimization and contamination reduction, the manufacturing yields and the performance of these devices have been substantially improved. These improvements are expected to lower the cost and improve the reliability of the advanced switches required by DoD pulsed power applications.

References:

[1] I.L. Somos, et.al, "Power Semiconductors Empirical Diagrams Expressing Life as a Function of Temperature Excursion", IEEE Trans on Magnetics, 29, (1993): 517-522.



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Cleaning Module of Boot Camp

The EMPF Boot Camp covers a wide range of course modules designed to provide participants with a basic knowledge of electronic manufacturing processes. The focus of this article is on the contents of the Cleaning module offered during the Boot Camp course. Students will gain an understanding of the concerns about cleanliness and residues common with electronic devices, the types of residues that are considered benign or harmful, the various cleaning chemistries and processes, safety issues and the most commonly used cleaning equipment.

Figure 2-1: Board before cleaning

One of the main reasons for cleaning residues left on electronic assemblies is to prevent corrosion of the components and boards. Improperly cleaned assemblies can also create problems other than corrosion. Specifically, the insulative properties of a board can be altered due to residue, the adhesion of conformal coating can be affected, or the residue may interfere with moving parts on the assembly. In some applications like RF, flux residue can change the RF properties (e.g. dielectric strength, surface resistance, Q-resonance, etc…) of the surface of the PWA.

Students will learn how to identify the commonly used processing materials considered harmful or corrosive and will learn the problems associated with contaminants left on a finished assembly.

Choosing a cleaning process involves understanding what is acceptable, either by meeting a cleanliness standard, using visual acceptance, or both. Identifying the type of contaminate to be removed will determine the type of cleaning materials. The through-put and specific manufacturer's limitations (e.g. disposal, space, auxiliary utilities, etc…) will dictate equipment choice. Students will learn about some of the more common equipment and chemistries used to clean electronic assemblies, in addition to the common incompatibilities between chemistries, equipment and materials used for cleaning assemblies. The following techniques - Solvent/Co-Solvent, Semi-Aqueous, Aqueous, DI Water, Emulsion and Plasma cleaning, will be compared and contrasted during the course, along with the following equipment - Batch Cleaning, In Line Cleaning and Ultrasonic Cleaning. The key process parameters/requirements for each technique/equipment will be discussed.

This course provides an overview of technologies available, and the ultimate goal is to ensure that the chemistries and equipment will remove the contaminants without degradation or damage to the product.

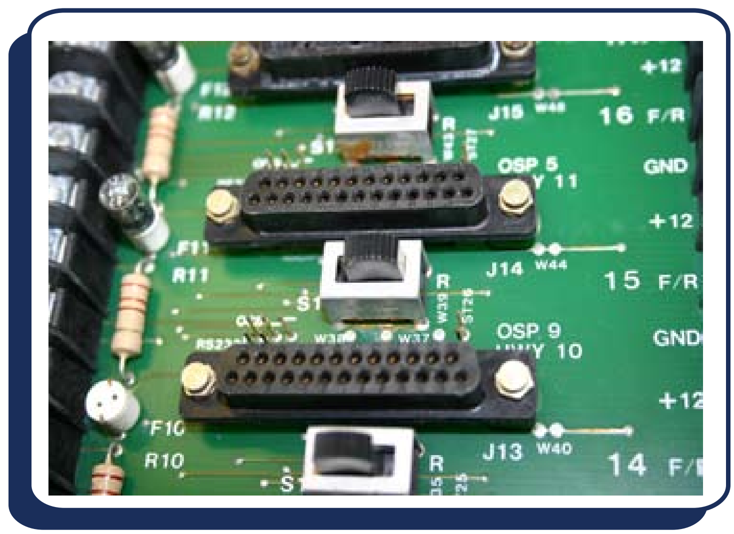

Figure 2-2: Board after cleaning

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Ask the EMPF Helpline!

A customer called the EMPF Helpline to obtain a visual assessment of their printed circuit boards that were assembled using a new Pb-free process and then subjected to accelerated aging tests.

