empfasis

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The EMPF is a U.S. Navy-sponsored National 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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Packaging Thermoelectric Modules for Demanding Environments

ACI has successfully ruggedized Thermoelectric Modules (TEMs) for a demanding application in rotary wing aircraft. In conjunction with a shape memory activator (NiTinol), the TEMs enable the twist of the rotor blade to be altered in-flight. For this application, the TEMs must be impervious to the marine (salt spray) environment as well as high vibrational, shock, vertical and centrifugal forces as high as 600G.

Rotary & Hybrid Wing Aircraft: Rotor Blade Twist Actuator

Rotary and hybrid-wing aircraft rotor design utilizes a fixed geometry with an optimized angle of attack between those most appropriate for various types of operation. This fixed rotor design is aerodynamically sound and proven. It is also less expensive than a rotor having the capability to alter blade twist in-flight. However, the fixed geometry is a compromise and is incapable of providing maximum performance among several flight modes.

Payload capacity and flight range can be increased by use of a rotor capable of reconfiguring the span wise distribution of the blade angle (twist) to optimize the flight configurations as needed. The in-flight reconfiguration of the rotor can be accomplished by incorporating a Blade-Embedded Rotational Actuator (BERA) to twist distribution of the rotor blades from the optimum angles for hover to the optimum angle for cruise, and back again. This process employs a Shape Memory Actuator, which is currently in development through a Shape Memory Actuator Demonstrator Project (SMAD) with a multi-participant effort including Boeing as the lead contractor. The design is based on technology developed by the ONR Shape Memory Actuator Consortium (SMAC), also led by Boeing, with support by the U.S. Defense Advanced Research Project Agency (DARPA).

Examples of typical commercial TEMs courtesy of Melcor

The TEMs, also known as Peltier devices, are small solid-state devices which function as heat pumps. A typical TEM is a few millimeters thick, and is a few millimeters to

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Packaging Thermoelectric Modules for Demanding Environments (continued from page 1)

a few centimeters square, although other device outlines (circles, ovals, triangles, etc) can readily be produced. The TEM is a sandwich formed by two parallel ceramic plates with an array of small Bismuth Telluride cubes (couples) in between. When a DC current is applied, heat is moved from one side of the TEM to the other where it is removed by a heat sink. Thus, the solid-state TEMs, can be an ideal means of controlling and actuating systems that utilize shape memory alloy.

An earlier experimental analysis indicated that for demanding aeronautical applications, a high temperature construction of TEMs was required to meet the reliability requirements of this program. Four commercial-off-the-shelf (COTS) TEM's were evaluated in that study. It was also shown that an epoxy composite fill within the TEM significantly improved shear strength before and after environmental stress testing. This finding was significant as TEM elements, characterized by poor shear strength, required an improved packaging system to withstand 600G forces in a high vibration environment.

TEMs are made from the two elements of a semiconductor (primarily bismuth-telluride), heavily doped to create either an excess (n-type) or deficiency (p-type) of electrons. Heat absorbed at the cold joint is pumped to the hot joint at a rate proportional to the current passing through the circuit and the number of couples.

To prepare a useful device, these couples are connected electrically (in series) and thermally (in parallel). Fortunately, commercial TEMs are available in a variety of sizes, shapes, operating currents, operating voltages and thermal capacities.

TEMs can produce a no load temperature differential of about 67^{O}C. The actual cooling effect, however, is determined by the proper choice of TEM for each specific job. Three specific system factors must be determined before the correct device selection can begin:

1. Cold Surface Temperature (Tc)
2. Hot Surface Temperature (Th)
3. Quantity of heat to be absorbed at the Cold Surface of the TEM (Qc)

In most cases, the cold surface temperature (Tc) is an independent variable - i.e., the target is intended to be cooled to some arbitrary temperature. If the target is in direct and intimate contact with the cold surface of the TEM, the object temperature can be considered to be the same as the temperature of the cold surface of the TEM (Tc). If this is not the case - for instance, where a heat exchanger is required on the cold surface of the TEM - then Tc may need to be several degrees colder than the desired target temperature.

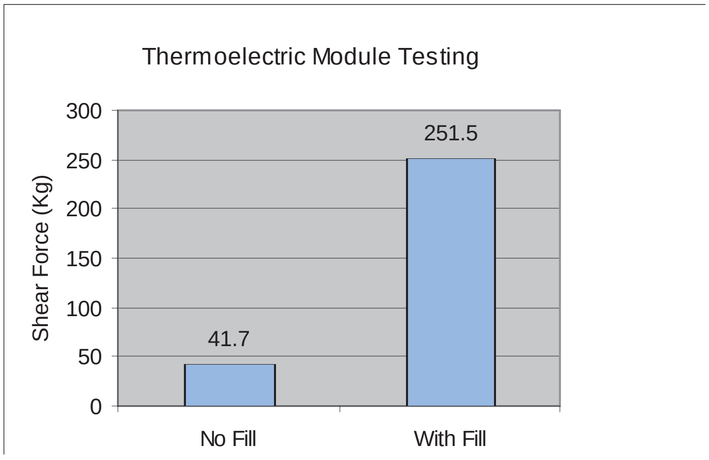
The Hot Surface Temperature (Th) is defined by two major factors: 1. The temperature of the environment to which heat is being discharged, and 2. The efficiency of the heat exchanger between the hot surface of the TEM and the environment.

