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 centers and laboratories in the U.S.

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In this Issue

Advanced Electronic Connector Technologies

Military electrical connectors have traditionally used very conservative design rules that provide the ruggedization needed for harsh military use environments. Commercial electronic connectors have typically used less conservative design rules that provide sufficient reliability in the less harsh environments of the commercial world.

The EMPF is adapting these two novel commercial connector design features to standard military connector applications. The result is military leveraging of innovative commercial connector technology for the benefit of the warfighter. In addition to the first applications targeted at the electronic systems used aboard the Navy's new Zumwalt class destroyer, other potential applications are:

- Additional Navy high power, high density interconnect applications
- Army (or other service) battery connector applications

Standard connectors are rated to electrical current carrying capacity typically based on two or three (bifurcated or trifurcated) sliding beams contacting each connector pin within each socket.

The two connector technologies being investigated enable higher electrical currents to be conducted through smaller connectors by multiplying the number of individual contact points making electrical contact between the pin contacts in the plug half and the socket contacts in the receptacle half of the connector pair.

The two new commercial technologies being investigated at the EMPF exploit multiple (tens or hundreds) electrical receptacle contacts to each connector pin. The first of these, from Bal Seal Corporation, is shown in Figure 1-1.

The second of these innovative designs from Methode Technology (formerly Tribotek) is shown in Figure 1-2.

Close-up photographs of the three socket contact methods are shown in Figure 1-3.

These multiple connection technologies reduce contact resistance by increasing the number of contacts between the pin and the socket, thus decreasing pin heating and allowing increased current carrying capacity for a given standard pin size.

Figure 1-1: Bal Seal Corporation's toroidal spring concept. Each coil in the spring provides an additional contact point between the contact pin and the contact socket. Several such springs are inserted into grooves in the socket contact. When the pin is inserted, many contact points engage the pin.

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Ask the EMPF Helpline!

Discoloration of Immersion Silver Board Finish

Recently, a customer called the EMPF Helpline after observing discoloration of an immersion silver (IAg) finish on their printed circuit boards (PCB). The customer wanted to know the origin of the discoloration (Figure 2-1) and whether the discoloration would affect the reliability of the assembly.

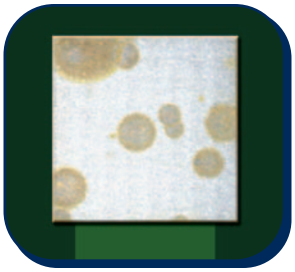

Figure 2-1: Discolored immersion silver finish (IAg).

Since the implementation of RoHS (Restriction of Hazardous Substances) and WEEE (Waste Electrical and Electronic Equipment) regulations by the European Parliament in 2006, immersion silver has become one of the choices for a lead free board finish. IAg is attractive because it minimizes copper oxidation from high temperature lead-free assembly processes better than organic solderability preservatives (OSPs). Also, the IAg finish does not form tin-copper intermetallic growth during storage as 100% tin finishes do. The consistent distribution of IAg plating thickness can meet the high density surface mount component requirements better than hot air solder leveling (HASL) finishes. The IAg plating process also does not attack solder mask and substrate and the IAg solder surface is compatible with lead-free and tin-lead solder temperatures.

IAg finishes have a 12-month shelf life in a controlled environment (<35ºC/<85 RH), which can be significantly shortened when exposed to air pollution with high sulfur and chlorine content. Silver embrittlement (Ag_3Sn intermetallics) of solder joints may occur when the finish thickness exceeds the IPC-4553 recommendations and lead-free, high silver content solders are used. IAg is not recommended for high reliability assemblies that must meet the IPC-6010 Qualification and Performance Series class 3 requirements, but is acceptable for class 1 and 2.

Fourier Transform Infrared (FTIR) spectroscopy was performed to confirm the presence of silver tarnish (Figure 2-2). The appearance of a broad peak around 3500 wavenumber (cm^{-1}) is typical of O-H bonding and is indicative of waters of hydration. From the FTIR spectrometric analysis, it is likely that the discolored area is a mixture containing silver tarnish (Ag_2S) which can further oxidize to silver sulfate (Ag_2SO_4).

Excessive tarnish can inhibit the effectiveness of flux during manufacturing and may eventually lead to corrosion of the silver finish and the underlying copper conductors. Evaluation of the solderability of tarnished PCB lots can be determined by testing to J-STD-003B, Solderability Tests for Printed Circuit Boards.

Discoloration of IAg finishes may originate due to problems in the board manufacturing process or due to poor storage conditions. Incomplete, thin, or low silver content finishes will affect the ability of the IAg finish to protect the underlying copper pad from oxidation. X-Ray Fluorescence (XRF) is a quick testing technique for measuring plating thickness and silver content. Plating issues typically have their origin in the plating bath. Check the bath for low temperature, excessive copper content and/or low silver content. Confirm that the cleaning process is removing solder mask residues from the PCB prior to plating.

When the IAg finish is applied correctly, silver tarnish may develop due to poor post cleaning or poor storage conditions. Exposure to sulfur, dirty rinse water, and improper drying can promote tarnishing. Sources of sulfur are air pollution, rubber bands, latex gloves, desiccant, and sulfur bearing paper used to separate parts. Use deionized (DI) water for the final rinse and thoroughly dry boards after rinsing. Check that the DI water filter system is functioning properly. Limit board exposure to atmosphere circulation by storing boards in sealed, dry bags or dry boxes. Use non sulfur content paper to separate boards. Do not use rubber bands and avoid desiccants containing sulfur. A common ingredient of commercially available laboratory grade desiccant is gypsum (calcium sulfate anhydrite, $CaSO_4$) which contains sulfur. If a desiccant is to be used, consider choices that do not contain sulfur, such as silica gel (silicon dioxide, SiO_2).

