Published by Buehler, a division of Illinois Tool Works
Volume 1, Issue7

TECH NOTES

Microsectioning for Soldered Connection Analysis

By: James A. Nelson & George Vander Voort

Introduction

Among the current trends in printed wiring board design and production is the increasing use of surface-mounted components, often in combination with through-holes and vias. Microsectioning of conventional throughhole boards has long been used to monitor the performance of the processes that produce quality through-hole boards. It was also possible to perform a rather thorough visual inspection after the soldering operation.

But what about hidden anomalies? As the components become smaller and their density continues to increase, it becomes more difficult to visually locate anomalies such as “J” lead connections that are hidden beneath the components. This makes surface inspection
impossible.

Microsectioning, as it has often been performed, frequently tends to be more destructive than is tolerable. This is particularly true of the roughing out stage where sections are initially removed from the parent board. Under such abusive conditions, can we fully rely on information we might obtain from microstructural analysis?

However, it is possible to remove and prepare microsections that are free from excessive initial damage and are capable of providing the much needed information. One major problem that has longed inhibited the widespread application of microsectioning to componentmounted boards has been the absence of a well thought-out methodology.

The purpose of this TECH-NOTE is to describe a working methodology that will enable board packagers to perform microsectioning with confidence and obtain the information they need to validate their processes. The following is a list of potential applications for surface-mounted board inspection.

Common Anomalies

The ability to gain an in-depth look at surfacemounted connections may reveal the following additional information not otherwise available:

- Solder wetting
- Solder porosity
- Solder meniscus
- Lead-to-pad geometry
- Lead-to-pad solder thickness
- Lifted leads and other flaws caused by soldering process stresses
- Unacceptable solder microstructure

Sampling Techniques

Documentation

Before any attempt is made to section boards, care should be taken to maintain the location and identity of each area to be investigated. Each area to be sectioned should be numbered and the entire board should be either photographed or sketched as a record of section locations after the board has been cut up. The section identities must be maintained by transferring them to the specimen mounts so that anyone will be able to see where a particular section was taken.

Figure 1: Table saw used to rough out component-mounted boards

Specimen Removal

There is little problem obtaining samples for microsectioning from bare boards since the landscape is generally flat and uncluttered. But, component-mounted boards may consist of a mixture of through-hole and surfacemounted components, with very little free space between them.

Most conventional microsectioning methods for removing specimens from bare boards do not work well on component-mounted boards. There is not enough free space to provide a safe path for sectioning between components as was once the case. Band saws and routers cut too wide a swath and are generally too destructive.

A precision saw with a table cutting accessory, such as the one shown above in Figure 1, is the best arrangement for roughing out sections of high density boards for analysis.

With an accessory table attachment, it is easy to section to the desired plane along a line of soldered leads. For this roughing- out, a 30 HC polymer sectioning blade is used rather than a conventional diamond wafering blade commonly used in the electronics industry. This special blade produces slightly more damage than the conventional wafering blade but is much more durable and is not easily damaged.

As illustrated in Figure 2, cutting with the 30 HC sectioning blade polymer blade (top) produces substantially less damage than cutting with a band saw (bottom).

Figure 2: (top) As-cut surface produced by a 30 HC polymer sectioning blade with an ISOMET® 1000 saw. (below) As-cut surface produced by a band saw with ideal parameters. (10x)

Specimen Mounting

Specimen mounting is needed to support and protect the section from damage during grinding and polishing. Most technicians consider this step of specimen preparation as too routine for concern. However, the effectiveness of specimen preparation depends on mounting components without gaps or air bubbles that could leave critical areas unsupported and unprotected from the mechanical forces of abrasive material removal.

As component spacing decreases, it becomes difficult to obtain complete penetration of voids and gaps between components, between components and the board, and between, under, and around component leads. The degree of difficulty is related to the component density as well as the type of component leads that predominate. "J" leads present a particular problem because the pads are beneath the components making visual inspection impossible.