The factors Tc, Th, and the difference between them must be accurately known to successfully determine the operating specifications of the TEM needed for any given application.

The amount of heat to be removed by the cold surface (Qc) of the TEM is typically the most difficult factor to quantify. This is because all the thermal loads to the TEM must be considered. These include the active (I2R) load from any device, thermal conduction through any object in contact with the cold surface, and all warmer objects in contact with the cold surface such as insulation, electrical leads, mechanical fasteners, air, etc. Sometimes radiant heat from surrounding objects must also be considered.

Once these three basic factors have been quantified, the cooling requirements for each application can be determined with the use of common heat transfer equations. These equations are found in most engineering handbooks, and are usually found in the literature and catalogs from commercial suppliers.

TEMs have unique advantages for thermal control in many harsh environments. But their effective application requires careful engineering, development and confirmation through exhaustive testing to assure thermomechanical performance in addition to the desired thermoelectrical effect.



ACI responded to this problem with an advanced packaging approach for the TEMs in which the free space within the TEMs was filled with an epoxy-composite material to support and add shear strength to the modules. The success of this approach is demonstrated in figure above, which confirms a six-fold increase in the shear strength of filled TEMs

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IPC-7711/7721 Certification

The increasing demand to properly train rework and repair operators is felt by many in today's electronic manufacturing industry. Manufacturers cannot afford to risk scrapping expensive assemblies any longer. The need for qualified operators to perform the most tedious of rework and repair operations is greater than ever. The EMPF Learning Center has seen great success from many companies in their first year of sponsoring IPC-7711/7721 at the Operator Proficiency level.

This course provides participants with a hands-on approach to rework, restoration and modification of electronic assemblies. Operators will learn the correct methods for rework, repair and modification to boards and assemblies. Candidates who successfully complete the course will receive a 2 year certification from the IPC.

The ability to customize training based on your company's needs is available. This offers companies the flexibility to select the modules in which their operators receive training (The only module that is a prerequisite for all other modules for both IPC-7711 and IPC-7721 is Module 1). For example, a company that only uses through-hole technology, and only needs their workers to be proficient in rework of through-hole components may only want to select Module 1 & 3 of IPC-7711. Companies manufacturing surface mount devices will be trained only to the modules of the surface mount devices that pertain to their manufacturing needs.

IPC-7711

The focus of IPC-7711 is on Rework of Electronic Assemblies. Students will learn and practice the techniques necessary to properly remove through-hole and/or surface mount components utilizing the latest tools, materials and technology available. All component acceptability criteria is based on IPC-A-610C and is reviewed for each module. Upon successful completion, students will obtain a 2 year IPC Operator Certification in the areas where proficiency has been demonstrated.

Module 1 covers general requirements and basic terminology of IPC-7711/7721. This module will also teach students basic considerations used in analyzing rework and repair, tool and material considerations, proper handling techniques, and basic cleaning procedures. The satisfactory completion of Module 1 must be done prior to training in any other modules.

Module 2 is designed to teach students the proper procedure for performing wire splicing. Students will learn to determine the feasibility of repair, the four types of splices used, as well as tinning and soldering considerations.

Module 3 concentrates on through-hole technology. In this module, students will demonstrate the skills of removing, land preparation, and reinstalling axial-leaded, radial-leaded and multi-leaded components on a PWA's utilizing continuous vacuum and wicking methods.

In Module 4, students develop the skills necessary to remove chip and MELF components, clean and prepare pads, and reinstall components. The use of various tips and techniques used in industry is taught.

Removing SOIC and SOT components, cleaning and preparing termination areas, and replacing components are covered in Module 5.

The focus of Module 6 is the removal, pad preparation and reinstallation of fine pitched (20-30 mil), multi-leaded, J-leaded and Gull/L-wing devices. Students who successfully complete this module will be capable of demonstrating their skills at the advanced level.

