SUMNotes

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# PRINTED CIRCUIT BOARD (PCB) MICRO-SECTIONING FOR QUALITY CONTROL

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## Introduction

Quality control in Printed Circuit Board (PCB) manufacturing is very important, including but not limited to drilling hole quality, Desmearing of drilled hole, plating thickness of various metals and integrating of the final production board. During the manufacture of printed circuit boards, test coupons are introduced in each production panel. This allows each panel to be tested without wasting actual production board. The coupon is separated from the panel to confirm product specifications have been met.

It is important to continually monitor the process rather than to perform final inspection as otherwise, by the time a problem is found, a large number of parts may have been produced and moved to the next process, that would need to be recalled. The objective is to detect any deviations from required manufacturing standards as early as possible, and to avoid adding value (more processing steps) to any defective product. For this reason, the rapid and accurate discovery of problems and subsequent corrections to the process should be made as soon as possible. This reduces scrap rate, increases productivity and achieves a more cost-effective operation.

Coupons from manufactured boards are extracted, mounted and ground/polished to the plane of interest for these quality control tests. This paper will discuss the various aspects of PCB coupon preparation, and advise on attaining the best efficiency and accuracy in the process.

## What is Micro-sectioning of PCB's?

Micro-sectioning is destructive technique used to evaluate the quality of a PCB by exposing a cross sectional view of microstructure at a selective plane. This plane is usually the center of plated through holes or vias within +/-10% tolerance of accuracy of plated material thickness. As this is destructive analysis so rather than actual printed circuit, test coupons are generally used from the same board.

IPC has introduced a specific coupon design which can be included on each panel so that the coupon will experience the same process - and be representative of the remaining board. This coupon can be removed at any stage of production for cross sectioning.

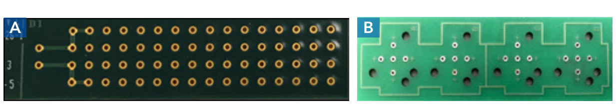


*Figure 1: Examples of PC boards (a) without reference holes and (b) routed and drilled ready for use*

In many cases, coupons can be manufactured into the board design and a test coupon to 'press out' of the board – this allows the most rapid transfer of coupons for testing. If another area of the board is needed, or the test coupon is not designed to be pressed out, then it is important to consider that the cutting method should not introduce any defects in the sample. If possible, do not use aggressive methods such as a Band Saw or Punch, which produces excessive damage in the sample. The best method for cutting the sample is either routing or cutting with a Diamond Wafering Blade and coolant. If a sample is required from a production piece or populated board, then it can be cut using a silicon carbide (SiC) abrasive cutting wheel on a high speed rotary tool. Always ensure cutting is done away from the specific area of interest.

## Challenges in preparing vias and plated through holes

1. The quality of final polishing should represent the true structure of sample.
2. No scratches or edge rounding should exist, as this can create errors in measurement.
3. There should be no sample orientation error during potting of sample. This means the sample coupon should not have any tilt after mounting (Figure 2a)
4. The center of the target must be hit, to avoid errors in dimensional measurement (Figure 2b)

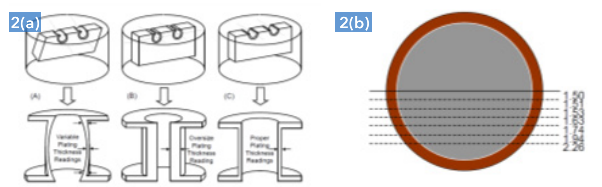


*Figure 2(a): Problems associated with tilt or target deviation*
*Figure 2(b): Change in apparent plating thickness due to improper targeting*

This requires excellent control of grinding and polishing steps so that each step should remove deformation completely from the previous step. The final polishing step should show true microstructure without edge rounding, and the target feature is found both accurately and with good alignment.

## Conventional Method:

In conventional preparation, many different mount sizes, shapes and mounting materials have been used, depending on the application. This does not support consistency of preparation, and the quality of the result tends to be variable.

In many PCB manufacturing labs, the procedure is to manually grind with several SiC papers from coarse to fine grit size on a rotating table with water, and then final polish with water base Alumina suspension on a napped cloth. This conventional process requires frequent stops during the procedure to visually inspect the sample to confirm the current location through the sample. There is also significant risk that the desired point is ground through, which might result in a complete loss of that production sample.

A typical conventional preparation method is shown in Table 1. Note that each sample can take 17-25 minutes or more to complete (assuming no operator errors).