The EMPF offers a wide rang of analytical services that support PCB failure investigations. These services include FTIR spectroscopy, elemental analysis using XRF, sequential electrochemical reduction analysis (SERA), solderability tests, optical and scanning electron microscopy. The EMPF also offers lead-free manufacturing process development support such as board design reviews and independent vendor qualifications. More information about these services can be found on the EMPF website, www.empf.org or by calling the EMPF technical staff at 610.362.1320.

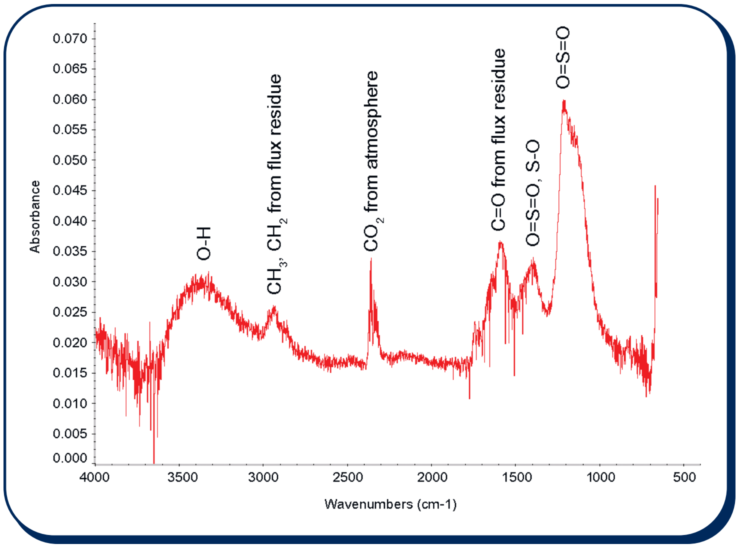

Figure 2-2: FTIR spectrum of discolored immersion silver finish (IAg).

Rebecca Morris | Materials Engineer

Method of Detecting Contamination

Minimizing contamination on a printed circuit board (PCB) is crucial to an assembly's performance and reliability. There are two classes of contaminants, ionic and non-ionic, that can be deposited during electronics manufacturing processes. The type of problem experienced by the customer determines the type of contaminant expected, which in turn determines the test method employed. Non-ionic contaminants are typically organic compounds, such as polymers, oils, or greases that are left on a PCB after production. An organic surface residue can cause problems with conformal coatings or may be an indication of an issue with the solder mask. Ionic contaminants can lead to corrosion and dendrite formation, both of which can cause electrical failures.

There are two IPC test methods for determining:

1. that an organic contaminant is present, in IPC-TM-650 2.3.38C, *Surface Organic Contaminant Detection Test*, and
2. the identity of the organic contaminant via Fourier Transform Infrared (FTIR) spectroscopy, in IPC-TM-650 2.3.39C, *Surface Organic Contaminant Identification Test (Infrared Analytical Method)*.

Surface Organic Contamination Detection Testing:

In the "Surface Organic Contamination Detection Test," the PCB samples are rinsed in a dropwise fashion with 0.5mL of acetonitrile onto precleaned aluminum coated glass slides. Using aluminum coated glass sample slides instead of glass-only slides reduces the background infrared absorption from the glass itself, increasing the signal to noise in the subsequent analysis. After the solvent has evaporated, more acetonitrile is rinsed over the PCBs and evaporated. This process is repeated until a total of 3.0mL of acetonitrile has been deposited and evaporated from the slides. A control slide is used to verify that no residue was left by acetonitrile alone.

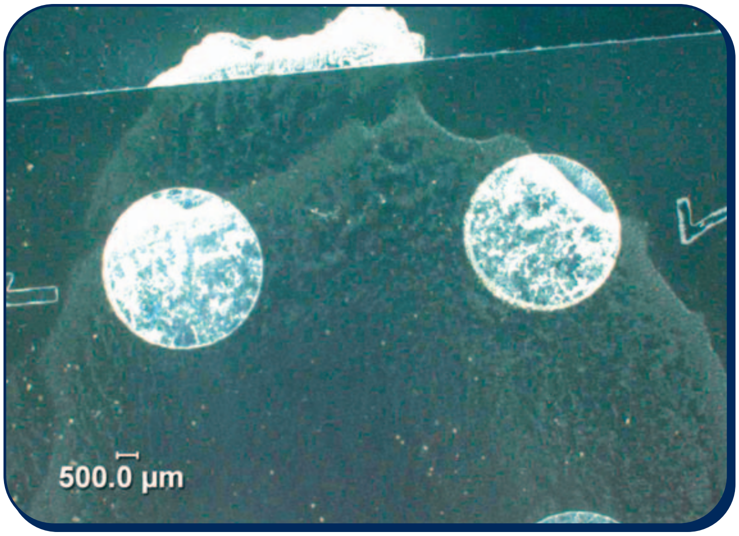

Figure 3-1: Image of residues obtained from rinsing a bare PCB.

The slides are examined for visible signs of residue. When residue is observed, images of the slides are captured using a microscope and analyzed with the subsequent FTIR testing procedures. An example of residue observed with this method is shown in Figure 3-1.

