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Effects of Plating on Reliability of Lead Free Assembly

The Restriction of Hazardous Substances Directive (RoHS) took effect on July 1, 2006 limiting the use of lead in electronic assemblies to less than 0.1% by weight in any homogeneous material (material that cannot be separated into component parts by mechanical means). The intent of the law is to limit the amount of lead that ends up in landfills when the electronic equipment is eventually discarded. Before RoHS, virtually all electronic hardware employed tin-lead (SnPb) alloy solder (~37% by weight Pb). "Pb-contaminated" electronics are now used only in the RoHS-exempt 1% of the electronics market that constitutes military electronics (Pb-free electronics pose a reliability risk in military systems from both long-term solder joint reliability and from the propensity of electroplated coatings to grow tin whiskers).

The RoHS law has compelled commercial electronics vendors to eliminate their tin-lead component termination finish which had been routinely used and switch to electroplating pure tin. While the SnPb electroplated surface finish exhibited good solderability and was virtually immune to the growth of tin whiskers, a termination plated with pure tin is very likely to spawn tin

whiskers, usually in months or years after plating. Tin whiskers, being electrically conductive, have been the cause of short-circuit electrical failure of the hardware in which they grow. Figure 1-1 shows tin whiskers growing from the electroplated tin finish on a relay terminal after 14 years in service. Figure 1-2 shows tin whiskers growing from the electroplated tin finish on a ceramic component after 200 temperature cycles from -40 to 90°C.

The RoHS law has similarly compelled printed wiring board (PWB) fabricators to final finish solder pads on their boards with electroless nickel/immersion gold (ENIG), immersion tin, or immersion silver (since none of these contain any Pb) instead of the SnPb hot air solder level (HASL) finish they have used successfully on PWBs for the preceding 60 years. The immersion tin finish has shown a propensity to allow the growth of tin whiskers from the immersion tin plating. The immersion silver finish reacts with sulfur-bearing atmospheres to form non-conductive silver sulfate which then reacts with any exposed copper on the board to form non-conductive copper sulfate, which also causes board failure. The long used ENIG finish is still usable under RoHS with no major

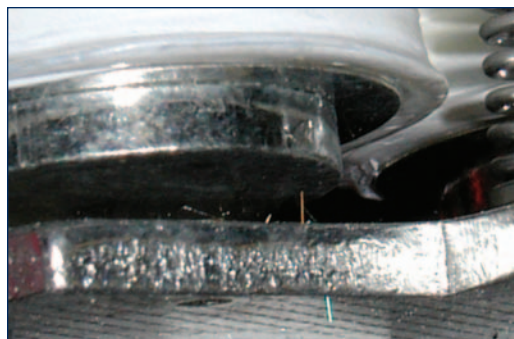


Figure 1-1: Tin whiskers growing on tin plated relay on NASA equipment after 14 years in service.



Figure 1-2: Tin whiskers growing from the pure-tin plated terminal of a ceramic component. Courtesy of NASA.

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Ask the EMPF Helpline!

Lead Free Control Plan

Recently a commercial systems manufacturer working on a major defense program contacted the EMPF Helpline for urgent assistance with an issue of failed parts during reliability testing.

They were attempting to incorporate commercial off-the-shelf (COTS) computer-related hardware into a battlefield system and were experiencing reliability issues. It was noted that the parts were labeled by the vendor as “compliant to military (or MIL) standards” but not clearly identified as SnPb or lead free. In recent years, the EMPF has supported a number of customers with lead free issues and we assisted the customer in developing a short term and long term solution to their problem.

For the short term, immediate support was provided in the form of an analysis of COTS components using both X-ray fluorescence (XRF) and scanning electron microscopy (SEM) with energy dispersive X-ray

the Pb-free Electronics Risk Management consortium (per GEIA-STD-0005-1 and GEIA-HB-0005-1).

In this case, the EMPF was able to successfully support the customer by developing short term parts identification, assembly method improvements, and a longer term focus on an improved lead free control plan. It is important to note that many COTS parts which are supposed to be compliant to SnPb manufacturing applications may in fact result in a high risk of failure. The best way to prevent unanticipated risk is through thorough parts identification and tracking, internally and externally, throughout the supply chain. Also, ensure that each vendor is aware that