A customer called the EMPF Helpline and explained their qualification strategy for a new Pb-free process. It consisted of manufacturing a series of boards using their lead free process, followed by environmental testing, and finally post-visual inspection and microsectional analysis. Their goal was to determine how well the joints survived exposure to environmental tests such as temperature cycling, and mechanical shock and vibration. The customer requested that the EMPF perform visual inspection to IPC standards as well as microsectional analysis of solder joints.

The boards were inspected at the EMPF. Excessive flux residue, burn marks, lack of vertical fill, board measling, and scratches are all symptoms of poor electronics manufacturing procedures, however, only some will ultimately affect the board reliability. The customer wanted to determine the relationships between quality and reliability before and after testing.

The manufacturer specified that the joints be cleaned and brushed with alcohol. In this case, the customer had procedures in place that were not being followed properly. Multiple boards and multiple joints were found with flux residue similar to that shown in Figure 3-1. Under high voltage application, these areas may develop ionic migration and ultimately cause a short circuit.

Burn marks were also noted indicating excessive tip temperature and extended duration of heat application. There were several instances of an unknown white residue also noted (Figure 3-2). Upon closer inspection and a further analysis, additional defects indicated a lack of attention to standard electronics manufacturing procedures. These ranged from a component in the meniscus (Figure 3-3), to scratches on the boards (Figure 3-4), to mis-formed leads on components (Figure 3-5), and over crimped leads and wiring at joint (Figure 3-6). These defects normally do not affect the board reliability, but are process indicators and should be eliminated from future production.

There were also boards that had measling (Figure 3-7). This is a condition that indicates a localized delamination of the epoxy fiber laminate. It can lead to reliability issues, especially with multilayer boards. Internal connections between vias can develop cracks and ultimately cause an open circuit in the field, resulting in a non-functioning assembly.

Another detrimental manufacturing defect detected that can affect long term reliability was an unacceptable fill of many of the vias (Figure 3-8). Without a properly formed joint, the mechanical strength of the joint is severely reduced. Over the duration of a severe environmental exposure, cracks will initiate and propagate, and ultimately cause an open circuit. Closer inspection of the image revealed that the unacceptable fill was present on the wide power trace of the component. The metal had acted as a heat sink, and reduced the solder flow to the point where it was not sufficient to complete the joint. The customer was advised of thermal profiling changes that would help eliminate this condition, improve long term reliability, and complete their intended goal of product qualification.

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Figure 3-1 Excessive Flux Residues

Figure 3-2 Unkown White Residue

Figure 3-3 Component in meniscus

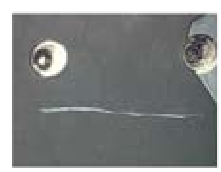

Figure 3-4 Scratches on board

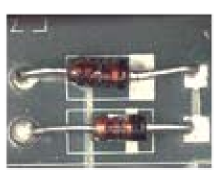

Figure 3-5 Glass diodes with mis-formed leads

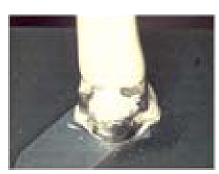

Figure 3-6 Overcrimped leads & wiring at joint

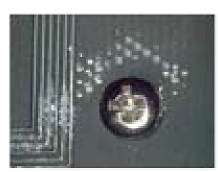

Figure 3-7 Board Measling

Figure 3-8 Lack of Vertical Fill

Conductive Anodic Filament Formation

Conductive anodic filament (CAF) formation is a well-studied phenomenon that is driven by chemical, humidity, voltage, and mechanical means. It is characterized by a sudden loss of surface insulation resistance. CAF can form between adjacent lines on a given layer of a printed circuit board (PCB), between plated through holes (PTH), or between a plated through hole and a line on the PCB. Flux chemistry, damage from multiple soldering steps, and excessive voltages (beyond designed voltages) accelerate the onset of CAF. The mechanism of CAF is an electro-chemical transport of ions across an electrical potential between anode and cathode.