Surface Organic Contamination Identification Testing:

FTIR spectroscopy is a technique in which infrared energy is used to excite fundamental vibrational and associated rotational-vibrational modes of molecules in the mid-infrared, approximately 4000 to 400 cm^{-1}. These vibrational modes correspond to molecular structures. Attenuated Total Reflectance (ATR) is a technique used with FTIR, which allows liquid and solid samples to be studied directly without further preparation. In ATR-FTIR, an infrared beam is directed through an optically dense crystal at a certain angle and internally reflects through the crystal, producing evanescent waves. When the crystal is pressed against an infrared active material, the infrared radiation from the evanescent waves, penetrates typically one to four micrometers into the sample.

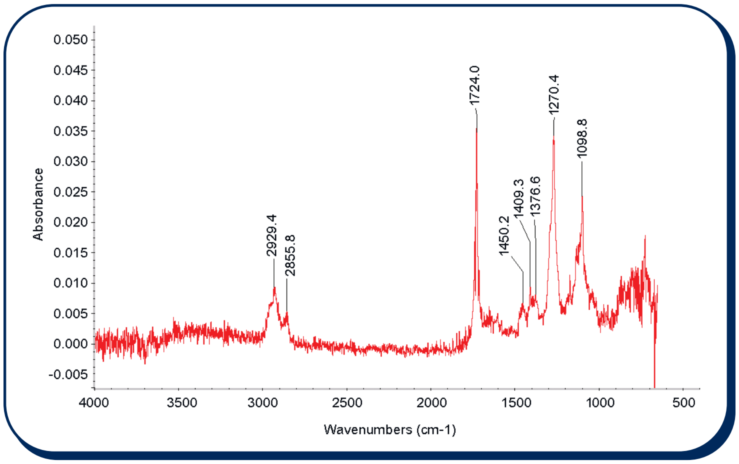

Figure 3-2: FTIR spectrum of residue rinsed from a PCB.

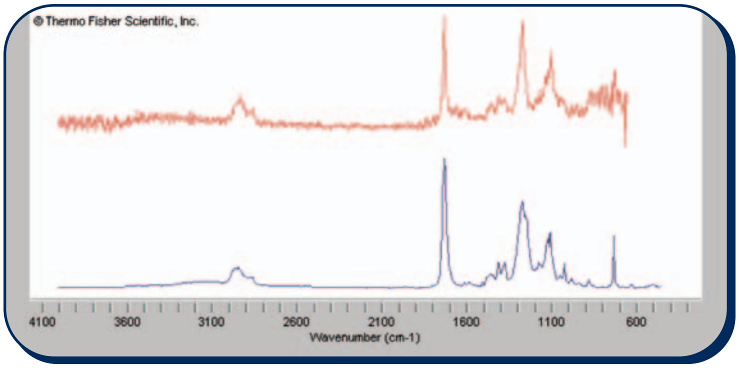

Figure 3-3: FTIR spectra compared for the residue from the PCB (top, red) with a known adhesive compound (bottom, blue).

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Conformal Coating Module of Boot Camp

In today's tough competitive production market, a student emerging from a college or university often learns very quickly that text books and lectures, while useful and necessary, rarely provide the practical preparation needed in the marketplace for the large-scale production of electronic assemblies and equipment. So too, the seasoned engineer or technician may find it difficult to keep up with the rapid changes in process technology, component packaging, and other assorted manufacturing concerns. The Electronics Manufacturing Productivity Facility (EMPF) offers a number of courses specifically designed to provide training in both theory and application. The Electronics Manufacturing Boot Camp draws upon sources from the fields of physics, statistics, metallurgy, material sciences, and electronics design to provide a comprehensive understanding of the processes used in manufacturing electronic devices. Although the course contains several subject specific training sessions (modules), the focus of this article will use conformal coating as a means to illustrate how the course combines theory with practical application.

Conformal coating is defined as a thin polymeric material which covers the surface of an electronic assembly and protects it from a variety of life cycle contaminations which will degrade performance or negatively impact the reliability of the circuitry. Conformal coatings generally do a good job of providing physical protection from assembly debris such as wire clippings, loose hardware, dust or fibers, but it is important that coatings have a low dielectric constant to provide an insulation barrier as well. They may also provide protection against vibration damage in the assemblies' end-use environment.

Although conformal coatings do provide an immediate barrier from fluids, it is a commonly held misconception that they are "water-proof." The degree of protection from moisture (and vapor as well) provided by a conformal coating is dependent not only upon its specific chemistry, but also the length of exposure. All coatings, except paraxylene, are hygroscopic to some degree and will eventually admit either vapor or fluid to the surface of the coated area.

Coating Types

The specific chemistries of modern conformal coatings can be engineered to suit almost any circumstance in today's manufacturing landscape, yet almost all coatings can be classified into one of five categories.

- Type AR - Acrylic resin
- Type ER - Epoxy resin
- Type SR - Silicon resin
- Type UR - Polyurethane resin
- Type XY - Paraxylene

Note: IPC-CC-830 lists a sixth type (FC-Fluorocarbon) but is very rarely used and will not be examined in this article.

Acrylic Resin: Acrylics are usually glossy and smooth in appearance. They provide good electrical protection and generally have good dielectric qualities. They are usually hard and may be mistaken for an epoxy. They will soften forming a gummy residue when heat is applied. These coatings form a surface bond that often yields to chipping and flaking and are **not** recommended for assemblies that require a high abrasion resistance (see Figures 4-1 and 4-2).