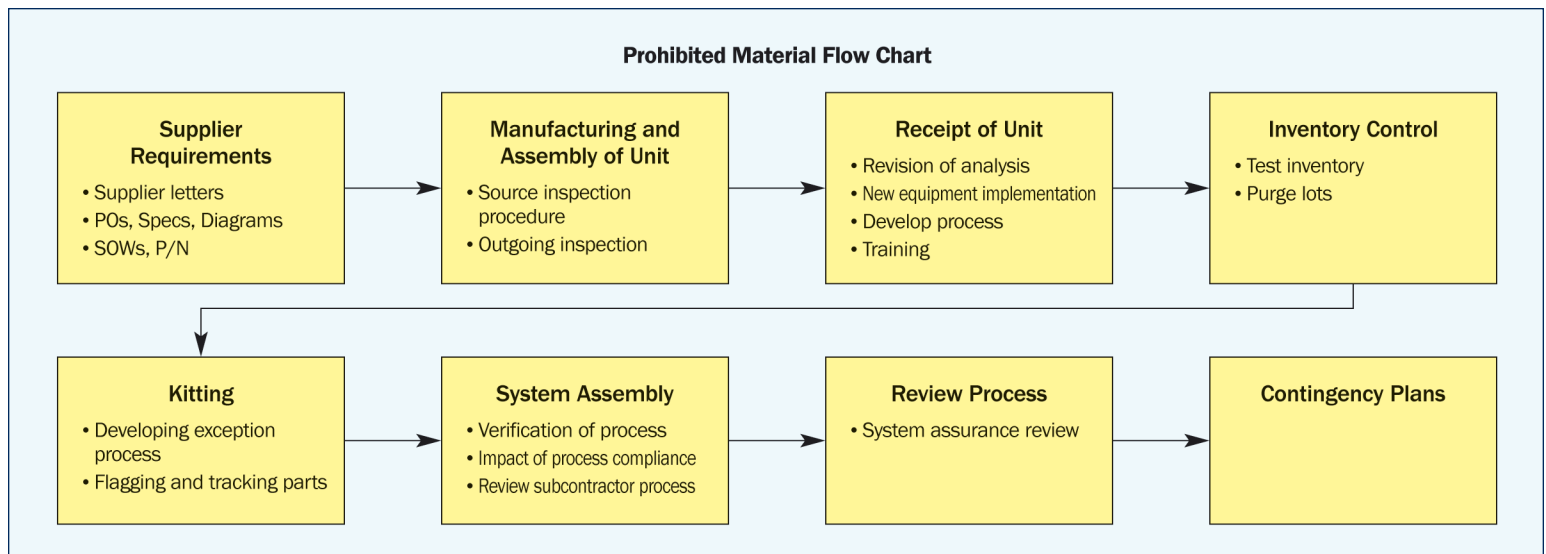


Figure 2-1: .Example of a prohibited material flow chart which can be used to track implementation of COTS parts in adherence with a lead-free control plan

spectroscopy (EDS) techniques for chemical identification of lead containing parts. The lead free components were clearly identified and assessed on the associated failure risk based on its intended application environment. This risk analysis allowed for a cost trade-off consideration to determine whether the parts be refinished with SnPb or used with a modified process for mixed lead and lead free components. This allowed the minimum amount of program delay and resulted in improved reliability testing performance.

The recommended longer term solution was a more proactive approach in development of a lead free control plan both internally and through their vendors, so that risk associated with particular COTS components is more clearly identified in the future. A prohibited material flow chart was created (similar to that shown in Figure 2-1), to ensure the proper implementation of components throughout the process — from parts receiving to final assembly. It was recommended that a lead free control plan be developed in advance of the upcoming Department of Defense (DoD) requirement in accordance to guidelines provided by the AIA and

implementation of the Lead Free Control Plan will soon be a requirement for parts associated with DoD programs in order to simultaneously support supply chain transition and improve program reliability.

The EMPF has both R&D and Manufacturing support staff equipped with the knowledge and experience to support your lead free manufacturing related questions. The EMPF also offers several training classes which focus on lead free manufacturing and reliability. Contact the EMPF Helpline via email at helpline@empf.org or call 610.362.1320. You can also visit http://www.aciusa.org/forms/helpline_form.php to access the form directly and submit your inquiry.



Dan Perez | R&D Engineer

Lead Free Risk Mitigation – A Case Study

A company approached the EMPF for assistance with a new product that was about to undergo its initial proof-of-concept prototype build. This product was an item that was being furnished to the Department of Defense for a program designed to increase the technical capabilities of computer equipment issued to the war fighter. The requirements for this item specified the use of tin-lead solder during assembly of production units. One of the main responsibilities for the EMPF during this project was to assist the client in mitigating the risk introduced by the use of commercial off-the-shelf materials that may be lead free.

The EMPF's first task in this process was to identify the components (from the client's Bill of Material) that were unavailable in a tin-lead finish. The item was a modified version of a familiar commercial PC architecture and as such was designed around a standard CPU platform from a large worldwide component manufacturer. This platform was comprised of a number of ball grid array (BGA) processors that were widely available lead-free but unavailable in tin-lead. Unlike a leadframe component, where the lead would only be present as a layer of plating on a tin-lead part, a BGA uses a small ball of solder to form the interconnection between the component and the printed circuit board (PCB).

These differences lead to a serious dilemma for the team. Two standard concerns when mixing tin-lead and lead-free solders and components are the effect on long-term reliability of the solder joints and the potential impact of tin whiskers. The initial build was not expected to undergo any form of accelerated life reliability testing so those two concerns were not significant at that time. However, a new concern arose regarding the compatibility of the lead-free BGAs when used with tin-lead solders. The issue was that a tin-lead reflow profile would not properly reflow the lead-free solder on a BGA.

The initial strategy was to have the lead-free balls removed from the BGA and replaced with tin-lead balls. (Techniques to perform this task are described in detail in the [BGA](#)

[Reballing](#) article also in this issue of *Empfasis*.) This is the best method of mitigating this risk factor, as a properly reballed BGA using tin-lead balls will be perfectly compatible with the use of tin-lead soldering processes. The client contracted with another company to reball the BGAs in question and that company was to supply the parts directly to the EMPF for assembly. Upon receipt, EMPF staff identified damage that occurred during the reballing process. This damage (as shown in Figure 3-1)

The timing of the discovery of the defects when the parts arrived at the EMPF meant that there was not sufficient time to perform that exercise again and maintain the original project schedule. As the assembly's main requirement was functionality for proof-of-concept, the decision was made to assemble the board using lead-free solder at the EMPF. At the same time, the client's factory organization worked to acquire properly reballed BGAs with tin-lead for future builds.

