



Automated Microsectioning: An Economic Justification

Introduction

Microsectioning has become a standard requirement of printed wiring board (PWB) quality assurance due to the potential for hidden, subsurface defects, and for process control. In recent years, increasing numbers of PWB customers have begun to require certified vendors to perform statistical sampling of their product. Cost reduction initiatives are the driving forces which have shifted this responsibility to the vendor. Many wiring board manufacturers, however, are unprepared for this shift. Their microsectioning capabilities remain manual in nature, and they are poorly equipped to handle the volume of coupon cross-sectioning necessary to meet their customer's requirements. Often, all that is needed is a small investment in microsectioning automation, but the perceived costs keep many PWB production houses from taking this critical step. In addition, many are fearful that automation will result in loss of jobs. While it is true that automation will free significant amounts of time for workers to focus on other efforts, it does not eliminate the need for operators altogether. This paper offers a look at manual and automated microsectioning of PWB's, with the purpose of illustrating the time and cost benefits of automation.

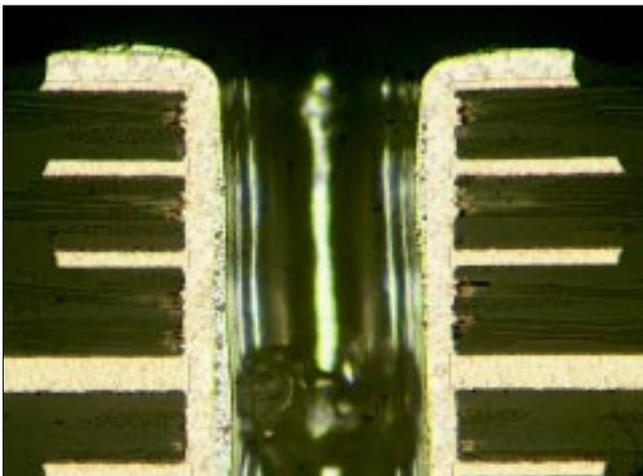


Figure 1. A cross-sectional view of a printed wiring board at the centerline of a plated through-hole.

What is Microsectioning?

Microsectioning is a destructive technique used to evaluate PWB quality by exposing a cross-sectional view of the microstructure at a selected plane. This plane is usually located at the center of a plated through-hole, or via. (Figure 1). Due to the destructive nature of microsectioning, test coupons are generally used. These standardized coupons are typically taken from otherwise unused areas of production panels. As a result, they undergo the same processing steps as the boards, and they are, therefore, statistically representative of the overall panel.

Removal of coupons from the production panel can be accomplished in a number of ways. One of the more common means of extraction is the punch and die method. This method utilizes a shearing force to punch the coupon from the surrounding material. For relatively thin boards, this method provides a fast means of coupon removal with minimal disruption to the integrity of the coupon. For thicker boards, a diamond saw such as the ISOMET® 1000, with Table Saw accessory, is a fast, low deformation means of coupon removal. See Figure 2.



Figure 2. ISOMET® 1000 Precision Sectioning Saw with Table Saw accessory effectively sections or trims printed circuit boards

The first step in microsectioning is to encapsulate the coupons in a protective resin. This resin material is critical since it supports the plated and solder-coated structures during the cross-sectional preparation process. For medium to high volume coupon preparation,

acrylic mounting compounds are typically used for their fast curing capabilities. Once mounted, the coupon is ground and polished to the centerline of the through-hole. Cross-sectioning in the close vicinity of the through-hole centerline is critical, as it allows statistically accurate plating thickness measurements to be taken.

Microsectioning Requirements

Microsectioning of a test coupon usually has two requirements: (1) The first is that the finished cross-section must be representative of the true structure. This means that proper grinding and polishing procedures must be followed so that deformation produced during each step in the process is reduced by subsequent steps, until virtually no deformation remains; (2) The second requirement is that there must be minimal sample orientation error. Sample orientation error occurs in two forms: Tilt Error and Planar Error.