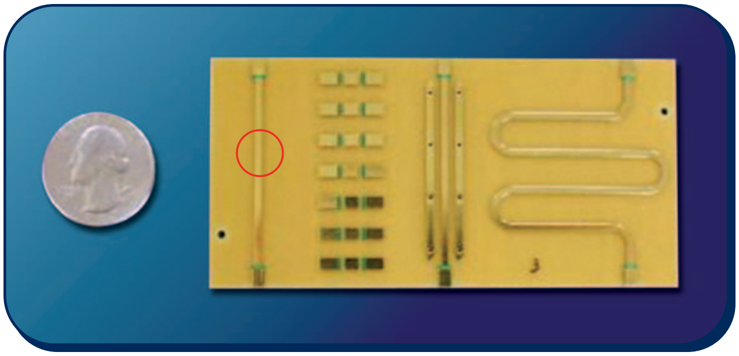

Figure 4-1: Printed circuit board sample - the red circle indicates the edge of trace shown in the cross section of Figure 4-2.

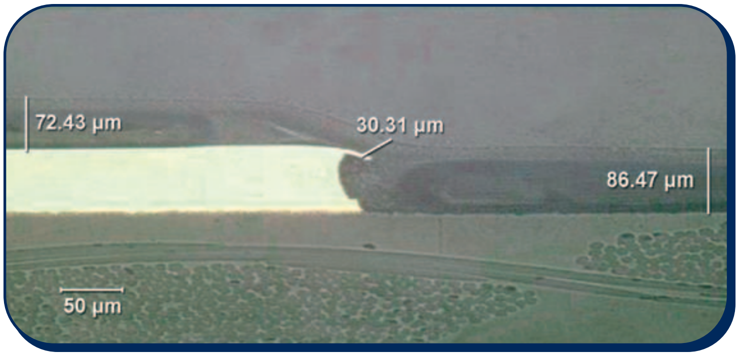

Figure 4-2: Cross section of Acrylic Resin (AR) conformal coating on the profile of a circuit conductor, showing good coverage of the conductor edge, although simultaneously showing the expected thinning of the coating at the conductor trace's edge.

Epoxy Resin: Epoxy resins are usually characterized by a hard, smooth, and nonporous surface. The two biggest advantages of these coatings are a strong surface adhesive bond and a strong resistance to most solvents. Unlike acrylics, this type of resin is a good choice when high abrasive resistance is needed. The main drawback of this coating is that it very difficult and labor intensive to rework.

Silicon Resin: Silicone resins can vary greatly in their characteristics, but they are often soft and pliable. Their adhesive strengths range from easily detachable to tightly bonded. The application thickness is

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Tech Tips: Fiducial Marks

Very often pick and place machines are programmed using CAD data. This data increases the accuracy, precision, and repeatability of its component placement objectives. CAD data makes fine pitch and small component assemblies repeatable, but cannot adjust to a particular board unless it is exactly the same size and shape of the original board used for programming. The process by which printed circuit boards (PCBs) are made only allows some minor changes in board size and shape, but these small differences are enough for parts to be misplaced. For this reason we use fiducial marks to increase the chances of precise component alignment.

Fiducial marks are standardized symbols (typically circles, squares, triangles, and crosses) used for circuit pattern recognition which provide common measurable points for an automated assembly process. The circle is often selected for automated pick and place and is most commonly used for panel, circuit, and local fiducials.

Panel fiducials are located outside the body of the board where components are placed. Usually only three are necessary for programming, but when possible, four are placed on the PCB. If the orientation of the board needs to be changed for any reason, the extra fiducial allows the programmer flexibility in the machine set up. Panel fiducials are the most often recommended method since they are far from the components. This allows easier camera resolution and contrast for automated machine inspection and less chance a via or component might be confused as a fiducial mark.

Circuit fiducials are located inside the component placement area near the corners or as far apart as possible (see Figure 5-1). When three (or four) circuit fiducials are used properly, they can correct theta distortions and compensate for scaling, stretching, and twisting or warpage of the PCB. These fiducials are a secondary method for increased reliability of placement, and are used in place of, or in addition to, panel fiducials. If panel fiducial inspection is not providing a precise placement for a panelized matrix PCB, then the fiducials must be used on each board in the matrix. Vision recognition is more difficult to program for circuit and local marks, because vias, surface mount, and through-hole components can be mistaken for fiducials.

Local fiducials are used to find the precise placement of an individual land location. They are usually used for fine pitch components like quad flat packs or ball grid arrays (see Figure 5-1). Local fiducials increase the precision of fine pitch placement, but it is vital to program the mark using the proper light level and contrast because of the close proximity of parts and vias to the fiducial.

Fiducials are between 1mm and 3mm in size and should not vary on the same PCB. Marks should be at least of 2mm away from any similar feature which could cause an error. In addition, the mark should be more than 4.75mm from the board edge to prevent obstruction by the board locking mechanism. The search window size varies from machine to machine. A window three times the size of the mark in x and y direction is an acceptable search size. Usually search windows are set so the mark is in the center, but it may be necessary to move the search window slightly off center to mistakenly recognize a similar looking, unwanted mark. This can succeed, but some machines have automatic fiducial search window correction which will automatically set your window back to the center and occasionally find the wrong fiducial mark. When assigning a light level during programming you must be able to clearly see the mark, but not create a shiny reflection. When an automatic fiducial inspection is not working properly, additional contrast can often help. If you see a blurry image, change the contrast level until the shapes are solid and easily identified. If fiducial marks are intermittently recognized, check to see if oxidation, solder mask, or some sort of coating is covering the mark. Taking a simple pencil eraser and rubbing it over the unrecognized mark can sometimes alleviate a very annoying problem. If this still does not work and there is no manual fiducial alignment, washing and reprogramming the PCB may be necessary.