Grinding and polishing has historically been done on a rotating platen with manual speed control setting as below. The first step is a sequence of grinding stages. Some applications use all of the papers listed in sequence, and some would use 3-4 spaced through the range. Each paper would be used for ~1 minute.

This type of approach has the following limitations.

1. Low sample throughput
2. Inconvenience of switching different grit sizes of SiC papers during grinding process
3. Inconsistent in quality due to operator variability
4. Cross contamination due to cleaning if not handled properly
5. Uncontrolled load can cause smearing – which can hide important features such as micro-cracks, voids or delamination
6. Uncontrolled times can cause polishing relief, making both focusing and accurate plating thickness measurement difficult
7. Frequently stops to inspect the sample during processing, to ensure accurate targeting
8. High degree of operator skill required to maintain plane of grind and hot target
9. Need to restart entire process if area of interest is missed

Running one sample at a time with poor preparation may end up in delays for production, poor interpretation of results, not enough statistical data for analysis and ultimately may cost money and business.

| *Surface/Abrasive* | *Base Speed (RPM)* | *Time (min)* |
|---|---|---|
| Plane back SiC papers with paper holding band: (Grit/FEPA Size):<br>120 (P120), 180 (P180), 240 (P280), 320 (P400), 600 (P1200), 800 (P1500), 1200 (P2500) | 150-300 | 3-7 |
| MicroCloth with suspension MicroPolish Alumina powders with water from:<br>1.0, 0.3, 0.05<br>*Typical polishing time: 3-4 minutes* | 100-150 | 9-12 |
| Typical grinding/polishing time per sample | | 12-19 min |
| Processing time including cleaning between stages per set sample | | 17-25 min |
| (15s for sample each step, 1min for cloth) | | |

*Table 1: Conventional preparation method*

## Modern method

To overcome the conventional method problems, Buehler has manufactured accessory kits for semi-automatic grinder-polisher equipment – the PC-Met High Volume accessory, and the PWB-Met Small Hole accessory.

### PC-Met Precision High Volume Printed Wiring Board Accessory™

This option is designed for users with a high volume of samples and can accommodate up to 36 coupons (at 0.125" thickness). It is able to accurately target the center of features down to 0.008" (200µm). Up to six coupons are place in each sample position, held in place using two indexing pins having a 0.094" diameter. All samples are ground and polished to target simultaneously.

This option is designed for users with smaller target feature sizes. It is able to accurately target the center of features down to 0.004" (100µm) and can accommodate up to 18 coupons at once (up to 0.125" thickness). There are 6 specimen positions, each of which has three slots. Each coupon occupies one slot and is held in place using two short pins with 0.094" diameter. As each coupon is pinned separately, the accuracy of targeting in the center of hole is much better than PC-Met Accessory.

Both of the Buehler Accessories for Printed Circuit Board produce accurate micro sectioning of coupons within target requirement, as well as true microstructure at area of interest, within four preparation steps. They have the added benefit of excellent reproducibility, as the end result is not operator dependent and every sample will maintain the correct orientation and reach the target area.

## Coupon Requirements

To use automation to target features, a standard coupon is required. This sets the distance between the locating pins and the plane to which we need to grind. In theory, this distance can be changed at will by setting up the distance appropriately, but the following standard coupon dimensions are recommended (Figure 3)

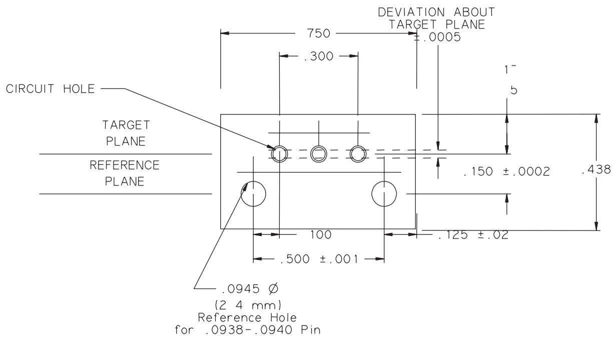


*Figure 3: Dimensions of test coupon for use with PC-Met and PWB-Met.*
**All mesurements are in inches*

## Operation procedure

Once the coupons have been mounted into their holders, the operation of PC-Met and PWB-Met is essentially the same.

### Set Dial to Zero position

As previously mentioned, it's necessary to set the total grinding distance from a reference pin on which the sample is mounted to the feature of interest. In the standard equipment, this distance is set to 0.150" as shown in Figure 3.