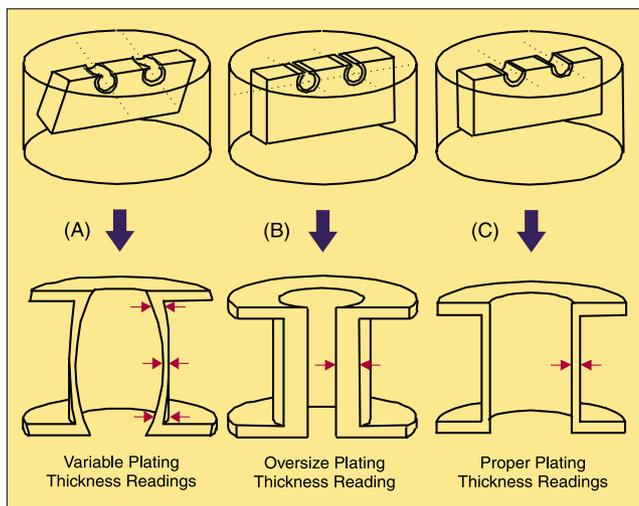


Figure 3. Illustration A shows the results of tilt error. Plating thickness appears to vary. Illustration B shows the results of planar error. Plating thickness is exaggerated. Illustration C represents a properly prepared section.

- Tilt error is the failure to produce a finished cross-section parallel to the centerline of the target through-hole or via. The result is a perceived variation in plating thickness from one end of the through-hole to the other, where one might not exist.
- Planar error is the failure to produce a finished cross-section within $\pm 10\%$ of the hole diameter from the centerline of the target through-hole or via. This causes a misrepresentation of the true plating thickness, as illustrated in Figure 3. Plating thickness appearance becomes exaggerated as the plane of sectioning moves farther from the centerline of the hole.

Let us now consider various options for producing microsections in quantity.

Manual Microsectioning

For laboratories that prepare fewer than 10-20 coupons per day, manual microsectioning may be appropriate. It may also be necessary when through-hole diameters are extremely small (0.008"/200 μ m or smaller).

When preparing a microsection, there is a significant time and cost advantage to preparing more than one coupon per

mount. With manual microsectioning, however, the problem is the inability to precisely align target through-holes in more than one coupon at a time. These through-holes must be aligned exactly so that the preparation process results in a section near the centerline of the target through-holes in every coupon. Once aligned, resin must be cast around the coupons without causing misalignment.

Because this is such a difficult task, most laboratories, which produce microsections manually, generally produce one coupon per mount to avoid potential problems. This results in loss of throughput, and high consumables cost.

In addition, manual preparation assumes that whomever produces the sections will hand grind them accurately and consistently, with no alignment error. This is a big assumption since manual sectioning requires regular inspection during the preparation process, and an experienced eye is needed to detect tilt and planar errors even when appropriate microscopic techniques are used. This regular need for inspection results in long preparation times for manual methods.

Medium Volume Manual Microsectioning

An alternative to standard manual micro-sectioning is available in the form of the PC-MET® JR. (Figure 4). This system incorporates a pinning process to align as many as six coupons together. (Figure 5).

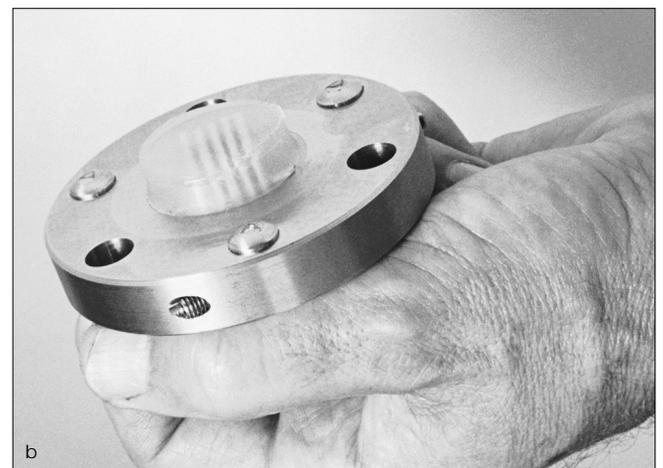


Figure 4. a) Coupons being encapsulated in Acrylic resin, and referenced to the body of the PC-MET® JR. b) PC-MET® JR. accessory with cast coupons in place ready for grinding and polishing