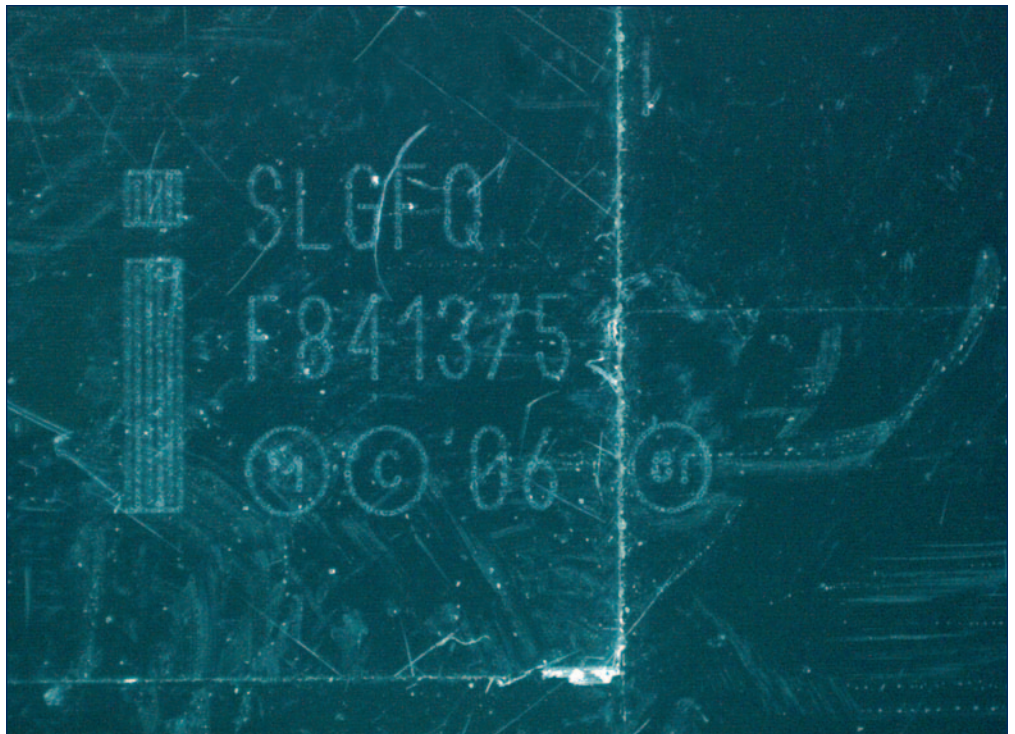


Figure 3-1: A fracture in the exposed die surface.

was a fracture in the exposed die surface of a number of the components provided to the EMPF. This damage was a result of improper handling of the parts with regard to exposure to moisture and is known as a "popcorn" defect. Popcorn occurs when moisture within the device is rapidly heated during rework processes causing the absorbed moisture to expand causing die fractures. The IPC/JEDEC J-STD-033B provides the requirements that must be followed in order to prevent this type of damage.

The change to the use of lead-free solders required some changes to the manufacturing process. The most significant change was the elevated melting point and its effect on the reflow process. An additional concern was the capability of the components to withstand the elevated temperature. The original plan involved the use of tin-lead solder so little information was readily available regarding the maximum ratings for some of the parts. However, many of the parts and all of the high value parts were dual-rated for both tin-lead

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Tech Tips: The Reballing Process

Ball Grid Arrays (BGAs) are a common component in modern high value and often expensive circuit boards. When a failure is isolated to the BGA, the root cause is often the solder ball interconnection, not the BGA itself. Removing and reworking the BGA is often an economically attractive alternative to replacement with a new part. There are several manufacturers that offer equipment to remove and replace the BGA on circuit boards. However, if the intent is to reuse the same BGA, the solder balls must be replaced before it can be resoldered to the circuit board. The BGA removal process will render the existing solder balls unusable.

Reballing is also performed when the only available parts on the market have lead-free solder balls, and the application requires eutectic solder. The salvage market also reballs BGAs for resale. This article describes the required BGA reballing process, specifically the preform method.

The reballing process continues by removing the existing solder balls and cleaning the surface. The solder balls can be removed using a soldering iron with a blade tip attached. Uniform heating of the part with auxiliary heating is necessary to avoid localized thermal shock to the BGA from the hot blade. This method is adequate for bulk solder removal. Care must be taken not to scratch the surface of the BGA. The generous use of flux increases the effectiveness of the heat transfer and also removes any oxides. Solder braid is used next to remove smaller flecks of solder, also used with generous flux.

As a final cleaning and preparation, the BGA is carefully washed with isopropyl alcohol (IPA) to remove the flux. The part is then carefully inspected. Cleanliness can be confirmed using standard Resistivity of Solvent Extract (ROSE) or SEC (Solvent Extract Conductivity) testing.

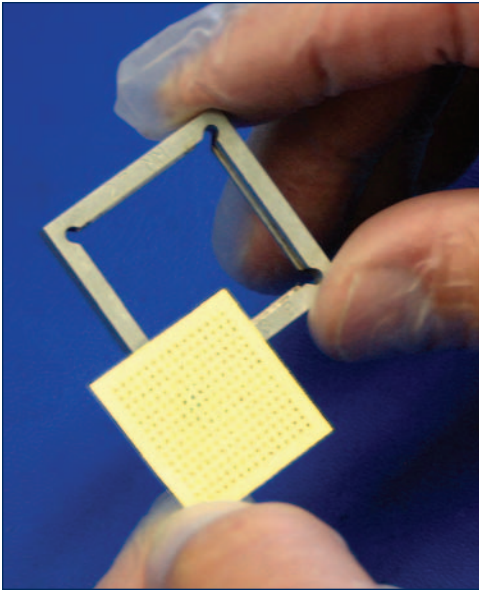


Figure 4-1: Preform being inserted into fixture.