The perfect target is reached by grinding to diamond stops in the fixture. Setting the diamond stops accurately is of paramount importance in accurate targeting. A Dial Gage is used to do this. When the Dial Gage is set to zero with a calibrated reference pin, the target plane is set at the center of holes. A standard distance of 0.150" requires a reference pin of 0.1972" diameter. For other distances, different reference pins may be used. This can be calculated as follows:

Distance from Reference holes to Target holes + 0.047" (half the value of 0.094" diameter index pin).

## Diamond Stops setting:

The Sample Holder on both accessory kits has six diamond stops, three "Long" Diamond Stops and three "Short" Diamond Stops. The long diamond stop is to set the position for the first grinding step, and the short diamond stop sets the position for the second grinding step. Recommended settings are 0.007" (177.8µm) for the Long Stop and 0.003" (76.2µm) for the Short Stop. These distances are set directly on the Sample Holder fixture by adjusting the position against the Dial Gage (Figure 4). This ensures that the grinding surface plane remains above the target plane and will not pass beyond the center.

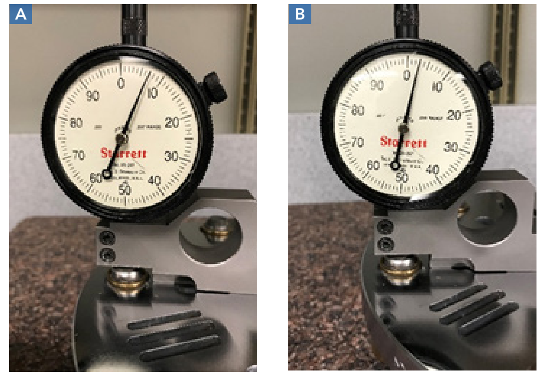


*Figure 4: Setting the position for (a) diamond 'Long Stop' and (b) diamond 'Short Stop'*

## Coupon pinning

Coupons are mounted on to pins, which allows them to be held firmly in place in the Sample Holder. The coupons are placed on to the pins before mounting, with the aid of a positioning tool (Figure 5). For the High Volume PC-MET system, multiple coupons are placed on two long pins (60-5053) with regular spacing maintained by the pin loading tool. Keeping space between each coupon is important to ensure best penetration of mounting media. For the high accuracy PWB-MET system, each individual coupon is loaded on to two short pins (60-5186).

*Figure 5: Coupons are loaded on to the pins with the aid of the Pin Loader*

## Mounting

Historically used resins, such as polyesters, can cause both health hazards and inferior preparation results. Epoxies either generate too much heat or take a very long time to cure. Buehler have developed SamplKwick acrylic resin specifically for this application, with a fast cure time (~10min) and excellent wetting characteristics. A mixture of 1 part powder to 1 part liquid is recommended. Before mounting, each coupon is dipped in to the liquid part to improve the surface coverage of acrylic material inside the holes – this is very important for smaller hole sizes.

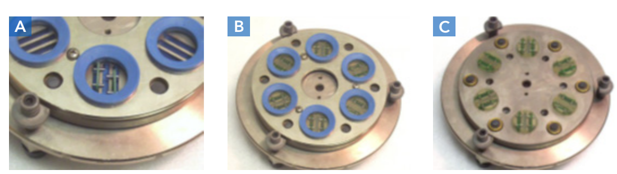


*Figure 6: (a) Coupons mounted into holder prior to pouring the resin (b) cured mounts in the mounting assembly (c) the grinding fixture with the molding plate removed*

Load each sample holder with coupons in a balanced manner to achieve best polishing results (Figure 6a). If there are not enough coupons for all six mounting positions, space the available coupons evenly around the sample holder for best results.

Fill each cavity up to the top edge of the coupons with SamplKwick (Figure 6b). Fill each cavity to an equal height, and do not over-fill as excess mounting media will not have any benefit but can increase grinding times. Fill any empty cavities with mounting media, to ensure an even level of support around the Sample Holder. Once cured, the molding plate can be removed and the sample holder is separated ready for grinding and polishing (Figure 6c)

## Grinding/Polishing:

### Step 1: Coarse Grinding

Silicon carbide paper can grind quickly through polymer based PCB coupons. The first step starts with 240-320 grit SiC paper along with running water until the Long Diamond Stop is reached. Change the SiC paper every two minutes and continue grinding until all Long Diamond Stops contact the surface. Marking the end of each stop with permanent marker can be a useful way to confirm contact with the grinding surface.

Rinse specimens and holder with water thoroughly after each step to stop cross contamination.

Back out all three Long Stops by ½ turn.

