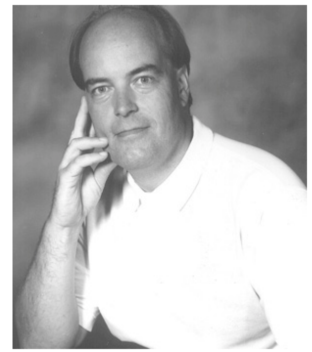


Basic Introduction to Microsectioning Printed Circuit Boards

Bob Willis

Bob Willis Process Guides

This document was originally edited from material produced for training courses run by the Institute of Circuit Technology (ICT) part of the PCIF which is now part of Interlec. The ICT training workshops were originally presented by many of the well known engineers working in the PCB industry in the UK. The courses were re-launched by the PCIF with Bob Willis during the late 90s. For further information on PCB related matters go to www.pcif.org.uk/

Introduction

Microsections are an essential tool in the quality evaluation and control of PCB manufacture. It is very important that the people who produce and assess these microsections are well trained and supervised by a person who is well versed in the methods of PCB manufacture. Regardless of some of the standards in the industry there are areas where cosmetic defects should be considered to be indicators for improvements rather than rejection of products. Visual standards are available from the author on CD or as wall charts and also from the IPC for training and reference.

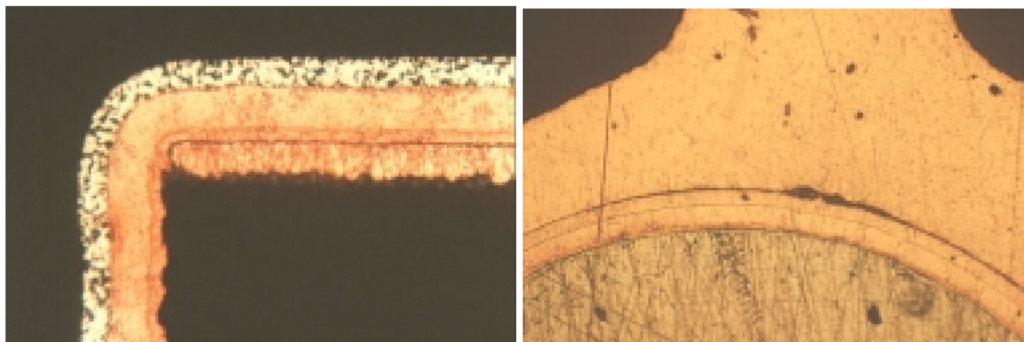
The majority of microsections are taken from test coupons, test boards or scrap boards. Test coupons are manufactured due to the prohibitive cost of loading spare test boards. There are drawbacks with test coupons, their proximity to the edge of the board and differences in make, e.g. number of layers at different hole positions, must be taken into consideration. If a specific issue comes to light it is fairly simple to add test coupons and, with care, they can be representative of the real board. It easier to change a test coupon than change an international standard.

These are other variations which should be evaluated on each design. Once the variables are known test coupon results may be used with more confidence.

Before taking samples for microsectioning, the following should be considered:

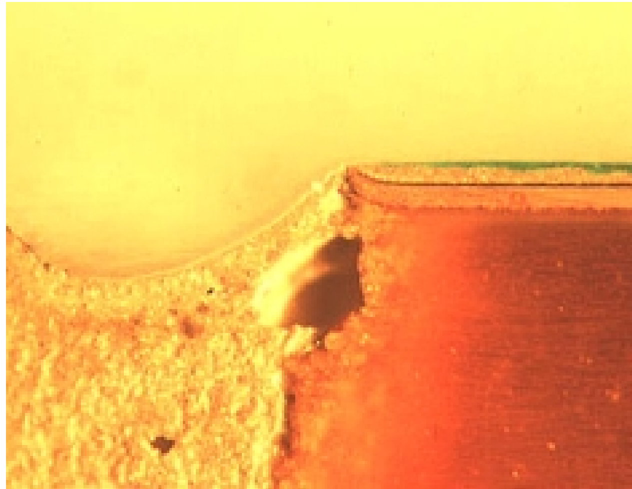
1) What are we looking for? This may seem an absurd consideration but the parameter being checked will determine which part of the board/test coupon should be sectioned.