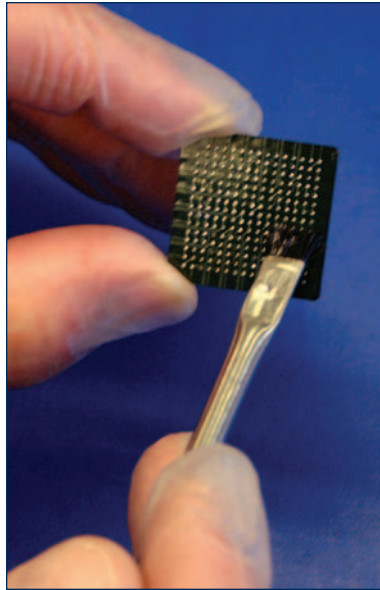


Figure 4-2: Applying sticky flux.

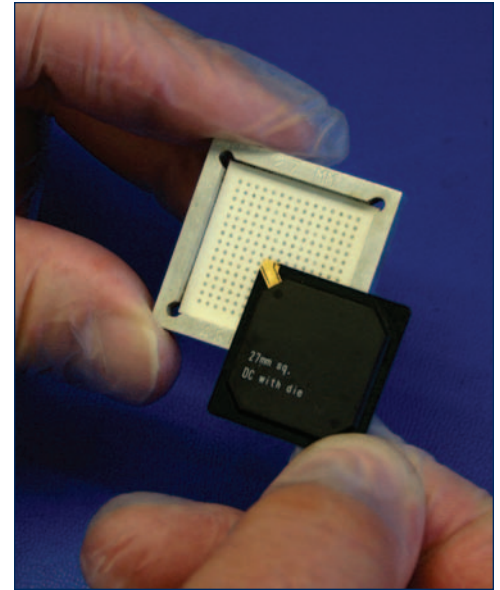


Figure 4-3: Mating BGA onto preform in fixture.

BGAs can develop problems due to unreliable solder joints which have become more common with the advent of lead free solder balls. Lead free components require a more stringent process control, and without tight process control, the BGA solder joint can be unreliable.

Starting with a BGA removed from the circuit board, the first step is to bake the moisture out of the component to prevent a defect called “popcorning.” This defect appears as craters in the BGA package which are caused by the explosive expansion of absorbed water vapor during the reflow process. It is easy to see on the top and sides of components, but after the solder balls have been reflowed, it can be more difficult to see on the underside of the component. This baking step eliminates “popcorning” risks and must be performed.

By specifying the BGA type and part number to the BGA reballing vendors, the correct preform parts will be obtained. Companies such as Winslow Automation offer a huge range of preforms and can deliver most in less than a week.

Continuing with a clean and solder free BGA, the next step is to perfectly position the balls under the BGA. With hundreds of solder balls to be exactly positioned, a mechanical device is required to maintain the alignment and position the solder balls under the chip. The two most popular methods to actually attach the solder balls are the “Preform” method and the “Specialized Fixture” method. The Preform method holds the solder balls in the exact pattern using a water soluble paper carrier. (Figure 4-1). This precise paper form is the key to this process

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Manufacturer's Corner: ORAFEC

The influx of counterfeit electronic components is an epidemic in modern board level manufacturing and is a problem which shows no immediate signs of slowing. The damage done by counterfeit electronic components entering the supply chain of US electronics manufacturing is estimated to be in the several billions of dollars and that figure is increasing annually. Many standards of physical detection such as advanced levels of microscopy (including SEM analysis), X-Ray, XRF, delidding, and chemical testing have been established as the norm, but until recently there hasn't been an easy way to test the suspected part electrically.

The EMPF uses the ORAFEC-09 counterfeit component detector (ORAFEC is an acronym for the Organization Against Fraudulent Electronic Components). This device is designed to provide the next level of quality assurance to buyers and sellers of electronic components.

device. To accommodate different components, the ORAFEC-09 can be configured to adjust voltage range, low and high peak voltage, source resistance, and the frequency. This quick test can eliminate a vast majority of counterfeit parts which cosmetically look authentic but lack the electrical properties or characteristics of the original.

Many package configurations can be tested including:

- Dual in-line (DIL)
- Small outline integrated components (SOIC)
- Small outline packages (SSOP, TSOP)
- Plastic leadless chip carriers (PLCC)
- Quad flat packs (TQFP, PQFP, LQFP)
- Ball grid arrays (BGA)

The ORAFEC-09 can also be used for complete modules.