IPC-7721

IPC-7721 concentrates on the repair of electronic assemblies. Students will learn the latest techniques used to

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American Competitiveness Institute

Electronics Manufacturing Learning Center
Class Schedule for Calendar Year 2003

Electronics Manufacturing

BOOT CAMP A - Week 1
January 27-31
May 5-9
August 4-8
October 13-17

BOOT CAMP B - Week 2
February 3-7
May 12-16
August 11-15
October 20-24

Skills

SMT Manufacturing
March 10-14
June 16-20
October 6-10

BGA Manufacturing, Inspection & Rework
February 24-25
June 23-24
August 25-26
December 1-2

NEW! **Chip Scale Manufacturing**
January 22-24
April 30 - May 2
September 10-12
November 5-7

Continuing Professional Advancement in Electronics Manufacturing

NEW! **Design for Manufacturability**
February 10-11
May 19-20
August 18-19
November 17-18

Failure Analysis and Reliability Testing
March 19-21
September 24-26

Characteristic Properties of Materials
February 19-21
August 27-29

Certifications

IPC J-STD-001 Instructor Certification
January 6-10
February 24-28
March 31- April 4
June 2-6
July 14-18
September 8-12
October 27-31

IPC-A-610 Instructor Certification
January 13-17
March 3-7
April 7-11
June 9-13
July 21-25
September 15-19
November 3-7

IPC Challenge
February 12
April 23
May 21
August 20
November 19
December 10

IPC-A-600 Acceptability of Printed Boards Instructor Certification
February 19-21
October 8-10

J-STD-001 Instructor Recertification
February 10-11
April 21-22
May 19-20
August 18-19
November 17-18
December 8-9

IPC-A-610 Instructor Recertification
February 13-14
April 24-25
May 22-23
August 21-22
November 20-21
December 11-12

NEW! **IPC-7711/7721 Rework, Repair and Modification of Printed Boards and Electronic Assemblies (Operator)**
March 17-28
September 22 - October 3

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Course schedule is subject to change, please contact our Learning Center for the most current scheduling information.

Solder Reclamation

For years solder dross has been considered one of the most costly and wasteful contamination issues experienced in the wave soldering process. This led the industry into using nitrogen gas blanketing over the solder pot to reduce the amount of oxygen. The results were less dross build up, better soldering yields, and less overall solder replenishment. In some cases, this could save manufacturers up to a $1000 a week depending on the number of printed circuit boards assembled. However, because this system only controls the amount of dross build up, there was still a considerable amount of solder being wasted. Then, solder recovery systems were developed to help recycle more of the dross and reclaimed it into usable solder.

Today, solder reclamation systems (see Figure 1) can process up to 40 lbs. of solder per 10 minute cycle, recovering an average of 75% of dross by weight. For example, an eight hour shift can generate 25 lbs of dross. Given five shifts per week for 52 weeks, 6500 lbs of dross is accumulated. 4,875 lbs of dross may be recovered yielding an annual cost savings of $14,625.

How the System Works

With the combination of oxygen and impurities such as copper, contamination of the molten solder forms a layer known as dross. This dross is then removed from the surface of the molten solder using a ladle or large spoon. It is then disposed in a bucket or can be transported directly into a solder recovery system, which are designed to handle hot solder dross. A pneumatic pressure is invoked to extract the solder from the dross at temperature. The solder could then be either stored or returned immediately to the solder bath. In the case where stored dross is loaded, it is heated first to preset operating temperatures. Pressure is then applied using pneumatic cylinders to compress the dross being extracted. Any spent dross is disposed of through the operating chamber into a bucket by way of a dross chute. An air filtration and extraction is also added to help remove any dust particles which may accumulate during the dross ejection phase of the process. Finally, the reclaimed solder becomes an ingot that gets released into a drip tray where safety interlocks are active until the process is complete.

Figure 1
EVS 4000 Solder Recovery System
Compliments of Technical Devices

Would you like more details about an article?
What electronics manufacturing issues would you like addressed?
Would you like to receive the empfasis via or e-mail?

Let us know!

610-362-1320 or empfasis@aciusa.org

IPC-7711/7721 Certification

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repair circuits and laminates, including conformal coating/solder resist removal and reapplication. Upon successful completion, students will obtain IPC Operator Certification to IPC-7721 in the areas where proficiency is demonstrated. (Module 1 is a prerequisite for Modules 6, 7 or 8.)

In Module 7 of IPC-7721, students will learn PWB circuit repair. This includes learning the procedures applicable to, and demonstration of the skills used to fix a lifted pad/land repair, install an eyelet into a damaged plated through hole, repair a damaged trace and installation of a surface jumper wire.

Module 8 focuses on laminate rework and repair. Students will learn the procedures in addition to developing and demonstrating the skills of repairing damaged laminate materials using the newest materials and tools available to the electronic manufacturing industry.

The procedures and processes for removal and replacement of conformal coating is covered in Module 9. Students will learn about various conformal coating removal techniques including mechanical, thermal and solvent methods.