Specimens that have been removed from the parent board must be cleaned thoroughly to remove any contamination, such as cutting fluids, from all the surfaces. Careful application of ultrasonic cleaning is very helpful to pull contamination from recesses and other areas where dirt and oily substances may collect.

Figure 3: Vacuum impregnation equipment.

Epoxy resins are the best choice because they are harder and more solvent resistant than other castable resins. If time is a factor, an accelerated curing epoxy such as EPO-KWICK® may be used. Although they cure very rapidly, acrylics cannot be used for vacuum impregnation because of their high shrinkage and tendency to boil under vacuum.

Vacuum impregnation of the specimens assures penetration of the resin into all the recesses of the specimen. A multiple specimen vacuum impregnator, shown in Figure 3, allows multiple mounts to be vacuum impregnated in one pumpdown.

Specimen Preparation

Planar Grinding Stage

If at all possible, avoid any abrasive coarser than 240 grit (45µm). This requires that low damage sectioning, as previously described, was performed and that the starting point (close or "short" cut) be next to the very edge of the soldered connections. Long cut (further from desired plane) versus short cut manual preparation sequences are shown in Table 1.

Table 1: Typical Specimen Preparation Sequence for Component Mounted Boards (long vs. short cut)

Name	Composition
Planar Grinding Stage	120 grit silicon carbide paper* (optional -- long cut start)
	240 grit silicon carbide paper (short cut start, or second step for long cut start)
Specimen Integrity Stage	400 grit silicon carbide paper
	800 grit silicon carbide paper
	3µm diamond on napless cloth
Final Polishing Stage	0.05µm alumina on napped cloth

** Use only when the sectioning plane is far from desired examination plane.*

Specimen Integrity Stage

The specimen integrity stage is intended to remove the remaining abrasive damage left from planar grinding. Intermediate polishing employs one or two steps with napless cloths and diamond abrasives as listed in Table 1. This combination removes abrasive damage from the prior steps more effectively than alumina and maintains flatness at this stage of preparation. Alumina tends to round the edges.

Final Polishing

Final polishing removes very little material and cannot correct the errors of the previous steps. Final polishing uses a very fine (0.05µm) alumina on a napped cloth to remove any remaining fine scratches and superficial deformation. If the previous steps have been done thoroughly, the final polish should take only 30 to 60 seconds. Although prolonged final polishing will cause the laminate fibers to show more clearly, the board edges will become rounded obscuring some details.

Polishing Equipment

Some laboratories prefer to polish individual sections manually to control the plane of polish. This is satisfactory unless the number of sections to be prepared is excessive, requiring the use of automated equipment to increase productivity. If the initial starting point for multiple specimen mounts can be controlled within reason, automated specimen preparation is feasible.

Figure 4 shows one form of limited automation where the polishing parameters are controlled but the grinding/polishing surfaces must be changed between each step. Although this equipment was designed to prepare up to 6 mounts simultaneously, a single-mount specimen holder is also available.

Figure 4: ECOMET® 3 Grinder/Polisher with AUTOMET® 2 Head.

A fully automatic specimen preparation system is one that allows multiple specimens to be prepared without operator intervention. In the system shown in Figure 5, the abrasive grinding and polishing surfaces attached to platens are changed automatically. The controlled polishing program produces more uniform, superior results than is possible with manual preparation. It also frees the operator to perform other duties.

Figure 5: VANGUARD™ Fully Automated Polishing System

Results

Use of this methodology produces specimens that are well polished and free from damage as shown in the following examples. Figure 6 shows a "J" lead that reveals an unusual feature (arrow) that is probably a burr from the original forming operation. Figure 7 shows a large gas void (arrow) in the soldered connection of an "L" lead to the surface mount pad.

Summary

The trend toward higher component densities has complicated the evaluation of component-mounted boards. Traditional visual inspection of boards is difficult, if not impossible, with higher component density boards.

Recent advances in techniques, equipment, and abrasive products makes low-damage microsectioning a viable alternative. Successful microsectioning of component-mounted boards requires careful attention to damage control beginning with the original roughing-out where the greatest damage is most likely to occur.