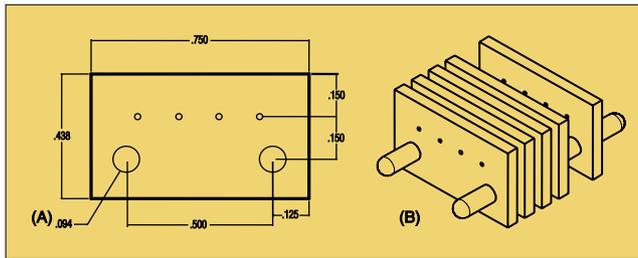


Figure 5. a) A typical coupon design for high volume specimen preparation, b) The pinned coupon concept

By pinning the standardized coupons together, it is possible to align the target through-holes of each coupon to one plane. These prealigned coupons are then encapsulated in protective resin, directly within the body of the PC-MET JR. By this method, the coupons and the centerline of their through-holes are referenced to the fixture for the remainder of the preparation process. 'Quick Adjust' Diamond down-stops then allow the operator to manually grind all of the coupons to the same plane without the need to continually check them. The advantages? Up to six coupons can be prepared together, reducing preparation time. In addition, consumables usage is reduced by a factor of six, and the pinning system and diamond down-stops eliminate sample orientation error, resulting in consistent microsectioning accuracy.

Automated Microsectioning

While the PC-MET JR. improves accuracy and throughput, there are still those whose sample volume requires more automation. In addition, whether performed one coupon at a time, or with a fixture that supports the preparation of multiple coupons, manual preparation yields the potential for repetitive motion injury, and thus, laboratory downtime. By automating the cross-sectioning process, these concerns are eliminated, and throughput is dramatically improved over manual preparation. The NELSON-ZIMMER® 2000 System (Figure 6), which is capable of preparing as many as 36 coupons at one time, reduces operator involvement in the preparation process



Figure 6. NELSON-ZIMMER® 2000 System

by passing the strenuous grinding and polishing tasks to a mechanized system. As with the PC-MET JR., the NELSON-ZIMMER 2000 System utilizes the pinning method to prealign as many as six coupons at one time. Six of these prealigned groups are then referenced to the bottom surface of the grinding fixture for a total of 36 coupons. Once the groups are referenced so that the through-holes in each coupon are aligned to the same plane, protective resin is used to encapsulate the coupons and lock them in place for the remainder of the preparation process. 'Quick Adjust' diamond and tungsten carbide down-stops are used to control grinding depth so that all of the coupons are ground and polished to the centerline of their respective target holes. Minimal operator involvement includes charging abrasives, adjusting the 'Quick Adjust' down-stops, and starting the system for each step. By automating the grinding and polishing tasks with the NELSON-ZIMMER 2000 System, it becomes possible to accurately prepare hundreds of coupons per day with no sample orientation error, and no possibility of repetitive motion injury. The resulting cost and time savings of an automated system are dramatic as well...

NELSON-ZIMMER® 2000 System Four Step Process

The NELSON-ZIMMER System is easy-to-use; laboratory technicians who are not knowledgeable in sample preparation can quickly get accurate results using the following four step process:



Step 1. The sectioned board samples are loaded onto the alignment pins using Buehler's proprietary no-stress press



Step 2. Pinned samples are placed in the carrier cavities and held in position magnetically to prevent movement during casting



Step 3. The mold cover is positioned over the samples and SAMPL-KWICK® Mounting Compound is poured. Samples are then ground and polished.