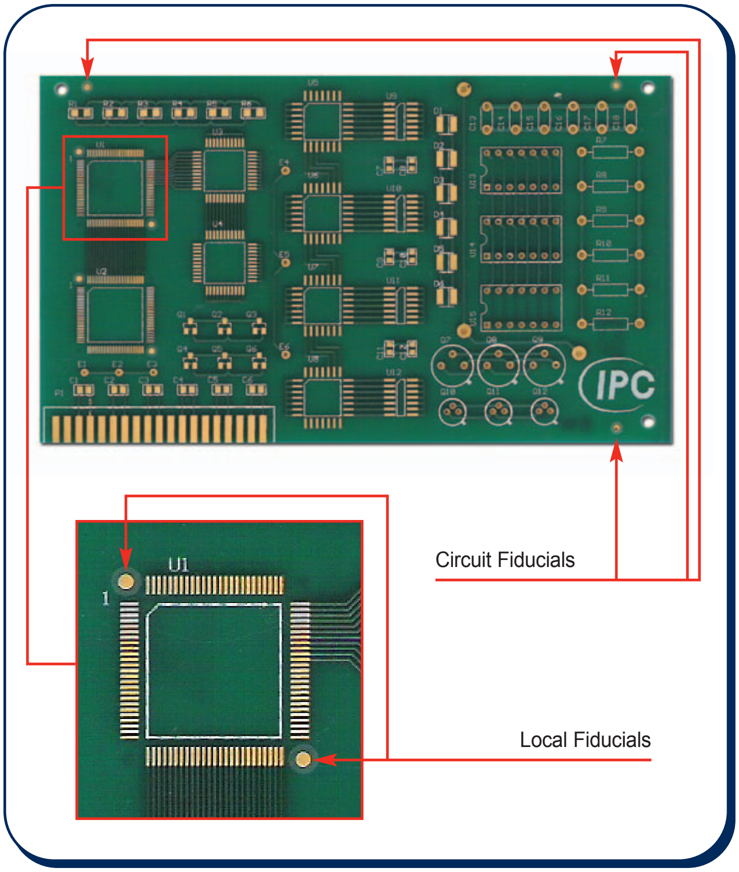

Figure 5-1: Circuit and local fiducials.

Ken Wolfson | Technician/Instructor

Manufacturer's Corner: Aqueous Batch Cleaner

Just a few decades ago, commercial consumer products were normally cleaned in an inline (conveyorized) defluxing machine operating with nothing more than water. The most common flux was water soluble (OA), eliminating the need for a chemical additive to remove the flux. Military and other high-reliability assemblies were soldered using rosin-based fluxes and were most often cleaned using a batch process vapor degreaser. In short, commercial defluxing processes utilized inline cleaning technology while high reliability applications were cleaned using batch-format technology.

After the implementation of the ban on chlorofluorocarbons (CFCs) in 1987, no-clean fluxes emerged in the marketplace. Most commercial manufacturers converted their assembly processes to a no-clean flux, but the high reliability industry (military, aerospace, medical) continue to remove the flux residues from their assemblies. There are various reasons for defluxing, all relating to product reliability. Assemblies with no flux are inherently more reliable than their flux-residued counterparts.

The EMPF demonstration factory has received the new Trident series batch defluxer from Aqueous Technologies of Rancho Cucamonga, California. Early batch defluxing equipment more closely resembled household dishwashers than industrial defluxing machines. After the CFC ban and subsequent decline of commercial defluxing, manufacturers of inline defluxing equipment focused their sights on the high reliability market. Inline defluxing systems, while capable of removing flux residues, were large, loud, expensive, and consumed high quantities of electricity, water, and chemicals. These were not significant issues with commercial assemblers given the high volume of products produced. But for a low volume, high reliability application, a less expensive batch defluxing system was needed.

Over the past two decades, manufacturers of batch format defluxing systems have not only improved their cleanliness results, but also their throughput capabilities. As a result, there has been a steady increase in the sales of batch cleaners versus other cleaning venues. There are several reasons why batch technology has caught up to other cleaning technology for high reliability devices. These reasons include cleanliness, dryness, statistical process control (SPC), environmental footprint, and throughput.

Cleanliness

Since batch format defluxing systems do not rely on a fixed conveyor speed setting to determine the amount of wash, rinse, or dry an assembly requires, each process is independently controlled. For example, long washes may be combined with short dry times, allowing unique cleaning profiles to be developed for a particular batch of assemblies. Batch machines are also uniquely capable of providing real-time cleanliness testing. Because each process cycle is independent, the rinse water can be collected and subjected to ionic testing in real time. This analysis allows the machine to expand or contract the cycle time in order to meet the user's cleanliness requirement. By knowing how clean the boards are at the end of the defluxing process, cleanliness testing becomes more predictable while producing drastically lower failure rates.

Figure 5-1: Trident Aqueous Cleaning System

Dryness

Drying is often the most overlooked segment of a defluxing process. Because the drying time is independently controlled, assemblies will only be subjected to the actual time required to eliminate all moisture under components and in between layers. Most batch format machines provide a rapid bake-out process, combining convection and radiant technology rather than a mechanical removal of moisture. This ensures that the specific drying temperature and time are achieved for thorough drying.