The IPC-7711/7721 Operator Proficiency level certification available through the EMPF Learning Center addresses the increasing demand to properly train rework and repair operators in today's electronic manufacturing industry. Certified operators are able to perform the most challenging of rework and repair operations while reducing costly errors in manufacturing electronic assemblies. Please contact the EMPF Registrar (610-362-1320 or registrar@empf.org) to enroll in an IPC-7711/7721 certification course or to obtain information regarding multiple student discounts and on-site training.

Packaging Thermoelectric Modules for Demanding Environments

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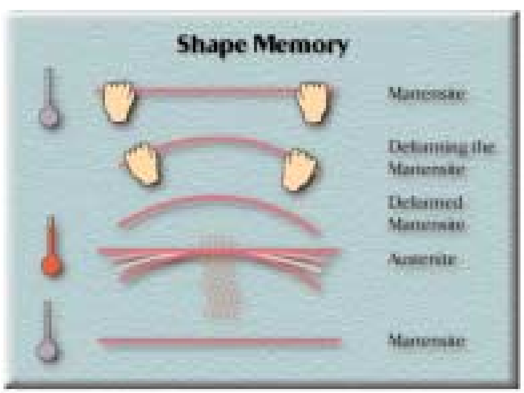
Shape Memory Alloy

NITINOL (an acronym for NIckel TItanium Naval Ordnance Laboratory) is a family of intermetallic materials, which contain a nearly equal mixture of nickel (55 wt. %) and titanium. Other elements can be added to adjust the material properties. Nitinol exhibits a unique behavior called Shape Memory.



Courtesy of Nitinol Devices & Components

The shape memory effect describes the process of restoring the original shape of a plastically deformed sample by heating it. This is a result of a crystalline phase change known as a thermoelastic martensitic transformation. Below the transformation temperature, Nitinol is soft and highly deformable, reflecting its martensitic structure. Heating the material converts Nitinol to its high strength austenitic form. While the transformation from austenite to martensite (cooling) and the reverse cycle from martensite to austenite (heating) does not occur at the same temperature, there is a hysteresis curve for every Nitinol alloy that defines the complete transformation cycle and it is highly repeatable.

With cold-working and continuous annealing, the metal, in the soft martensite form, cannot become deformed or stabilized in the deformed configuration. Now the thermally reversible conversion from austenite to martensite and back again engenders a controlled and reproducible change in the configuration of the Nitinol. This change in configuration (shape) can now be used to perform physical work - actuate a switch, operate a valve, rotate a mirror, work a lever, advance a gear, etc. - based on a control of the Nitinol temperature.

The currently proposed actuator employs Nitinol, and thermoelectric modules (TEMs) as its primary components. The Nitinol alloys mechanically activate the span wise change in rotor twist when heated above critical temperatures. The TEMs provide an efficient means of thermal management, both heating and cooling the Nitinol alloy electrically on demand.

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Cut here and save!

TECH TIPS...