2) If plating is to be assessed avoid areas in the proximity of jigging fixtures. Choose holes as near as possible to the board centre. Section holes in "x" and "y" axis.



3) Drilling and plating evaluation; choose an area where a range of hole sizes and inner pad configurations occur. It is good practice to arrange for the first and last holes drilled to be adjacent to each other, this allows evaluation of both in one section

4) Consider the colour of the resin; if you are going to take photographs a white or yellow coloring agent added to the resin can improve the colour separation on solder mask images



The example used white ink to make the colour of the solder mask and the silver through paste stand out for inspection.

5) Decide whether the sample requires overplating and with what material; overplating reduces the distortion of the plating for measurement purposes and it is normally confined to tin/lead.

Overplating

This acts as a support to the plated deposit under evaluation, preventing the outer edge of the deposit from deformation and profiling during polishing.

The overplated metal should not chemically react with the plated deposit or be softer. Overplating should be carried out where possible prior to the pattern being etched. The samples shall be degreased and chemically cleaned to allow the surface to "water wet" prior to overplating. Without the pre-clean the overplate will peel away and possibly give misleading results.

In most cases overplating is unnecessary if adequate care is taken in the preparations and assessment of the microsection. Gold can be used as it is nice and hard, copper is simple and readily available. It is softer than gold but harder than tin/lead.

Sample removal

Thin laminates of 0.25mm (0.010") or less. A hammer and chisel with the sample supported on a firm base, or scissors, will very successfully remove the requisite sample. Thicker materials may be cut with a variety of tools, from dental burr to fly press. Use of punches or presses to remove thicker samples is not recommended unless carried out under very controlled conditions. Some methods are listed below:-

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Punch/Press – may cause deformation to the sample. Accurate fixturing is essential. Method is dust free.

Dental Burr - slow but accurate. Very little sample damage likely to be incurred. Very fine dust produced.

Abra file/Jigsaw - awkward, can cause vibration damage. Some dust.

Drill route - when fitted to an engraver allows fast sample removal. Accurate fixturing not required. Variable sample size removed. Does generate dust.

If sections are being prepared of assembled boards care must be taken with the method of sample removal to avoid damage. It is often the case that chip components are damaged during preparation of samples or microsectioning and not caused in the process of assembly.

Whichever method of sample removal is adopted ensure it is carefully evaluated and the shortcomings known. Never cut too close to the sample and where possible use control samples. It better to cut a larger sample then grind down the sample too close to the point of interest before plotting the section. It is faster, quicker and avoids uneven sections.

Sample Encapsulation

Encapsulation of the sample prior to microsectioning is necessary for two main reasons:

1) To prevent the break-up of the plating under evaluation which can occur when it is not supported, thus preventing an accurate assessment of the sample.

2) To make handling of the sample easier. The media used to encapsulate the sample is dependent on the finish of the board from which the sample is taken and the sample makeup.

Hot Pressing using Acrylic Thermoplastic

This is a very quick and efficient method of encapsulating samples. There are several hot presses on the market, some manual and some automatic. Typically a temperature of about 180°C and a pressure of 290 1bs/in2 is used. Their operating parameters limit the use of the method to samples which will not be affected by temperature and pressure. Methods of encapsulation; a measured quantity of the resin is poured into the press barrel. The sample which will have been degreased and dried is placed onto the resin, an identification label is also placed in the resin, push both the sample and the label lightly into the resin. This will prevent the sample moving during the heating and pressure cycle.

When using a manual press

Raise the pressure again. After heating for 10 minutes turn off the heater and allow the press/sample to air cool for a period, then turn on the water cool. When the sample has been cooled sufficiently (10 minutes) release the pressure and remove the sample. With automatic presses the heating and cooling times are pre-set, also the pressure.