Statistical Process Control (SPC)

SPC is a required element of any high reliability assembly process. Common SPC mandates can be found in all quality standards such as ISO and TQM. Because each process element is independently controlled, each process step and result can be individually recorded for statistical analysis.

Environmental Footprint

Batch defluxing systems require about thirty gallons of water per hour, while inline processes may require as much as three hundred gallons of water per hour. With batch defluxing technology requiring only one tenth of the water and drain requirement of inline, as well as a fraction of the electrical current, it is logical that batch technology is less environmentally intrusive than most inline processes and has a smaller environmental footprint.

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Manufacturer's Corner: Aqueous Batch Cleaner

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Throughput

The new high-yield batch technology preserves all of the advantages associated with batch processes while providing throughput rates equal to or better than an inline alternative. With a growing high reliability market, there is a higher demand for higher volume defluxing systems.

Increasing expectations of reliability and rising concerns over liability practically mandate the use of defluxing technology equipped with the highest degrees of process control. For more information related to this equipment, or to schedule a demonstration of the Trident series batch defluxer at the EMPF, contact Ken Friedman at 610.362.1200 ext. 279 or via email at kfriedman@aciusa.org.

Ken Friedman | EAB Coordinator

Advanced Electronic Connector Technologies

(continued from page 1)

Manufacturing applied R&D tasks include:

- Manufacture connectors using the new Bal Seal and Methode (formerly Tribotek) multiple receptacle contact technologies to apply to military interconnects.
- Test these new connectors built at ITT Canon (using the Bal Seal technology) and DCX CHOL (using the Methode technology) to standard military specifications.
- Compare current capacities to existing standard connectors having the normal standard two or three receptacle contacts at each pin.
- Down select optimal connectors for field tests in DDG 1000 high current, high density applications.

The new technology contacts are expected to allow significantly higher current carrying capability (40-400% increase) over a comparable size traditional electrical contact.

For example, a commonly used #20 AWG M39029 contact can carry 7.5 Amps. These new contact technologies claim to be capable of carrying more than 17 Amps per comparable #20 AWG contact. If applicable in standard military connectors, this higher current density will facilitate significant performance benefits resulting in reduced cost as well as higher reliability by reducing the overall number of power cables as well as reducing cost of the remaining cables.

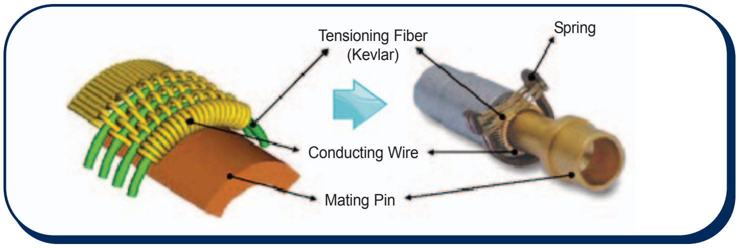

Figure 1-2: The Methode Electronics design for high power contacts uses a Kevlar aramid fiber tensioned with a spring and woven with gold-plated copper wire. The result is a large number of electrical contacts (at each Kevlar/wire knuckle) that reduce contact resistance and increase current carrying capacity for the contact.

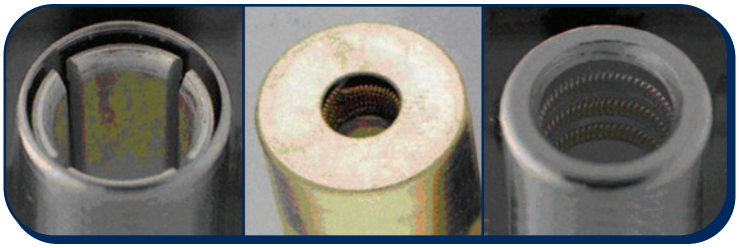

Figure 1-3: Shown left to right are Standard #4 socket contacts (4 contact beam springs), DCX CHOL/Methode (woven Kevlar), and ITT Cannon/Methode (toroidal spring). The DCX and ITT contacts represent substantially higher current carrying capacity than the standard contact.

This EMPF program will help achieve lower interconnection costs by incorporating emerging contact technologies into commonly used military specification configurations and testing them to ensure they can meet the advertised increased power densities and military requirements. Reduction in the cost is strongly related to power density and interconnection hardware. Connectors, cables, and even small Z-Axis sockets can be significant contributors to the overall cost of a system. By introducing this new technology into circular and rectangular Mil-Spec connectors, the anticipated reduction in power cable assemblies and the reduction in cost associated with being able to utilize smaller, less costly connectors will be a significant cost reduction per new ship.

Fred Verdi | Senior Manufacturing Engineer

Method of Detecting Contamination

(continued from page 3)

In the "Surface Organic Contamination Identification Test (Infrared Analytical Method)," the slides with residues are examined with an ATR-FTIR microscope to attempt to identify the composition of the residues. A background spectrum is run prior to capturing the spectra of all samples.

Figure 3-2 contains an example of an FTIR spectrum. The spectrum is then compared to an in house commercial database and commercial database on the internet. Figure 3-3 shows that the FTIR spectra of the unknown residue and a known polyester resin adhesive compound closely match one another.

If a known compound is not found to be a match, the peaks in the spectrum are identified by the frequency and intensity. Table 3-1 shows how the peaks correlate to chemical functional groups. From the information below, it is suggested that the compound is an aliphatic ester with some ether functionality. This structural information agrees with the polyester resin result obtained from the spectral library search.