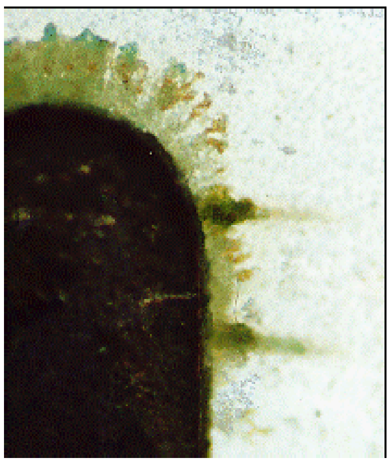

Figure 4-1: CAF that formed on the surface between lead fingers

Discovered by Bell Labs engineers in the late 1970's, (CAF) arises from a two-step process[1]. The first step involves the degradation of the fiber/epoxy interface of a PCB. Once the interface has degraded, delamination of the copper traces or a void in the PCB will occur. This is the first step to CAF formation. For a CAF to create a short circuit, the presence of a halide ion and a metal is required. Chloride ions were present in all of the CAFs found. However, other ions such as bromides have been found in the conductive path along with chlorides. The sources of halides in research studies have been associated with flux, but product line contamination, or the PCB itself cannot be ruled out.

Epichlorohydrin (C_3H_5OCl) is commonly used in the manufacturing of epoxy resin. Although most of the chlorine is driven out in processing, a trace amount of free chloride exists in the finished PCB. This is usually about 100ppm.

The Mean Time Before Failure (MTBF) for a CAF to create a short circuit is dependent on humidity, applied voltage, anode-cathode spacing, and the available halide source. The reaction will not take place without a void, or without a hollow glass fiber in the matrix to provide the pathway for electro-chemical migration. Many studies have found that CAFs follow the Arrhenius equation with primary acceleration factors of humidity, temperature, and applied voltage. Figure 4-1 shows a CAF that formed between a plated through hole and the power plane of a multi-layer board.

Additionally, the thermal gradients associated with component reflow increases the onset of debonding of the copper from the PCB and hence can decrease the time needed to produce a CAF by a factor of two[2]. Coefficients of thermal expansion (CTE) mismatches are a primary driver of degradation of the epoxy metal interface. However, butter coating of the surface layers of multi layer PCBs, with additional epoxy before stack up, has improved resistance to CAF. This butter coating process, adopted by many board makers, is routinely used today to enhance reliability of power PCBs.

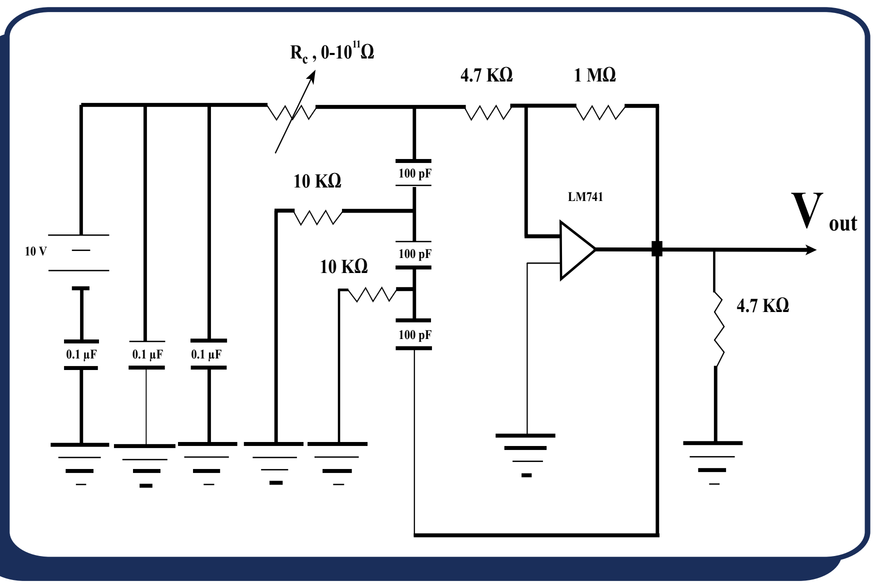

Figure 4-2: The linear circuit developed by Ready & Turbini[4]

Humidity pays a key role driving CAF formation, however, material/lot dependence for any given PCB on the MTBF at constant voltage, and physical spacing was found by Welsher[2] et al. His experiments also showed that by mixing triazine with fiberglass, a PCB with significantly better (20-30 times the standard) potential for reducing CAF formation was created.