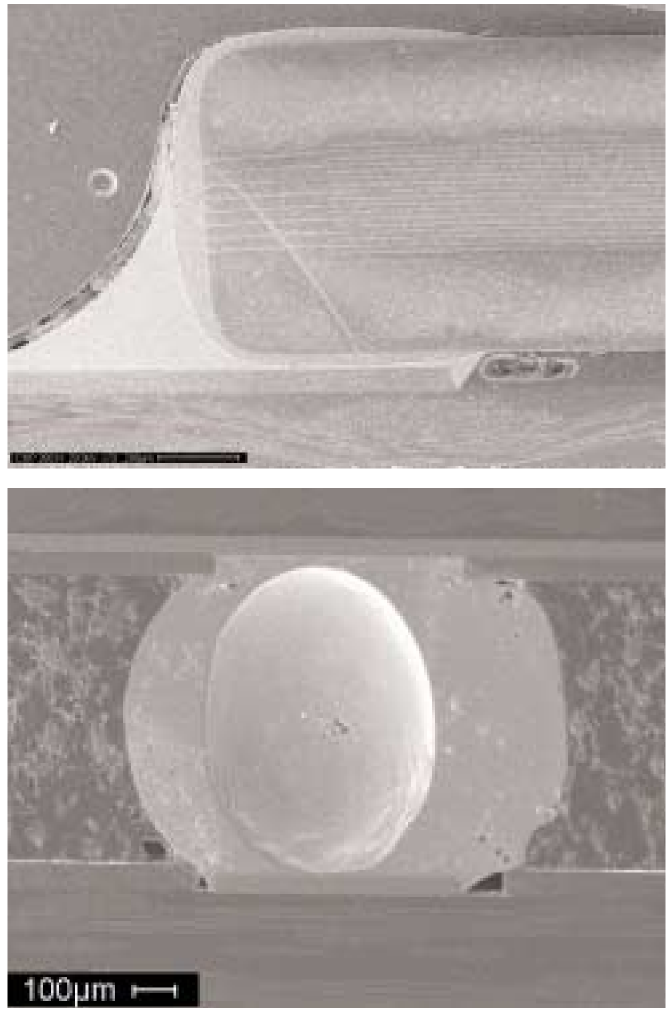
Microsectioning

Microsectioning is the most common technique used to prepare samples for examination under a microscope. In electronics, a microsection provides crucial information for failure analysis, process development, materials selection, and quality control. Materials are microsectioned (cross-sectioned) in any electrical failure analysis or examination to expose the interior features of components, packaging, PWB's and solder joints. This allows engineers and quality control personnel to make informed decisions about the condition of their product. Some typical microsectioning uses and applications include:

- Plating thickness and quality
- Solder joint intermetallics
- Ceramic substrates
- Printed wire board specifications
- Corrosion
- Welds and microwelds
- Solder joint geometry
- Junction conditions
- Wirebonds
- Internal metallizations
- Solder diffusions
- PWB quality
- Trace/barrel thickness and quality
- Contamination analysis
- Seal integrity
- Failure mode analysis
- Adhesion and delamination
- Dimensioning
- Voiding and cracking
- Cold solder connections
- Heat damage

Regardless of whether the section is prepared by a vendor, in-house, or by an outside laboratory there are a number of considerations that must be addressed. While the benefits of a good microsection can provide crucial information, the results from a poorly performed section can be misinterpreted and costly.

Considerations:
Laboratories that prepare microsections should be clean and well organized. Dirt particles and poor sample organization often lead to misinterpreted microsections.



Cracked chip component (top) and large void in a BGA solder joint (bottom) can be examined under a microscope after microsectioning.

Prior to any attempts to section a component, PWB, or assembly, careful planning is required. Planning includes identification of the area of interest and images of the area to be sectioned. It is beneficial to number locations on the assembly itself and record the locations on drawings or images. Drawings can be as simple as rough sketches or as detailed as high definition digital images. Accompanying the drawings should be specific instructions as to the location and description of the area of interest. Drawings also help illustrate the location and orien-

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Microsectioning (continued)

tation of the samples after they are mounted. This is particularly helpful for outside laboratories that are not familiar with specific component and PWB layouts.

It is recommended that the laboratory follow IPCTM 650 for microsectioning of PWB's. This sectioning procedure outlines the proper methods for rough sectioning, mounting, grinding, and polishing. Although some alterations to this test method are required when examining samples other than PWBs, this basic method with suit a large percentage of electronics analysis.

Often, because of surface defects created by the grinding and polishing process of microsectioning, etching of the sample is required. *If etching of a sample is required, the laboratory should have well defined etching techniques.* This includes defined methods, materials, and durations used for etching. Cracks, separations, and grain structure can easily be misinterpreted by over or under etching a sample or by using the improper etching materials. For example, over etching of a trace-barrel connection in a plated through hole can give the illusion of a separation.

Microsections should almost always be prepared in a mount. This mount provides stability to the sample while grinding, polishing, and examining the sample. However, the importance of the specimen mounting process is often overlooked when microsectioning a sample. Selection of mounting media is the first crucial mounting decision that can affect the output. Selection of mounting materials should be based upon the properties of the specimen, sample geometry, sample cleaning process, and curing time. It is important that the laboratory performing the microsection carefully review the material properties of the mounting media (shrinkage, transparency, rate of cure, edge retention, and exothermic properties) for application suitability. For instance, acrylics that exhibit a moderate level of shrinkage can expose the edges of a sample after curing. This creates a gap between the sample and the mounting media resulting in poor edge retention as leading edges of the specimen are now disproportionately exposed to the grinding and polishing process. In the case of plating and internal traces this reduces the overall dimension of the material layer resulting in accurate measurements.

If you have questions or would like advice on Microsectioning, please call the EMPF Helpline. An microsectioning expert will assist you with your request.

Cut here and save!