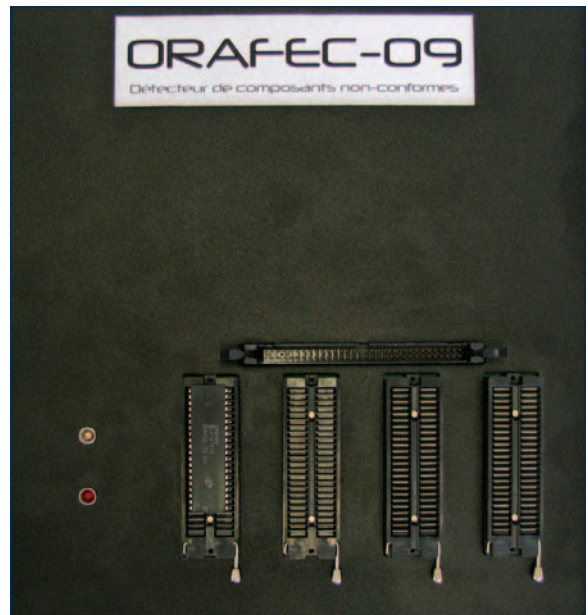


Figure 5-1: ORAFEC Counterfeit Component Detector

By creating an electronic record of a genuine part (a PinPrint); the machine can check any suspect part against the known good part to determine authenticity.

ORAFEC has also developed a software system designed to turn every ORAFEC-09 device into a network of testing sites, all working together to provide PinPrints for every company to use and test against their parts. By providing an industry-wide sharing of known good PinPrints, the spread and infiltration of counterfeit components can be reduced or eliminated.

But what is a PinPrint? By applying electrical signals to a component's pins, the ORAFEC-09 can record the electrical characteristics of those pins and save the unique information as a PinPrint. A known genuine component's PinPrint can then be used as an electrical standard for that

The ORAFEC-09 is a very valuable tool in the ongoing fight against a very aggressive enemy. Our industry must use every tool available to detect bogus parts and react appropriately. For more information related to this article or to see a demonstration of the ORAFEC-09, please contact Ken Friedman, the EAB Coordinator at 610.362.1200 extension 279 or via email at kfriedman@aciusa.org.



Ken Friedman | EAB Coordinator

Online and Distance Learning

Online training and distance learning are mature technologies which allow for high quality training programs to be delivered over the Internet. Wherever there is a computer terminal and Internet connection, candidates can stay abreast of advances in their field, maintain certifications and update their skills. Several aspects of distance learning will be discussed in this article, these being the advantages and features valuable to customers, the hardware considerations of distance learning and the software programs to engage an online training program.

Technical training requirements are well suited to be satisfied with online programs. The EMPF for example offers distance learning programs for IPC electronics standards like IPC-A-610 CIS and IPC-A-600 among others. For example, the 610 course is an industry-recognized consensus document which defines the acceptance criteria for electronic assemblies. Customers cite that the total “cost per person” is usually reduced with online programs versus traditional seminars. Key people can avoid travel costs and the disruptions to their personal lives. Also, since the total cost is usually less, managers can have more employees or an entire department attend an online seminar and take distance courses more frequently.

Online or Distance Training is essentially content and interactivity delivered over the Internet. Of the two, interactivity is arguably the more important. For example, the EMPF delivers electronics assembly training, so the presentations center on a real time instructor who presents the technical content to the audience and fields questions (Figure 6-1). This assures that the viewing candidates can receive immediate answers to any questions. PowerPoint presentations, pre-recorded video, and live video are all used to deliver content.

There are no special hardware requirements for the candidate to utilize web based training. For most web teleconferences, Voice Over Internet Protocol (VOIP) is used. A large monitor creates a greater sense of involvement and good speakers are recommended.

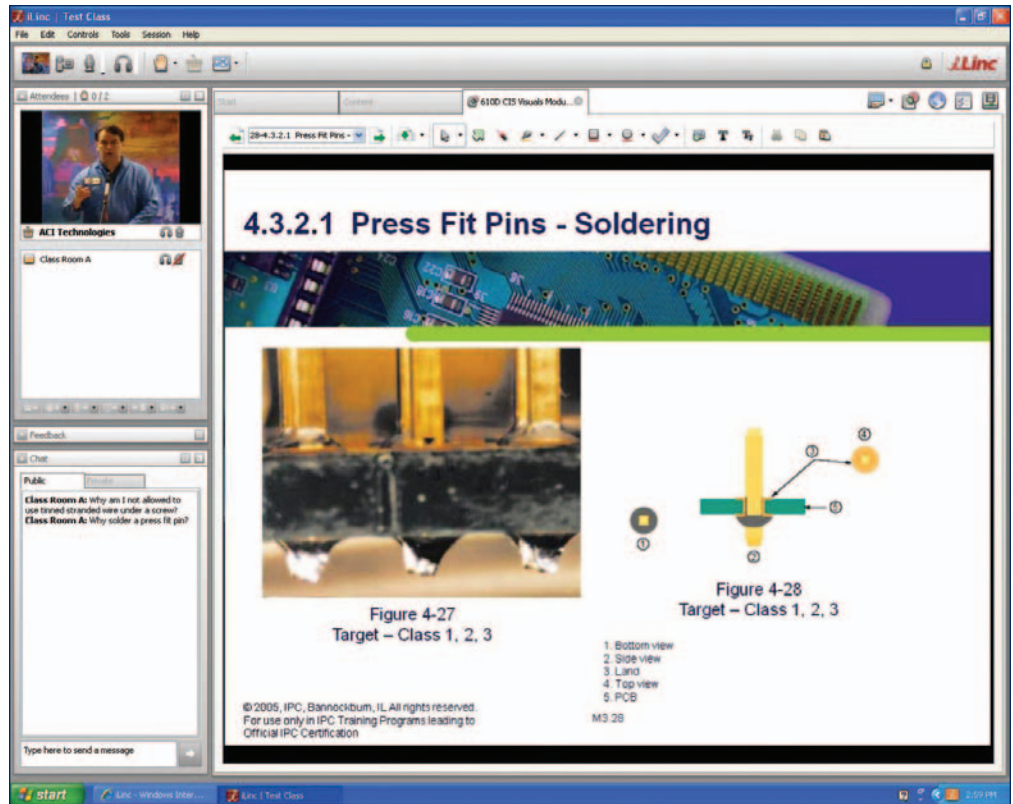


Figure 6-1: A real time instructor presents the technical content to the audience and fields questions.