Well prepared microsections will not only reveal the true condition of the soldered component connections but will also give the person evaluating the microsections full confidence that any defects that are observed are real and not induced by specimen preparation.

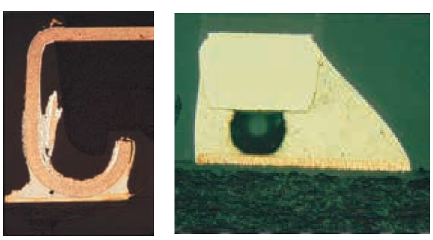

Figure 6: (left) Transverse section through "J" lead connection. (50x) Figure 7: (right) Longitudinal section through an "L" lead connection. (200x)

While the trend toward even greater component densities continues, research to meet the tougher challenges posed to conventional microsectioning are also continuing.

Tech-Tips

Question: When I have to remove a number of specimens from a board, how can I maintain the identity of the component and where it came from?

Answer: First you should examine the board using a low magnification stereo microscope to see if there are any signs of problems. Chances are that you will randomly choose certain components based on electrical tests or previously experienced problems with a particular board. Second, place sticky backed arrows pointing to the intended plane for sectioning or make marks using a fine permanent marker pen. Number each one and record in a note book for future reference. Draw a diagram of the locations or use a macro camera to capture this information quickly and effectively.

Question: When I epoxy mount specimens in plastic molds, the bottom surface tends to be non-planar or I get an odd cavity along the edge that I will be polishing. Is there any way to get a really flat surface as a starting point to begin grinding and polishing?

Answer: Yes, you can create a really flat surface if you use metal (aluminum) Ring Forms™ and an aluminum base plate. Ordinary aluminum sheet or plate will do, as long as it is flat, relatively smooth, and clean. But don't forget to coat the base plate and the inside of the ring form with release agent. The reason this works is that the aluminum draws the heat of curing away.

Question: Acrylic resins are less expensive and have a very short cure time. Why do you recommend the use of epoxy resins for vacuum impregnation?

Answer: The acrylics cannot be used for impregnation because they boil under a rather low vacuum. Epoxies are also better because they shrink less and are harder when cured. As a result, they keep the specimen edges flatter and provide better support to the specimen. One way to minimize the impact of the 6-8 hour cure time is to cast the specimens in the late afternoon and they will be cured when you arrive for work in the morning. The fast-cure epoxies are not recommended; the exotherm (heat of curing) could affect the solder.

Question: How can I improve the quality of my polished surfaces? The microstructure, particularly the interface between the solder and the copper, often appears indistinct.

Answer: When you etch the polished specimen, apply the etchant for a very short time at first. Then, polish the specimen for about 15-20 seconds to remove the initial etch. This will tend to remove the smear (superficial deformation) from the surface and cause the microstructure to be much more distinct.

Question: Are there any publications that would be helpful to evaluate circuit board cross sections in general?

Answer: Two documents that I recommend are IPC-A-610 (Revision B or later) and the Printed Wiring Board Defect Evaluation Wall Chart. The first one addresses a wide range of soldering issues including surface-mounted components. The second is strictly a through-hole defect guide. Both are available from IPC • 2215 Sanders Road • Northbrook, IL 60062-6135.

BUEHLER
An ITW Company

Connect with us:

BUEHLER Worldwide Headquarters
41 Waukegan Road
Lake Bluff, Illinois 60044-1699 USA
P: (847) 295-6500
www.buehler.com | info@buehler.com

BUEHLER Germany
info.eu@buehler.com

BUEHLER France
info.fr@buehler.com

BUEHLER United Kingdom
info.uk@buehler.com

BUEHLER Canada
info@buehler.ca

BUEHLER Japan
info.japan@buehler.com

BUEHLER China
info.cn@buehler.com

BUEHLER Asia-Pacific
info.asia@buehler.com

Printed in U.S.A. FN01035_0615