Manufacturer's Corner

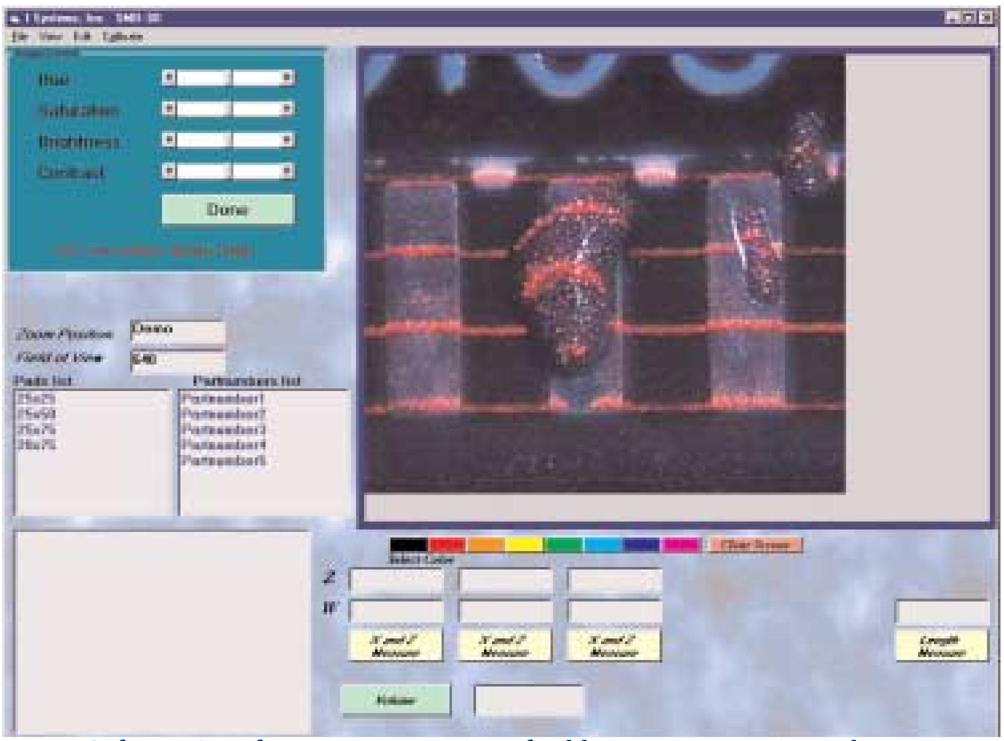
I-Systems: 3-Dimensional Surface Profiling

Visual inspection of SMT board assemblies is known for being inconsistent. Many of the inspection tools in use (magnifiers, eye loupes, etc.) don't allow the inspector to be consistent, much less achieve consistency among a group of inspectors.

The EMPF uses the I-Systems model SMD 3-D Semi-automatic Inspection System for SMT board inspection. It is primarily used in the demonstration factory for solder paste inspection and verification. It is also utilized in Boot Camp training, BGA Rework and Repair and Advanced Packaging classes to illustrate the necessity of 3-D inspection systems.

Solder paste printing is still a complex process where many process variables, materials, environmental influences (temperature and humidity) meet with the human factor. Most boards today are printed "On Contact," meaning the stencil is intended to be placed flat against the top surface of the circuit board being printed and the pressure of the squeegees moves the paste over the stencil, forcing it forward and down into the stencil apertures. It sounds simple but it is consistently reported that this process step continues to be responsible for the greatest number of end of the line defects. Changing the process to accommodate smaller packages, new stencil designs and paste formulas will make it more difficult to maintain high yields. The use of 3-D solder paste inspection equipment should help ease this transition.

3-D inspection systems are capable of providing both height and area measurements. True solder volume information can be acquired if a sufficient number of height data points can be measured. 3-D has the added benefit if being insensitive to color and contrast changes as well.



Software interface: Laser scanning of solder paste measuring volume.

Benefits of 3-D Solder Paste Inspection System

First, by finding defects where they occur, 3-D inspection can reduce rework costs by spotting problems before they go through the reflow process. The cost to repair a defect increases substantially as it moves undetected through the assembly process. Poorly screened solder paste can be washed from the board and the board can be printed again before a costly set of components are assembled.

Common defects that a 3D solder paste inspection system should be able to detect are: bridging, insufficient paste, excessive paste and paste misalignment. After solder reflow, these same types of defects can be much more costly to repair and there is a risk of board or component damage during repair. It will also be difficult to pin point the cause of a defect after reflow. Probably the most common end of the assembly line defect reported is solder bridging. Although bridging is frequently attributed to an excess of solder paste, it is difficult to make this judgement with certainty after reflow because other factors such as component leads, placement or a dirty stencil may be at fault. Using a 3-D solder paste inspection system can eliminate solder defects as a source of problems and help clarify the remaining causes of problems in the process. By eliminating solder paste problems and defects from the process, the remaining causes can be determined and corrected.