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Conductive Anodic Filament (CAF) Formation
(continued from page 5)

As stated earlier, flux chemistry plays a role in CAF formation. Water soluble fluxes (WSF) that are poly glycol based (polyethylene, polypropylene) and contain a chlorine activator increase the likelihood of CAF. Even bromine-activated fluxes can create CAF but the mechanism for bromine traced CAF requires 15% bromine in the flux to be found chemically[3].

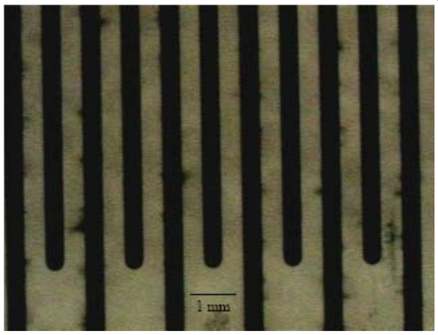

Figure 4-3: The Comb structure used[4]

For many years, the use of the J-STD-004 method for measurement of surface insulation resistance (SIR) could not identify a CAF. The method contained a reversing of the anode and cathode during testing, and continuous monitoring was not specified. This allowed CAFs that formed on the surface of a comb structure to be blown out by the test method. Clearly, a better method needed to quantify the phenomena that was observed in real use but could not be seen in SIR testing.

Ready and Turbini[4] developed a better method. They utilized a linear circuit containing an op amp that reduces the current flow as the CAF grows and reaches the short circuit stage. They fabricated a PCB structure that contained the circuit and used a comb structure with tight spacing to generate CAFs. With this circuit, Ready and Turbini created and recorded many CAFs successfully. Figure 4-2 is a schematic diagram of the circuit they used. Figure 4-3 is the comb structure they used. In figure 4-4, a dendrite that formed on the test structure was preserved by the action of the linear circuit.

In cases where incidence of CAF must be reduced or eliminated, there are a few options at our disposal:

1) Use triazine based PCB construction methods
2) Avoid use of water soluble fluxes based on medium to high molecular weight polyglycol chemistries containing high concentrations of halide activators
3) Avoid multiple reflows, or hand soldering rework
4) Use generous line and space rules (>5mil space minimum)
5) Butter coat the B staged PCBs before stack up and curing

Figure 4-4: Color Image of a conductive anodic filament

6) Use laser drilling rather than mechanical drilling, as mechanical drilling can pull voids when a dull bit is used

By taking the above steps, the onset of CAF formation can be slowed down to extend the useful lifetime of the product.

References

[1] Welsher, T.L.,J.P. Mitchell, and D.J. Lando, 18th Annual Proc. Reliability Physics (1980):235-237.

[2] Welsher, T.L.,J.P. Mitchell, and D.J. Lando, Annual Report of the Conf. on Electrical Insulation and Dielectric Phenomena (1980):234-238.

[3] Ready, W.J.[3] Master of Science in Metallurgical Engineering Thesis, Georgia Institute of Technology, (1997).

[4] Ready,W.J.[4], L.J. Turbini, R. Nickel, and J. Fisher, J. Electronic Materials. 28(1999):1158.

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Cleaning During the Assembly Process

In today's electronics manufacturing, there are several unique flux chemistries utilized in the assembly process. The decision to use a particular flux is based on the end use environment of the printed circuit board. This dictates the allowable flux residues left on the printed circuit board that may have long term reliability effects. Cleaning processes are defined based on these types of flux chemistries.

Types of Cleanable Flux Chemistries

The three common types of cleanable flux chemistries used today are Water Soluble, RMA only, and RMA/Low Solids (Hybrid).

Water Soluble – The most active of all fluxes as it contains mostly organic acids. It is primarily used to increase solder wetting especially on boards that have been oxidized or consist of land platings that are difficult to solder. Water Soluble chemistries require cleaning in deionized (DI) water that has temperatures ranging from 130^{o}F-150^{o}F. A cleaning agent or saponifier can also be used for better results.

RMA Only – Rosin Mildly Activated flux is less aggressive and consists of smaller amounts of activators than water soluble. This results in fewer residues left behind after soldering. However, because of the multiple types of rosins used, this flux requires a saponifier heated at 100^{o}F-150^{o}F to properly remove any residues. DI water is recommended for a final rinse. Regent grade isopropyl alcohol (IPA) can also be used for manual cleaning by agitating with an acid brush.