Frequency (cm^{-1})	Intensity	Peak Assignment
2929.4	Medium to weak	CH_2 and CH_3 Asymmetric and Symmetric Stretch
2855.8	Weak	
1724.0	Strong	C=O Stretch (Ester)
1450.2	Weak	CH_2 and CH_3 Bend
1409.3	Weak	
1376.6	Weak	CH_2 Rock
1270.4	Strong	C-O Stretch (Ester)
1098.8	Medium	C-O Stretch (Ester)

Table 3-1: Infrared Absorption Frequencies and Chemical Identification

In the case of this surface organic contamination, the residue is suggested to be causing a problem with a conformal coating. The resolution is to clean the board with more rigorous process conditions, such as a stronger surfactant or solvent. Ionic residues though, can lead to degradation of the electrical conductors via corrosion and/or dendrite formation, which cause problems with reliability.

To determine if there are ionic contaminants present on the board, there are two methods that give different levels of information. The more general method follows IPC-TM-650 2.3.25C, *Detection and Measurement of Ionizable Surface Contaminants by Resistivity of Solvent Extract (ROSE)*, in which a sample is immersed in an isothermal bath (at 35ºC) containing a 3 to 1 solution of isopropyl alcohol to deionized water. Ionic contaminants extracted from the sample pass through a conductivity cell which continuously measures the conductivity of the solution. The conductivity values are integrated over the time of the extraction. The ionic material then passes through a deionization column before being recirculated back into the test chamber. As the ionic materials are extracted from the assemblies, the conductivity (and hence resistivity) of the solution will change dynamically until nearly all of the extractable ionic material has been removed.

Results from dynamic extraction by Ionograph are reported in micrograms of NaCl equivalent per square inch. For assemblies soldered using rosin based fluxes, the ionic cleanliness requirement per J-STD-001D is a maximum of 10.06 micrograms of NaCl equivalent per square inch (1.56 micrograms NaCl equivalent per square centimeter). There is no industry standard for acceptable bulk ionic levels, but it is better to have as low a value as possible. The EMPF recommends Ionograph results to not exceed a level of 2 to 3 micrograms of NaCl equivalent per square inch.

The more specific method of ionic contaminant analysis is IPC-TM-650 2.3.28A, *Ionic Analysis of Circuit Boards, Ion Chromatography Method*, in which the samples are sealed in a Kapak bag with a 3 to 1 solution of isopropyl alcohol to water and heated in an 80°C water bath for 1 hour to extract any ionic residues. The extract solution is analyzed against known standards to confirm the presence of and quantify each of the following anions: fluoride, chloride, bromide, nitrate, phosphate, and sulfate in units of µg/mL. The surface area is calculated from the board dimensions and the final results are reported in $\mu g/in^2$.

The EMPF's maximum recommended amounts of fluoride, chloride, bromide, nitrate, and sulfate for bare boards are 2, 4, 5, 1, and 3 $\mu g/in^2$, respectively. The recommended levels of ionic contamination for populated assemblies will depend upon the application. However, for typical component packages on FR-4 or a like substrate, the maximum recommended amounts of fluoride, chloride, bromide, nitrate, and sulfate are 2, 9, 15, 1 and 10 $\mu g/in^2$, respectively. Both sets of acceptance criteria were developed from experience and in conjunction with industry leaders.

An example of an ion chromatograph is shown in Figure 3-4. The anions in solution are separated from one another by their different rates of interaction with the quaternary ammonium groups in an ion-exchange column. A set of standards is run with the samples to compare elution times (how long it takes for an anion to leave the ion-exchange column) and corresponds to the identity of the anion. The peaks correspond to different anions passing through an electrochemical detector, which measures changes in conductivity resulting from the flow of ions in solution when moving through an electric field. The level of conductivity is directly proportional to the concentration of the anion, which is calculated by integrating the area under the peaks.

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Method of Detecting Contamination

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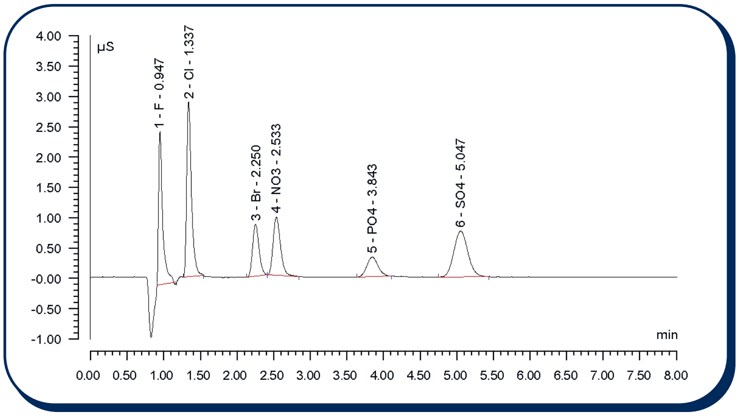

Figure 3-4: Example of an ion chromatograph, featuring a standard solution containing fluoride, chloride, bromide, nitrate, phosphate, and sulfate anions.

The EMPF facilities are well equipped to assist with cleanliness testing for both organic and ionic contamination, in addition to the demonstration floor capabilities, where testing of different cleaning chemistries and techniques can be used to optimize cleaning methods.