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Use of thermosetting resin

These may be two part liquids, one of which is the hardener, or liquid/powder mixes. Of the media evaluated the liquid/powder mixtures give the harder resin finish. Soft resins should be avoided as profile edges will occur. The resin cures due to exothermic reaction at a temperature of about $70^{o}C$. The time it takes to cure is dependent on the temperature of the room in which it is left to cure. The sample itself will affect the rate of cure and temperature reached during polymerisation. Most samples will be unaffected by the temperature but the drawback with these resins is the critical mixing. Good or bad results will be attained depending on how the resin is mixed and under what conditions it is allowed to polymerise. Excessive stirring and air temperature will result in aerated encapsulations, into which debris will collect during grinding and polishing.

Standard two part epoxy is also very effective and is a relatively low cost material for many different types of materials. Care needs to be taken when handling materials as some people can suffer from rashes when contacting these materials. Wherever possible wear gloves.

Examples of different sections materials, size of sections and applications

Sample Identification

For traceability each sample should be given a unique number possibly with the last two digits being the year. The batch number and board number should also be stated on the label. A simple log book with the microsection numbers in numerical order, date and sample description completes the traceability. Any paperwork will carry the relevant microsection number. Of course today everything can be logged on PC with all the images taken before and after preparation to provide a full report on the investigation.

The encapsulated samples are ground using silicon carbide papers either on a rotary wheel or flat bed strip grinder. A range of paper grades should be used starting with the coarse one and progressing through to the finest one. A continual flow of water of adequate flow rate to cover the paper and prevent clogging of the papers by ground off debris shall be maintained. Unlike the dry method of grinding, the wet method allows pressure to be placed on the sample to speed microsection preparation without more and deeper deformation of the sample. Deformation will be at its greatest with new papers and so the newness should be removed before critical grinding.

Grinding section manually, watch the tips of your fingers

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Three general rules during grinding:

1) The pressure on the sample shall be as high as is comfortable.

2) The paper should be slightly worn.

3) The time on each paper during grinding should be at least twice the time for removing the scratches left by the coarser paper. When microsectioning holes the coarse paper should be used until almost halfway through the holes. Then progress on to the finer grades until half the hole is exposed and the scratches are at a minimum. If there is any evidence of voids or lack of resin just before breaking through the hole wall consider adding some more potting compound and curing. This avoids damage to what may be the only sample being examined.

Polishing

Using a cloth impregnated with diamond paste on a rotary wheel 5 and 2.5 um pastes will give suitable finishes. A lubricant is fed on to the cloth during polishing. When not in use the cloth shall be kept covered to prevent dust contamination. The polishing stage should be kept to a minimum to avoid rounding of the outer plated edge. Thoroughly rinse the sample and dry with a soft tissue or cloth.

State of the polished sample

For photomicrography and critical evaluation of such attributes as intermetallics a much higher degree of finish will be required than for routine plating thickness measurements. The finish should be of such a degree that the person looking at the sample can draw the right conclusions. It will be found that the results of a highly finished microsection viewed by a lesser experienced operator will equate with results found by highly trained operator looking at a lesser finished sample.

Etching the sample

The etch selected should provide the clearest possible contrast between deposits. The etch removes any slight traces of metal spread over the surfaces during polishing

Preliminary examination of the microsection prior to recording of results.

1) Ensure holes if sectioned are, as near as possible, cut halfway. Under or over grinding will give false plating thickness results. (Plating will appear thicker than it really is)

2) Ensure the hole sample has been ground at 90°0 to the surface.

3) Check for resin shrinkage and separation between sample and encapsulant.

4) Ensure sample has not been squashed. Normally due to insufficient resin being used or poor removal

5) Check for deep scratches which may give the appearance of voids. The tell tale sign is that the scratch will be evident in the resin as well as on the sample.

6) Ensure the sample was not damaged during removal.