Several software and networking companies provide the necessary software presentation tools. Among the products offered are “WebEx” offered by Cisco, “Connect” by Adobe, “Live Meeting” by Microsoft and “iLinc” by iLinc Communications.

Compatibility with the desktop computer software is absolutely an issue. Adobe “Connect” performs on all platforms, Windows, Mac or Linux. iLinc performs on a Mac or PC. Microsoft “Live Meeting” and “MeetMeNow” from WebEx perform on Windows but not the Mac Platform. Most online programs can easily handle 15 participants and more with Microsoft handling up to 100.

For this online experience to be effective, software features like meeting capacity, desktop sharing, desktop recording and interactivity are desirable. Desktop sharing enables the attendees to share a specific element of their computer desktop with the rest of the group.

Desktop recording allows the presentations to be recorded on your computer and played back at a later date. The EMPF online programs have these features.

Live video can suffer from a lack of interactivity because the presence of the instructor is missing. This means it can be difficult for the instructor to draw diagrams and highlight items as would be done with a live presentation. The solution to this is to use a “White board” and pen. This is a digitizing pad upon which the presenter can sketch and highlight items and have these items appear on the attendees computer screens.

The EMPF’s web conferencing package for distance training utilizes software that divides the computer into three sections. The main and largest section of the computer screen presents the content. This could be the video presentation, PowerPoint slideshow or other content. The upper left of the screen is the live

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Effects of Plating on Reliability of Lead Free Assembly

(continued from page 1)

drawbacks. Figure 1-3 shows tin whiskers growing from the immersion tin finish on a PWB through-hole wall.

Unfortunately, the military, in spite of being exempt from the RoHS law, must use the same supply line as the non-exempt commercial electronics world when selecting components and circuit boards. They comprise too small a yearly volume (relative to the commercial electronics world) to influence any aspect of the market (e.g. surface finish) for components or boards.

The military would prefer to have all component terminations (and PWBs) finished with the known-reliable, SnPb alloy rather than pure tin, because the lead (Pb) content in the tin prevents the potential of tin whisker induced failures in electronics systems. To overcome the tin whisker risk with the pure tin plated RoHS-compliant components (which are the only ones available), critical military electronics require expensive and time consuming re-finishing of the component terminals. This is usually done by dipping the tin coated component contacts in molten SnPb solder, one at a time.

Because of RoHS, the military is forced to accommodate the added expense and time of re-finishing electronic component terminations. Adding to that turmoil, component refinishing adds the risk of thermally damaging the dipped components due to the hot-dipping procedure, potentially reducing the reliability of Pb-free electronics.

The Department of Defense (DoD) is now challenged to develop a department-wide policy that will preserve the reliability previously enjoyed by SnPb electronics. This policy will inevitably include the idea of a Lead-Free Control Plan (LFCP) documenting the methods used by each DoD supplier to mitigate risks for every bit of electronic hardware acquired by any DoD program. This acquisition policy would cover any electronics, commercial off the shelf (COTS) or otherwise, for any military use. One uniform policy across all DoD components (services and agencies) would go a long way toward mitigating the confusion among vendors about the need and techniques to limit the Pb-free electronics risks.

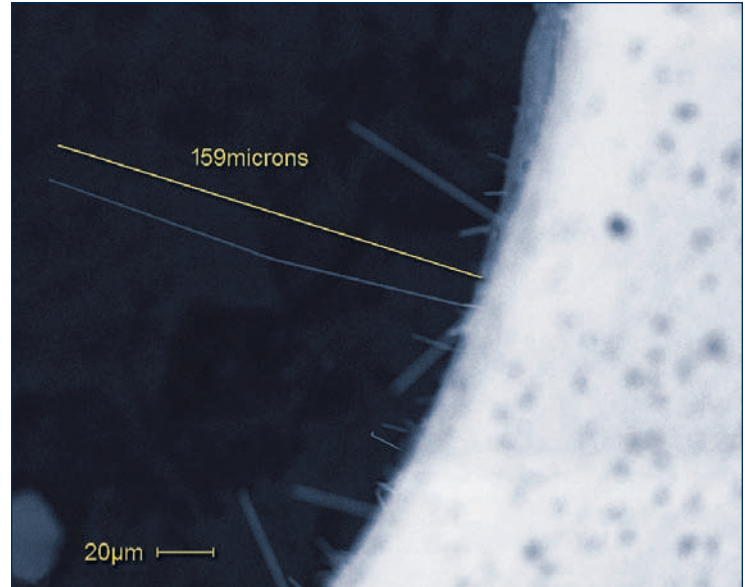


Figure 1-3: Tin whiskers growing from immersion tin plating on a PWB plated through-hole wall.

For more information on the risks imposed by RoHS compliant component and PWB finishes, or the latest information on the coming LFCP requirement for DoD-acquired electronic hardware, please contact the EMPF Helpline at 610.362.1320, or via email at helpline@empf.org.