Sean Clancy, Ph.D. | Research Associate / Chemist

Conformal Coating Module of Boot Camp

(continued from page 4)

also variable over a wide range. Silicone coating is most useful for high electrical resistance and for low and high temperatures. Rework can be difficult but solvents are available that can break down specific coatings.

<u>Polyurethane Resin:</u> Polyurethane coatings are intended for use where good resistance to moisture and abrasion is required (although they can be dented or scratched with light pressure). Their appearance is usually smooth, glossy, and nonporous. These coatings range from extreme hardness (similar to epoxies) to a relatively soft consistency (like a rubber). They normally form a bond that can be removed in large pieces and can be softened at solder melt temperatures.

<u>Paraxylene (also called Parylene):</u> Parylene coatings have good dielectric strength, low thermal expansion, good abrasion resistance and outstanding chemical resistance. These coatings form a strong surface bond and provide a thin uniform coverage that conforms fully to the PCB contours. They are used to protect circuits against high humidity, intermittent immersion, salt fog, pollution and aggressive solvents. They are FDA approved for use in medical applications. They are effective in high voltage applications because they can coat sharp edges. However, Parylene coatings are applied by the vacuum deposition process and can be very costly and very difficult to rework.

In addition to the above mentioned characteristics of the various types of conformal coatings, there are other concerns when establishing a coating process and choosing the right chemistry.

- **Raw material characteristics:** viscosity, one-part/two-part
- **Application method:** brush, spray, dip
- **Curing method:** heat, ultra-violet (UV), vacuum deposition
- **Cost of equipment**
- **Environmental impact:** volatile organic compounds (VOCs)
- **Cleanliness of PCB prior to coating**
- **End use application**

After completing the Electronics Manufacturing Boot Camp course, participants will be better equipped to incorporate new processes, such as conformal coating operations, into their current manufacturing regimens. In addition, they will better understand the constraints associated with specific materials, designs, and processes, while learning the principles associated with electronics manufacturing.

If you would like to experience the challenge of the Electronics Manufacturing Boot Camp, please call 610.362.1320 or email registrar@empf.org to enroll.

Ross Dillman | Technician / Instructor

American Competitiveness Institute

National Electronics Manufacturing Technology Center of Excellence
Monthly Class Schedule for the Calendar Year 2008

Contact the Registrar for course information and pricing:

610.362.1295

FAX: 610.362.1289

registrar@empf.org

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Contact the EMPF Helpline for Electronics Manufacturing Assistance

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Electronics Manufacturing

Boot Camp A
January 28 - February 1
April 14-18
June 2-6
September 8-12
November 3-7

Boot Camp B
February 4-8
April 21-25
June 9-13
September 15-19
November 10-14

IPC Certifications CIT/Instructor

IPC J-STD-001
January 7-11
February 11-15
March 10-14
April 7-11
May 19-23
June 16-20
July 14-18
August 18-22
September 22-26
October 20-24
December 8-12

IPC J-STD-001 Recertification
January 17-18
February 21-22
April 24-25
June 5-6
August 21-22
October 30-31

IPC A-610
January 21-25
February 25-29
April 14-18
May 12-16
June 9-13
July 21-25
August 11-15
September 15-19
October 13-17
November 3-7
December 1-5

IPC A-610 Recertification
January 15-16
March 18-19
May 13-14
July 15-16
September 9-10
December 9-10

IPC A-600 PWB Acceptability
January 8-10
February 26-28
April 8-10
May 27-29
July 29-31
August 26-28
October 7-9
November 18-20

Rework, Repair, and Modification of Electronic Assemblies IPC 7711/7721 CIT Certification
January 28 - February 1
March 3-7
June 9-13
July 7-11
September 22-26

IPC 7711/7721 CIT Recertification
February 18-19
April 1-2
June 23-24
September 2-3
November 17-18
December 2-3

CIS/Operator

IPC J-STD-001
Call for Availability

IPC/WHMA-A-620 Wire Harness Manufacturing
March 11-13
June 24-26
September 30 - October 2
December 16-18

SMT Rework and Circuit Repair IPC 7711/7721 (Modules 1 & 4-7)
February 11-14
May 5-8
August 11-14
October 27-30

SMT Rework/ IPC 7711 (Modules 1, 4-6)
February 12-14
May 6-8
August 12-14
October 28-30

Surface Mount and Through-Hole Rework of Electronic Assemblies IPC 7711 (Modules 1 & 3-6)
March 17-20
July 28-31
October 6-9

Repair and Modifications of PCB's IPC 7721 (Modules 1 & 7-9)
February 4-7
April 28 - May 1
August 4-7
November 10-13

Circuit Repair IPC 7721 (Modules 1 & 7)
February 4-5
April 28-29
August 4-5
November 10-11

IPC Challenge
January 18
February 22
March 21
April 25
May 16
June 6
July 18
August 22
September 12
October 31
December 5

Skills

Chip Scale Manufacturing
March 25-27
June 17-19
October 21-23

BGA Manufacturing Inspection and Rework
January 17-18
April 3-4
June 19-20
July 23-24
August 27-28
October 15-16

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Lead Free Manufacturing
February 27-28
May 28-29
October 16-17
December 10-11

Design for Manufacturability
February 20-21
April 9-10
May 21-22
August 6-7
October 8-9

Failure Analysis and Reliability Testing
January 9-11
March 4-6
May 20-22
July 8-10
September 9-11

Wave Soldering
January 22-23
April 1-2
September 2-3
December 16-17

Please visit www.aciusa.org to see the 2009 Course Schedule!

All courses and dates subject to change without notice.