RMA/Low Solids (Hybrid) – This flux leaves behind low active residues that do not have to be washed. However, it is active enough to solder like an RMA with the option to be cleaned. This too can be cleaned using a saponifier heated at 100^{o}F-150^{o}F as well as manually with IPA.

Choosing a Cleaning Process and Equipment

The cleaning process is defined by the quantity of printed circuit boards produced, the type of flux being used, and the types of components populated. The four types of cleaning processes used on printed circuit board assemblies are Semi-Aqueous, Aqueous, Emulsion, and Vapor Degreasing.

Semi-Aqueous – This system is typically a two part batch process that consists of a solvent step in one unit and DI treatment in a second (Figure 5-1). The organic solvent is used to clean flux residues and is then rinsed under heated DI water.

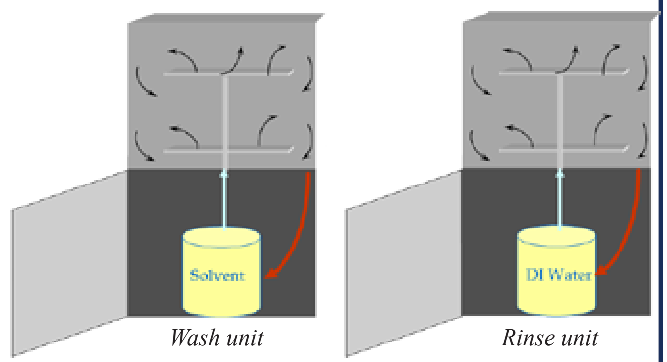

Figure 5-1: Semi Aqueous Batch Cleaners

Advantages:

- Can be closed looped and have zero solvent discharge
- Environmentally friendly
- Excellent cleaning ability
- Low cost solvents
- Good compatibility with most electronics materials

Disadvantages:

- Requires DI water rinse and dry
- Water may be difficult to remove:
  - From complex shaped parts
  - Parts cleaned in large batches
- Water may corrode parts / assemblies
- Generally requires waste treatment
- Some semi-aqueous solvents have flammability issues
- Capital equipment may be costly

Aqueous – Is typically a one part process that can be either inline or batched. Aqueous cleaning consists of using either DI water alone (for water-soluble fluxes only), with a saponifier, or surfactant (Figure 5-2).

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Cleaning During Assembly
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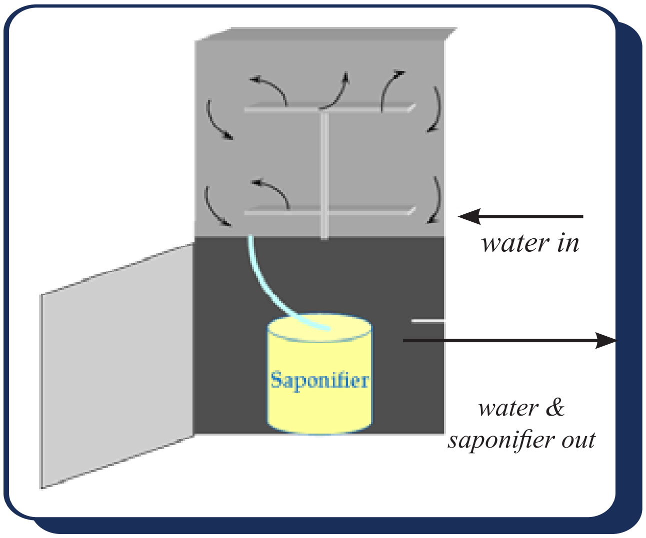