Step 4. After the preparation is completed the samples can be removed and optically examined.

Cost and Time Savings!

As a basis for analysis, let us consider a microsectioning laboratory producing 10,000 coupons per year. Such a laboratory, preparing microsections by inefficient manual means, would spend approximately \$12.78 per coupon on consumable supplies alone (All analyses are based on 1999 US\$ prices. 1 use per abrasive paper and 5 uses per polishing cloth are assumed). If this laboratory were to automate the process using the BUEHLER® NELSON-ZIMMER® 2000 System, which can produce 36 coupons at a time, their consumable costs would decrease to \$0.63 per coupon, for savings of \$12.15 per coupon! See Table 1. Consumable costs, however, are not the only savings that automation brings.

	Manual 8" consumables 1 coupon per cycle	PC-MET® Jr. 8" consumables 6 coupons per cycle	NELSON- ZIMMER® 2000 12" consumables 36 coupons per cycle
Total Cost (\$US)			
per mount	\$12.78	\$12.96	\$22.73
per coupon	\$12.78	\$2.16	\$0.63

Consider the time for a laboratory technician to prepare one coupon per mount. Table 2 illustrates the typical time for preparation of coupons produced manually versus automatically. While the time savings, due to automation, are dramatic, one must also consider the additional time savings created by the elimination of the need to inspect for sample orientation errors.

	Manual 8" consumables 1 coupon per cycle	PC-MET® Jr. 8" consumables 6 coupons per cycle	NELSON- ZIMMER® 2000 12" consumables 36 coupons per cycle
Preparation Step			
Alignment Pin Placement	0:00*	1:00	6:00
Encapsulation	1:00	10:00	10:00
Initial Grinding Step	1:00	2:00	2:00
Second Grinding Step	3:00	0:30	0:30
Third Grinding Step	3:00	2:00	2:00
Course Polishing Step	1:30	1:30	1:30
Final Polishing Step	1:10	1:10	1:10
Prep Time Per Cycle	10:40	18:10	23:10
Prep Time Per Coupon	10:40	3:02	0:39

*10 mounts created at one time (10:00 min) Time per mount (1 coupon) is 1:00 min

In order to convert this time savings to a monetary value, let us assume that our laboratory technician, in this example, earns \$10.00 per hour. When we use this hourly wage to calculate Total Yearly Costs (See Table 3), we find that Manual preparation costs \$145,578 per year, whereas automatic preparation costs only \$7,383 per year, for a difference of \$138,195. This amounts to an overall saving of 1972% when the NELSON-ZIMMER® 2000 System is employed, as compared to manual preparation.

Conclusions

While an argument can be made that manual or automatic preparation might take slightly more or less time than

	Manual 8" consumables 1 coupon per cycle	PC-MET® Jr. 8" consumables 6 coupons per cycle	NELSON- ZIMMER® 2000 12" consumables 36 coupons per cycle
Costs			
Consumable Costs (Cost per coupon x 10,000 Coupons)	\$127,800	\$21,600	\$6,300
Technician Costs (Time/coupon x \$10.00 x 10,000 Coupons)	\$17,778	\$5,056	\$1,083
Total Yearly Costs	\$145,578	\$26,656	\$7,383

described here, such an argument would not negate the fact that automation dramatically reduces the yearly costs of volume microsectioning. Based on the above analysis, and on current US pricing, the NELSON-ZIMMER® 2000 System has an initial payback period of less than two months.

Consumable costs and time savings are important, but automation offers much more than this. Automation also brings quality and consistency to the microsectioning process. By providing a means of preparing numerous microsections simultaneously, and with the assurance that each automatically prepared coupon will yield a more accurate analysis, the NELSON-ZIMMER® 2000 System has proven itself to be a necessary part of the modern PWB microsectioning laboratory.

If you have a question that you'd like to see answered, or a tip that you feel would benefit our readers, please write, call or fax to:

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