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Manufacturer's Corner - I-Systems 3-D Profiling System

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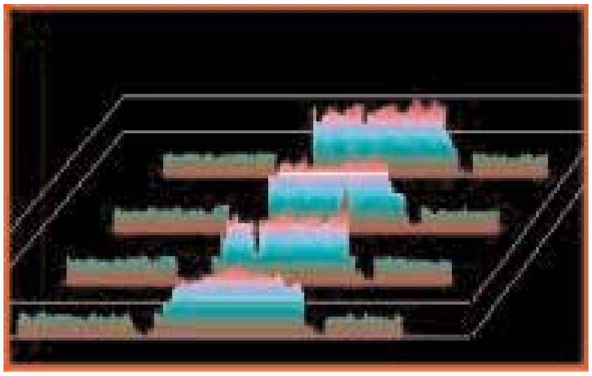
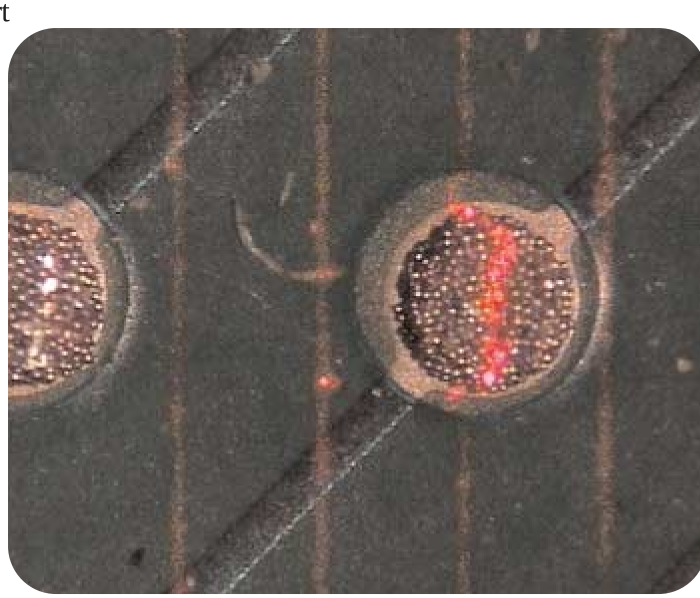


3-D profile plots.

Second, a good 3-D-inspection system does more than sort good product from bad. By providing accurate and repeatable measurements of important process parameters, it is easy to get valuable process control data. This data can contain not only defect information, but it's easy to see the normal process variations and identify the causes of defects and process trends. Process chart generation is frequently part of the systems software package and can be a good method of detecting abnormal variations in the paste printing process.

Third, SMT inspection tools that provide accurate, repeatable solder volume and height measurements can also be used to accelerate process refinement and help reduce product introduction cycles. Both CSP ad 0201 packages are still at an early stage of their introduction cycle and much remains to be learned before their usage become common place.



BGA pad being scanned to measure solder paste volume.

The solder paste deposition process continues to be the leading source of end of the line defects in SMT Assembly process. Process changes driven by the usage of emerging CSP and 0201 packaging technology will further complicate the paste deposition process. Solder paste volume will continue to be the best predictor of a good solder joint at the end of the line. 3-D solder paste inspection can be used to detect solder paste problems before they result in expensive rework or scrap. End of the line inspection may prevent defective parts from leaving the factory but does little to improve the quality of the product in the first place. A more effective strategy would be to improve first pass yields and prevent these defects from occurring in the first place.

The leading edge of the SMT process is continually changing with new materials, new components and new assembly methods being introduced to reduce the cost and improve product performance. When the assembly process changes, it should be requalified to ensure high product yields. In many cases, process studies can also be done on existing production methods to further improve yields. This type of engineering work is simpler to perform with reliable data from 3-D inspection machines that are monitoring critical steps in the process. Products such as the I-Systems 3-D solder paste inspection system, helps the EMPF maintain its technical edge.

If you would like to see a demonstration of the I-Systems 3-D profile system capabilities or would like information of this specific system, please call Jeff Stong at the EMPF at 610-362-1200 extension 224.

3-D Inspection can provide the user with the following data:

- Measurement of stencil apertures
- Part skew
- Dimensional measurement of mechanical parts
- Compare parts to a known good image
- Image documentation, annotation, part number, lot number or image capture archiving
- X, Y, Z measurement capability
- Volume calculation
- 3-D image profiles

If you would like more information or a demonstration of the I-Systems 3-D profiling system, please call Jeff Stong at (610) 362-1200 x224 or e-mail jstong@aciusa.org

Ask the EMPF Helpline!

CUSTOMER ISSUE: The caller described the cold tin-lead solder joints as having a grainy appearance and irregular shape. They seemed to have displayed poor wetting and the caller was concerned about the long term reliability of his product. His product, incidentally was a sensor that is exposed to outside environments in every region of the United States. His company expects the PWB to be able to withstand changing temperatures for over 20 years.

The described appearance of the solder joints was typical for tin-lead that has not endured sufficient temperatures during reflow. The result is solder that does not fully become molten and traditionally performs poorly under thermal and mechanical testing. Many cold solder joints result from soldering components with a large thermal mass that absorbs heat from the solder during reflow. What made this Helpline caller's problem interesting was that the cold solder joints were appearing on a small chip inductor. We promptly asked the caller to send a PWB that exhibited this problem for further review.