Figure 5-2: Aqueous Batch Cleaner

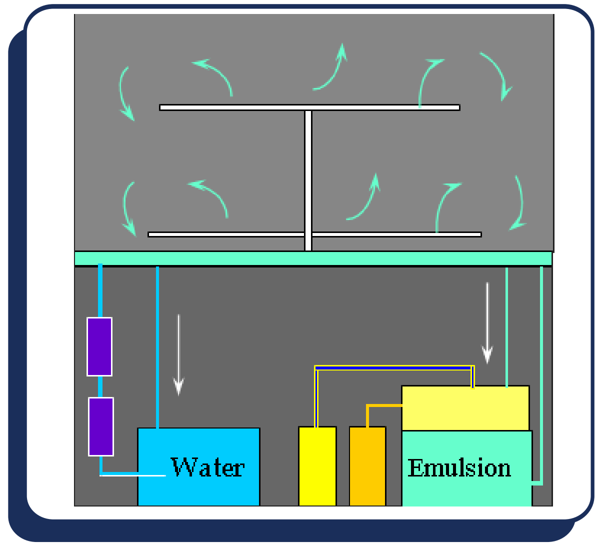

Figure 5-3: Emulsion Batch Cleaner

Advantages:

- Can be a partially closed-loop process
- Minimizes discharge
- Less costly process and chemistry than semi-aqueous or solvent / co-solvent processes
- Aqueous solvents do not have flammability issues
- Allows flexibility - use either water soluble or rosin based fluxes

Disadvantages:

- Requires DI water rinse and dry
- Water may be difficult to remove from complex shaped parts or parts cleaned in large batches
- Water may corrode parts / assemblies
- Generally requires waste treatment
- Capital equipment may be costly
- Requires process monitoring when using saponifier

Emulsion – This process consists of the suspension of water in small globules. The water is then mixed with an immiscible solvent where suspension is attained by agitation to remove manufacturing residues. DI water is used to perform the final rinse (Figure 5-3).

Advantages:

- Can be closed-loop, zero discharge
- Solvent readily separates from water
- Allowing for easy waste treatment
- Less costly
- It only uses 5% solvent with 95% water
- Less waste disposal
- Environmentally friendly

Disadvantages:

- Requires DI water rinse and dry
- Water may be difficult to remove
  - From complex shaped parts
  - Parts cleaned in large batches
- Water may corrode parts / assemblies
- Limited drying ability

Vapor Degreasing – The solvent or rinse tank is boiled creating a vapor atmosphere that encompasses the board removing any residues. The board, traveling in a basket, is then cooled at room temperature (Figure 5-4).

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cut here and save!

Tech Tips...
Identifying Flux Residues

Why identify flux residues? The primary purpose of flux is to reduce species of metal oxides from solderable surfaces, and to act as a mechanism for lifting and removing debris. If the assembly is not properly cleaned after manufacturing, flux may continue to reduce metals and may eventually corrode the assembly. When the assembly is powered, the metal ions may precipitate along electromagnetic field lines and form dendritic shorts. In addition, the presence of residue can alter the insulation properties of a board, affect the adhesion of the conformal coating, or interfere with the moving parts of the assembly. In RF (radio frequency) applications, flux may change the RF properties on the surface of the PWA such as the dielectric strength, surface resistance, and Q-resonance.

Different flux chemistries require different cleaning chemistries. Identifying the presence, amount, and type of flux residues helps the manufacturing engineer judge the effectiveness of the cleaning processes and the appropriateness of the cleaning chemistry.

Rosin (RO) is the traditional flux type and is based upon tree sap (colophony). Resin (RE) based fluxes typically are synthetic and contain some form of organic polymer as the matrix. Inorganic (IN) fluxes are synthetic and can be composed of salts, alkali, or mineral acids. Organic (OR) fluxes are composed of weak organic acids other than rosin or resin. Water soluble fluxes are generally organic fluxes with high (H) activity levels.

Fluxes are identified by the activity level of the flux and its residue. The activity level describes the flux's ability to "clean" (remove oxides and tarnish) from solderable surfaces. Historically, activity was achieved through the addition of halides. Halide residues are very corrosive and their concentration levels are important. Less aggressive flux activity is achieved by the addition of a weak organic acid. Therefore, flux activity is identified by the absence or presence of halide (0 or 1) and also by the activity of the flux residue as represented by letters: L=low, M=moderate, H=high.

"No-clean" fluxes are also referred to as "low solid" or "low residue" fluxes. These fluxes are designed to leave a benign residue that may or may not be cleaned. No-clean fluxes typically have low (L) or moderate (M) activity levels. It is important to remember that "no clean" actually refers to the electronics manufacturing process where low solids fluxes are used. These electronic assemblies may or may not be cleaned.