### Step 2: Fine Grinding

Grind with 600 grit SiC paper with water until all Short Diamond Stops are reached. Rinse specimens and holder thoroughly, with water.

Back out all three Short Diamond Stops by ½ turn.

When targeting the smallest holes using this method, it's recommended to check the height of the samples after each grinding stage to ensure that all diamond stops have been contacted fully. The Dial Gage should read 7 mil or less after step 1 and 3 mil or less after step 2.

### Step 3: Coarse polishing

Use 3μm Diamond Paste with MetaDi Fluid. Apply the paste evenly to a TexMet C cloth and spray enough MetaDi Fluid for lubrication (for repeated use, paste can be re-applied every 5-10 uses). Polish for three minutes. After polishing, clean sample and holder with water. Spray with Ethanol and then warm air dry. Inspect the prepared surface to confirm that SiC scratches are removed completely in this process.

### Step 4: Fine polishing

In this final polishing step, 0.05μm alumina suspension (MasterPrep) is applied to a medium napped polishing cloth (MicroCloth) and polished for 90 seconds. During the last 15 second of the polishing cycle, rinse with running water to clean polished surface as well as polishing cloth. In this step do not over polish by running extra time, otherwise rounding will occur at sample edges – especially on soft material like tin-lead coating – that can interfere with accurate measurement.

Note:

Variation to cross section preparation procedure may be required depending on the number, thickness and type of coupon material used in both accessory kits.

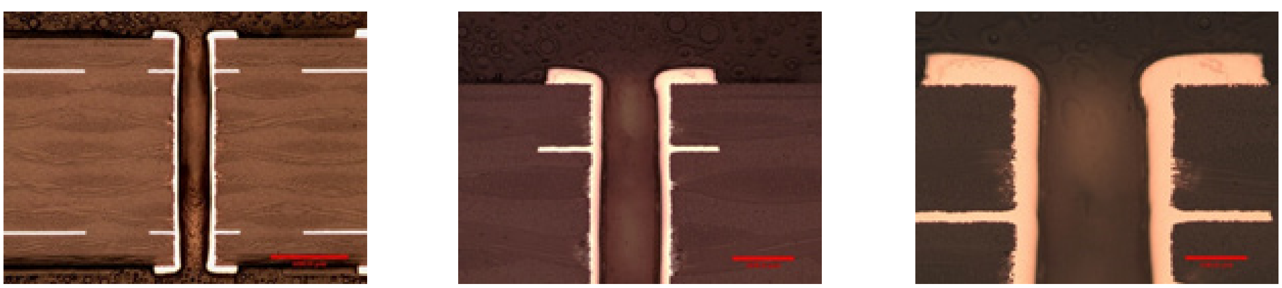

*Figure 3: Dimensions of test coupon for use with PC-Met and PWB-Met*

| Step No. | Surface | Abrasive | Lubricant/ Extender | Time (min:sec) | Head Speed (rpm) | Rotation |
|---|---|---|---|---|---|---|
| 1 | CarbiMet SiC Paper | 240-320 grit | Water | until Long Diamond stops are reached* | 250/60 | >> |
| 2 | CarbiMet SiC Paper | 600grit (P1200) | Water | until Short Diamond stops are reached | 150/60 | >> |
| 3 | TexMet C | 0.3µm Diamond Paste | MetaDi Fluid | 03:00 | 150/60 | >> |
| 4 | MicroCloth | 0.05 µm MasterPrep (Alumina) | • | 01:30 | 150/60 | >> |

| | |
|---|---|
| Typical grinding/polishing time per set of samples | 9-11 min |
| Processing time including cleaning between stages per set of samples (1min for holder each step, 1min for cloth) | 13-15 min |
| Processing time including cleaning between stages PER SAMPLE (PC-MET) | 47 sec |
| Processing time including cleaning between stages PER SAMPLE (PWB-MET) | 24 sec |

*Change the SiC paper after two minutes if all Long Diamond Stop are not reached.*

Table 2: Modern Preparation Method

## Discussion and Conclusions

The use of semi-automatic preparation, and multi-sample target grinding equipment, can clearly greatly reduce the per-sample processing time. In this example, the time to grind and polish the specimens has been reduced from around 20 minutes to less than 1 minute. Clearly, for any high-volume laboratory processing multiple samples this represents an enormous benefit. In addition to this, the improvements in reproducible targeting of features, reduction of re-work, consistency in finish, repeatability over time and between operators and the capability to process multiple sample types with fewer consumables will improve the performance of laboratories producing fewer samples as well.

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