Investigation Techniques

The EMPF Helpline team visually inspected the sample and determined that a cross-section of the joint and inspection using Scanning Electron Microscopy (SEM) would divulge more insight to the root cause of the solder joint's appearance. SEM examination would also help determine if the component would become a reliability risk. The reflow profile was reviewed to ensure that the PWB was not exposed to excessive heat during reflow. An unsoldered component was examined to assess the condition of the component prior to reflow.

The unsoldered component displayed a minimal amount of silver (Ag) plating on the sides and bottom of the component. Silver plating is commonly used on chip inductors, resistors, and capacitors. The thin plating appeared inconsistent resulting in light coverage of the ceramic body of the inductor. In some areas the plating was almost translucent. The coined copper wire that stems from the inductor winding appeared stamped to this plating surface and remained exposed during the soldering process. This was a concern as oxide layers could form on the copper wire and reduce solderability.

The microstructure of the soldered inductor appeared normal, displaying the lamellar tin-lead grain structure that is commonly observed in properly reflowed solder samples. The solder microstructure also displayed small areas near the surface of the solder where it is likely that Ag has accumulated. This would give the solder a dull grey appearance when looking at the exterior of the joint.

The Ag-Pt (silver-platinum) plating layer is applied to provide a solderable surface for the ceramic inductor body. This plating layer is soluble in molten Sn-Pb solder and provides a wettable surface for which the solder can attach. Typically, solderable surfaces such as this one are thick enough so that they do not fully dissolve during a normal solder operation and therefore remain in contact with the ceramic material. The samples investigated did not appear to have an adequate plating layer as much of the plating on the sides of the components investigated had dissolved into the solder. This created a separation of the solder joint on one side of the component and complete non wetting to the ceramic on the other side. These conditions resulted in the bulbous solder joints observed in the cross-sections. These joints may affect the parametric values of these components when used in high frequency applications by displacing the component, decreasing the dielectric value between the winds of the inductor and the solder, and even shorting solder to the winds of the inductor. A cross-section of the soldered component revealed that little spacing was observed between the solder joints and some of the winds on the inductor. The component was also askew and shifted to the right side of the pad.

To prevent conditions that lead to nonwetting and separations, manufacturers of components with similar materials utilize thicker plating layers to prevent total dissolution into the solder. One other popular solution is the use of barrier layers such as plated nickel (Ni) .

Conclusions and Recommendations

The EMPF Helpline team concluded that the soldering process and sampled components were not compatible. Several recommendations were made for future production:

- Use of an alternative component which includes a barrier metal to prevent leaching of the component metallization from the package body
- Use solder pastes with a less aggressive flux combined with an alloy containing 2% silver to slow the dissolution of the component
- Use of conductive adhesives to attach the inductor

Because the OEM requires extended service life in a harsh environment, EMPF Helpline team did not recommend use, as-is, of the assemblies manufactured with current inductors used. While there seemed to be a good solder connection to the coined lead under the component, we did not believe that it is adequate to support the package over and extended period of time in an outdoor environment. The presence of small gaps when the metallization dissolved into the solder combined with the use of an aggressive flux was a cause for concern.

If you have an electronics manufacturing problem, call the EMPF Helpline at (610) 362-1320

American Competitiveness Institute - 2003 EMLC Course Schedule

Electronics Manufacturing

BOOT CAMP A - Week 1
January 27-31 | August 4-8
May 5-9 | October 13-17

BOOT CAMP B - Week 2
February 3-7 | August 11-15
May 12-16 | October 20-24

Skills

SMT Manufacturing
March 10-14
June 16-20
October 6-10

BGA Manufacturing, Inspection & Rework
February 24-25
June 23-24
August 25-26
December 1-2

NEW! **Chip Scale Manufacturing**
January 22-24
April 30 - May 2
September 10-12
November 5-7

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IPC J-STD-001 Instructor Certification
January 6-10 | July 14-18
February 24-28 | September 8-12
March 31- April 4 | October 27-31 | June 2-6

IPC-J-STD-001 Instructor Recertification
February 10-11 | August 18-19
April 21-22 | November 17-18
May 19-20 | December 8-9

IPC-A-610 Instructor Certification
January 13-17 | July 21-25
March 3-7 | September 15-19
April 7-11 | November 3-7
June 9-13

IPC-A-610 Instructor Recertification
February 13-14 | August 21-22
April 24-25 | November 20-21
May 22-23 | December 11-12

IPC Challenge
February 12 | August 20
April 23 | November 19
May 21 | December 10

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March 19-21
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Characteristic Properties of Materials
February 19-21
August 27-29

For more information, please call (610) 362-1320 or e-mail: registrar@empf.org

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