Various laboratory techniques are available for quantitative and/or qualitative flux residue identification. The EMPF uses a dynamic ionograph for ROSE (Resistivity of Solvent Extract) tests. This test measures the overall ionic cleanliness of a sample by comparing the amount of flux residue left on a board to a salt (NaCl) standard. The ionograph works best with RO fluxes that easily dissolve into a bath of isopropyl alcohol (IPA) and water. Ion chromatography (IC) analysis is used to determine the types of ionic residues remaining on the assemblies. Specifically, IC measures individual levels of F, Cl, Br, NO_2, NO_3, PO_4, and SO_4.

The EMPF can perform Fourier Transform Infra-Red (FT-IR) spectroscopy on liquid and solid samples. This is an excellent technique for identifying unknown residues. In addition, Scanning Electron Microscopy with EDS can be used to identify the presence of Bromides and Chlorides.

Surface Insulation Resistance (SIR) determines the corrosive effects of fluxes, conformal coatings, and cleaning materials. SIR testing also characterizes the material's resistance to creating short circuits. SIR testing is often used when changing cleaning materials and or changing flux chemistry.

In conclusion, ionic contamination left by flux residues can lead to corrosion and dendrite growth, two common causes of electronic shorts and opens. Other residues can lead to unwanted impedance, poor adhesion of solder mask and conformal coating, and physical interference with moving parts. Flux residues need proper identification in order to choose effective cleaning chemistries. The EMPF offers various analytical techniques (ROSE, IC, FT-IR, SIR, etc.) to determine the root cause of contaminant problems and to evaluate the effects of process or materials changes on cleanliness.

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Manufacturer's Corner
Cleaning Lead-Free Prior to Conformal Coating

Process engineers are fully aware a number of contaminations, created during the soldering processes, will significantly impair the cross linkage of conformal coatings but are safely removed by an adequate cleaning process.

There has been a clear and consistent increase in the demand for no-clean (eutectic as well as lead-free) products over the last few years. This trend coincides – and has been correlated – to the growth of observed in-field service failures, particularly with conformal coated assemblies.

Figure 6-1: Optically Cleaned

Despite potential risks and shortcomings, the no-clean concept has established itself as a dominant production process for a majority of product segments.

Unfortunately, many companies have learned a difficult lesson by adopting no-clean processes that include additional production steps, such as component underfill, or applied conformal coatings.

At the same time, lessons learned within the cleaning community, have promoted new innovations, such as broader process windows, improved economics, higher industrial safety, and full material compatibility.

These improvements have assisted the return of cleaning as a value added production step. It has been said that cleaning behaves similarly to coating in that when introduced after the fact, it severely impacts the entire assembly process and becomes unnecessarily expensive!

It is commonly accepted that the cleanliness of assemblies plays a vital part in the quality of subsequent production steps. Industry standards such as J-STD 001D, item 8, are the most commonly applied and are the generally accepted procedures for assessing cleanliness. Light-optical magnification, for example, is used within the electronic manufacturing industry to identify visible contamination. Unfortunately, some of the critical residues are not easily visualized.

Ionic contamination measurement is currently the most widely used method. It quantifies the sodium chloride equivalent (VNaCl) in accordance to TM650. Geometries and surface areas of populated assemblies are unfortunately not taken into consideration. In other words, the measured values are only benchmark values and not scientific cleanliness assessments. For proper statistical control, three to five measurements of identical PCBs is the minimal requirement.

Current users of no-clean processes can attest to the very thin layered, transparent and often unrecognizable (i.e. by light optical inspection) flux-based films that remain. The latter are neither reliably authenticated via ionic contamination measurement nor can such residual contamination be cost-effectively substantiated using charge contrast measurements.