Fred Verdi | Senior Manufacturing Engineer

Upcoming Courses

IPC J-STD-001

Certification: June 7-11 | *Recertification:* May 26-27

This course provides an in-depth study and hands-on application of the national standard for soldering as well as all materials necessary to conduct operator training.

IPC A-610

Certification: June 14-17 | *Recertification:* May 24-25

Achieve the highest quality and most cost-effective productivity by knowing how to correctly apply the IPC A-610 acceptability criteria.

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Lead Free Risk Mitigation – A Case Study

(continued from page 3)

and lead-free temperatures. During assembly of the lead-free version of the item two components were discovered to have been damaged by the elevated temperatures in the lead-free process. The first damaged part discovered was a relay. It was deformed and apparent that the plastic used for the housing had begun to melt. The second damaged part was a wire wound inductor where the core had deformed and melted, damaging the windings and changing the value of the inductor.

The EMPF did not have extra parts on hand to replace the damaged parts and the assemblies were sent to the client for replacement at their engineering offices. However, upon arrival it was determined that the soldering irons on hand at that location were not capable of reaching the elevated temperatures required for lead-free solders. The parts were returned to the EMPF with replacement components in order to take advantage of the equipment and technicians familiar with lead-free rework available at the EMPF's facility.

A valid concern was raised regarding the risk of unobserved damage on other components on the lead-free assemblies. A decision was made to perform another build at the EMPF using tin-lead processes as a control in order to determine if any potential failures of the lead-free boards were related to the lead-free

assembly process. At that point there was still no availability of many of the BGAs in tin-lead and a mixed process had to be performed. The reflow oven was set to run at the high end of the tin-lead process window in order to maximize the opportunity for the tin-lead solder to join to the lead-free balls. The process was set to ensure that no components exceeded the upper rating for tin-lead components, which is 220°C for most components. The lead-free solder balls on the lead-free BGAs were not expected to significantly melt during this process and the tin-lead solder was expected to wet to the unmelted balls as it would on a plated lead or termination. This lack of proper melt results in a non-standard solder joint geometry that, although perfectly functional, is not expected to have the same level of mechanical reliability as a properly processed BGA solder joint. In this project the long-term reliability of the resulting solder joints was not a concern but in other situations this issue can be a reason to avoid mixing solder types on BGA solder joints.

This project exemplified some of the risks of mixing tin-lead and lead-free components and solders. Conversion of BGAs from a lead-free type to a tin-lead type has associated risk of damage but if performed properly will result in the optimal configuration (tin-lead solder joining a tin-lead BGA to the board). Processing parts that have not been specifically qualified for use with lead-free processes can lead to unexpected component damage. Installing a lead-free BGA with a tin-lead solder results in a non-standard solder joint geometry with unknown reliability but can be sufficient if the only objective is to assemble a board that functions.

The EMPF can assist you with difficulties encountered in an increasingly lead-free electronics world. Contact the EMPF Helpline via email at helpline@empf.org or by calling 610.362.1320. Access a form directly at www.aciusa.org/forms/helpline_form.php to submit your inquiry online.



Jason Fullerton | Sr. Product and Applications Engineer

Upcoming Courses

Chip Scale Manufacturing

May 26-28

Receive hands-on training utilizing advanced packaging equipment in the on-site demo lab. Identify and perform critical process steps when manufacturing ball grid arrays (BGAs), micro-BGAs, flip chips and chip scale packages. Identify and implement process control methods and practices when manufacturing assemblies with advanced packages.

Lead Free Manufacturing

June 7-8

ACT's comprehensive training program includes both lecture and hands-on factory experience. Gain an understanding of technical issues surrounding the lead free soldering process. Learn to manufacture lead free hardware using production-quality equipment in the on-site demo lab. Bring samples of your own hardware to evaluate responses to lead free solders.

CONTACT THE REGISTRAR via phone at **610.362.1295**, email at **registrar@empf.org** or online at **www.aciusa.org/courses**

Tech Tips: The Reballing Process

(continued from page 4)

and assures the balls are aligned on the carrier within 0.0004 inch. The perimeter of the preform is precision-cut to perfectly match the dimensions of the BGA. Mating the preform to the BGA is accomplished by applying paste flux to the BGA (as shown in Figure 4-2). The paste flux is sticky, and holds the BGA to the preform. A fixture is often used to speed the assembly and assure accuracy (Figure 4-3).

The next step is to reflow the two mating parts using a profile based on whether the solder balls are tin-lead or lead-free solder. The BGA assembly is processed through the reflow oven the same way a circuit board is processed. The solder balls are now attached to the BGA.

The last step in the preform reballing method is to remove the paper carrier (which is designed for easy removal). After part inspection, the BGA is ready to be assembled onto the circuit board.

With some experience, good equipment, and a mature process, the entire rework and BGA reballing process can be accomplished within an hour. Reballing is a mature process with no special skills required. This makes the reballing option economically justifiable to rework circuit boards.

For more information on reballing contact the EMPF Helpline via email at helpline@empf.org or call 610.362.1320.



Mike Prestoy | Senior Applications Engineer

Online and Distance Learning

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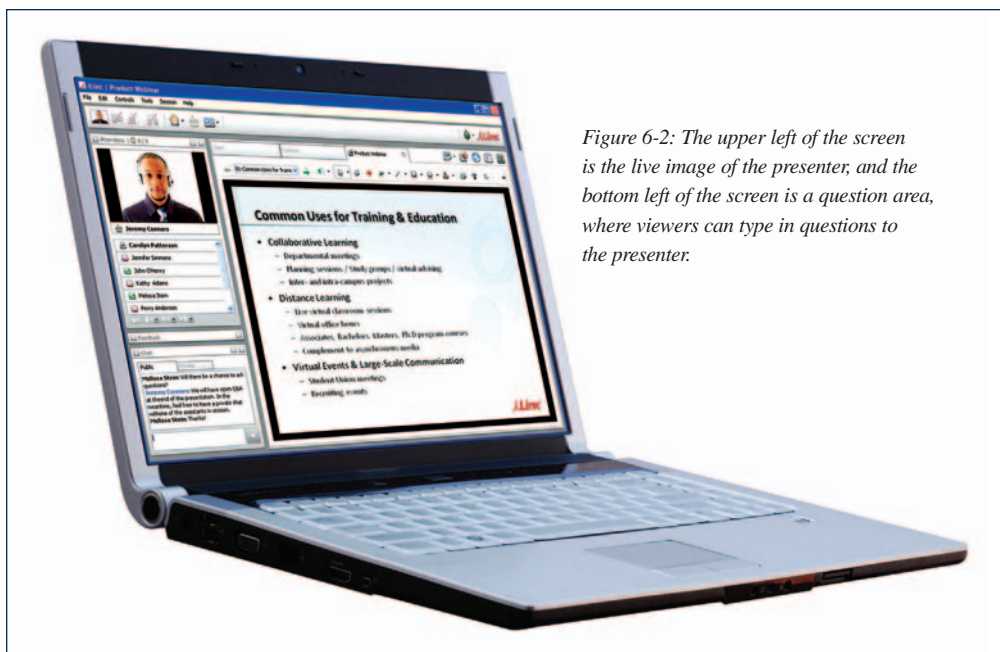


Figure 6-2: The upper left of the screen is the live image of the presenter, and the bottom left of the screen is a question area, where viewers can type in questions to the presenter.

image of the presenter, and the bottom left of the screen is a question area, where viewers can type in questions to the presenter (Figure 6-2). These questions appear on the Presenter's screen where he can respond and answer them. Live question and answer interaction is also available.

To summarize, the EMPF offers both online and traditional training programs and both are solid and reliable methods to deliver training content. However, for convenience, cost per student, and flexibility, online programs are an attractive choice. The technology is inexpensive and the content presentation is clear. Considering that it is no longer necessary to travel, distance learning is a reasonable method for all individuals to stay current with technology and skills training.



Mike Prestoy | Senior Applications Engineer

2010 Class Schedule

National Electronics Manufacturing Technology Center of Excellence



ISO 9001:2008
CERTIFIED



Electronics Manufacturing

Boot Camp A
March 1-5
May 3-7
September 13-17
November 1-5

Boot Camp B
March 8-12
May 10-14
September 20-24
November 8-12

CIS/Operator

IPC J-STD-001
Call for Availability

IPC A-610
Call for Availability

IPC 7711/7721
Call for Availability

**IPC/WHMA-A-620A
CIS Certification**
February 16-18
April 19-21
June 28-30
September 27-29
December 20-22

High Reliability Addendum

**IPC J-STD-001 DS
CIT Certification**
January 15
February 26
April 16
May 28
August 27
October 8

IPC CIT Challenge Test

January 29
February 19
April 23
June 18
July 16
August 20
October 15
November 19
December 17
Call for Additional
Availabilities

IPC Certifications CIT/Instructor

**IPC J-STD-001
CIT Certification**
January 4-8
February 1-5
March 15-19
April 26-30
June 7-11
July 19-23
August 30 -
September 3
October 18-22
December 6-10

**IPC J-STD-001
CIT Recertification**
January 13-14
February 24-25
April 14-15
May 26-27
July 14-15
August 25-26
October 6-7
November 17-18
December 15-16

**IPC A-610
CIT Certification**
January 4-7
February 8-11
April 19-22
June 14-17
August 16-19
October 11-14
December 6-9

**IPC A-610
CIT Recertification**
January 11-12
February 22-23
April 12-13
May 24-25
July 12-13
August 23-24
October 4-5
November 15-16
December 13-14

**IPC A-600
CIT Certification**
January 26-28
March 22-24
June 21-23
September 7-9
November 29 -
December 1

**IPC 7711/7721
CIT Certification**
January 25-29
March 22-26
July 26-30
October 25-29

**IPC 7711/7721
CIT Recertification**
March 8-9
May 17-18
June 14-15
September 13-14

Skills

**BGA Manufacturing,
Inspection, Rework**
January 19-20
April 5-6
June 28-29
October 11-12

**Chip Scale
Manufacturing**
February 16-18
May 26-28
August 11-13
December 13-15

Continuing Professional Advancement in Electronics Manufacturing

**Design for
Manufacturability**
February 8-9
May 24-25
August 9-10
November 22-23

**Failure Analysis and
Reliability Testing**
March 15-17
May 17-19
September 27-29
November 15-17

**Lead Free
Manufacturing**
February 22-23
June 7-8
October 4-5
December 20-21

Contact the Registrar for course information and pricing: phone: 610.362.1295 email: registrar@empf.org

Electronics manufacturing assistance is available via the EMPF Helpline: phone: 610.362.1320 email: helpline@empf.org

Custom courses and on-site training are available. ACI is conveniently located next to the Philadelphia International Airport.