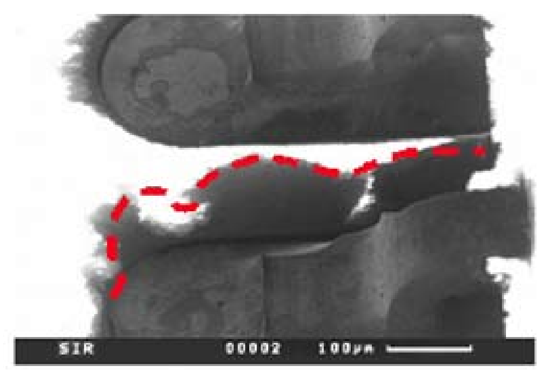

Figure 6-2: Electronically Contaminated

Innovative and simple-to-use procedures (i.e. Flux Test kits) can complement the above-mentioned shortcomings. By means of selective discoloration of residual organic acids, this test not only provides proof of their existence but also visualizes their local distribution. In addition, new innovative tests have recently attracted considerable attention.

As the transition to lead-free materials continues, more users will refer to new innovative methods such as a contact angle measurement (CAM) or Flux test kits.

continued on page 11

Cleaning During Assembly
(continued from page 8)

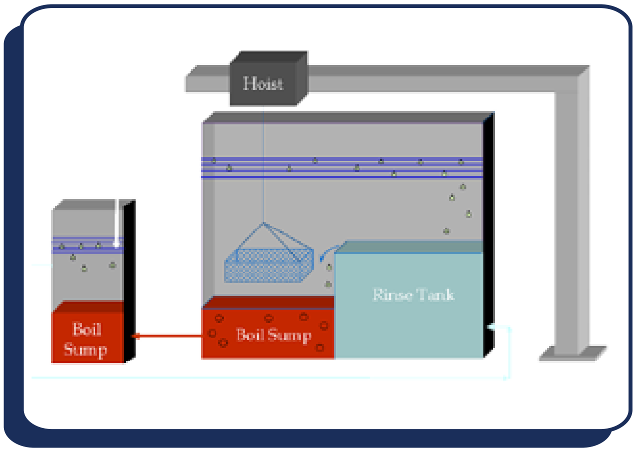

Figure 5-4: Vapor Degreaser

Advantages:

- Recycles solvent creating less waste
- Degreasing units are self contained and do not require recirculating systems as do in-line cleaners
- Less floor space is used compared to in-line cleaning
- Cheaper operating costs than in-line systems

Disadvantages:

- Limited in the number of boards cleaned simultaneously
- The solvent can be costly
- Some solvents used in vapor degreasing are environmental hazards
- Throughput is not as fast as in-line cleaning systems

In closing, the cleaning process used during assembly depends on factors such as flux chemistry, the type of populated components, and the quantity of boards being produced. These factors will also dictate whether to use a cleaning agent, as well as the type of equipment best suitable for the number of boards. It is important to understand and define the cleaning process being implemented, for it is one of the major concerns that effect long term reliability in today's electronics manufacturing.

Joe Cannella - *Joe* is an Instructor at ACI. Comments or questions pertaining to this article can be sent to tcannella@aciusa.org

Manufacturer's Corner
Cleaning Prior to Conformal Coating (cont. from page 10)

Through the emergence of new levels and types of contamination, their analytical detection becomes significantly more important than ever. With gained control over the contamination and the adequate cleaning process, users will then have to address the types of conformal coatings and their respective material properties and behaviors.

The susceptibility of assemblies to failure can range from delamination of conformal coatings to electrochemical migration, and even to the actual design of the circuit.

It has been demonstrated that the removal of contamination prior to conformal coating provides significant improvements in the adhesion of conformal coatings and at the same time reduces the possibilities of contamination induced failures.

Furthermore, it has been established the onset of lead-free products, the level of contamination, and its respective impact add to the complexity of adequate process control.

In light of this ongoing transition, research engineers are extending their investigation to provide even greater insight into lead-free initiated phenomena.

This in turn will lead to more adequate analytical tools for detection and complementary know how for coating materials and their respective performance.

For additional information on the above article or to schedule a demonstration at the EMPF, contact Robert N. Berta, 610-362-1200 ext 253 or via e-mail at rberta@aciusa.org.

Robert Berta - *Robert* is the Business Development Representative at ACI. Comments or questions pertaining to this article can be sent to rberta@aciusa.org

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February 12-16
March 12-16

J-STD-001 Instructor Recertification
January 17-18
February 21-22
March 21-22

IPC-A-610 Instructor Certification
January 22-26
February 26 - March 2

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February 23
March 23

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