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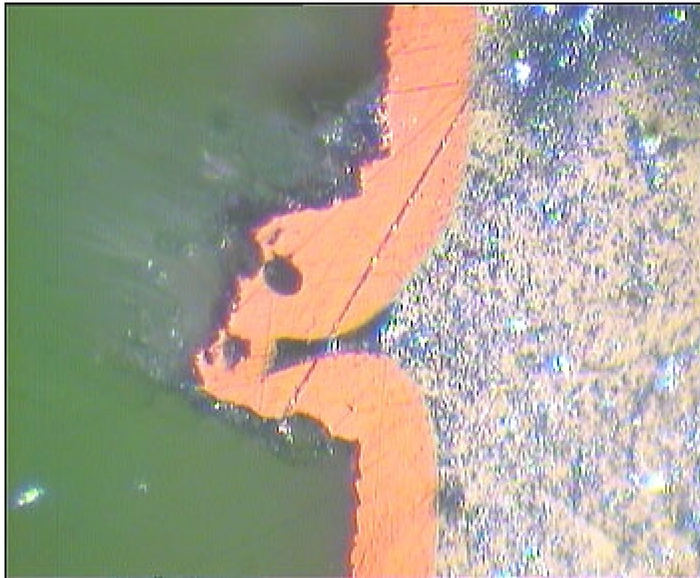
7) Plating Thickness. Results to plating shop and chemist. At least three readings should be taken per finish i.e. both surfaces and the hole. These readings plus the hole size and board thickness allow the results to be compared from day to day in manufacture, and thus show up any plating deficiencies.

8) Nailheading or drill burrs. Various causes for this defect. A few are drill condition, feed and speed, resin cure, backing material not flat. Not usually detrimental unless accompanied with resin smear. Which can cause high resistance connections or even open circuits.

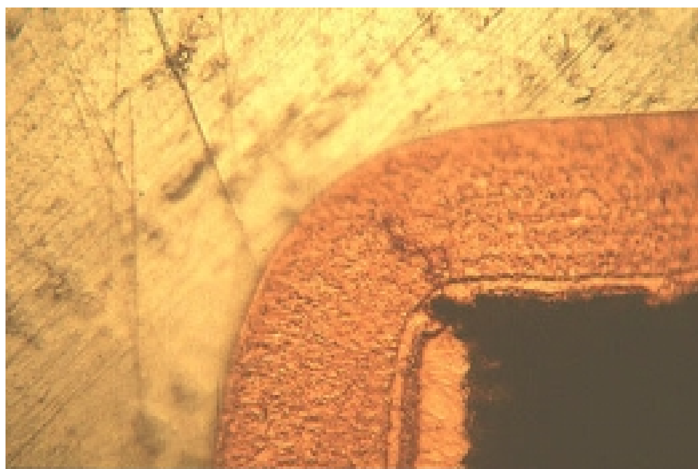
9) T.H.P. Void. Due to many variables some of which are grease on drills, poor hole conditioning, electroless failure, resin state etc. Any degree of voiding should be investigated.



Voids in plating as a result of poor drilling

10) Print, Plate and etch Voids. Generally due to surface contamination such as resist residues preventing plating of the etch resist finish e.g. tin lead, tin nickel gold

11) Barrel Cracks as a result of thermal-shock. Caused by "z" expansion of the base material exceeding the expansion rate of the copper. Normally it is a ductility issue with the copper.



12) Corner cracks as 11 above.

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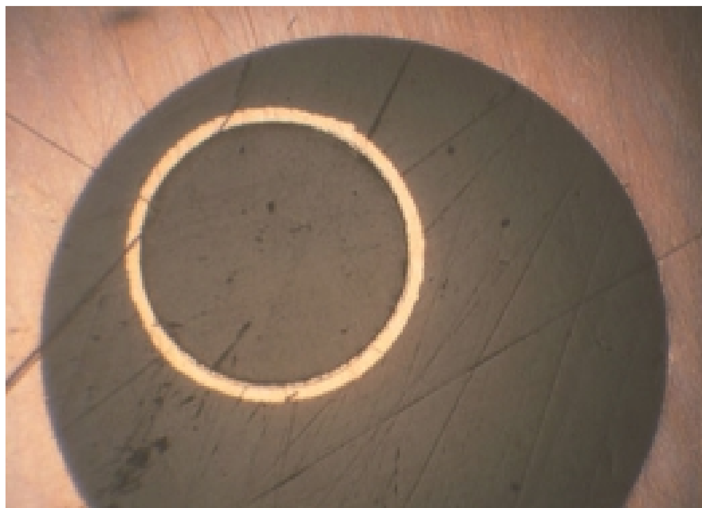
13) Misregistration of inner layer lands. May be due to inaccurate printing, laminate shift, artwork, drill tape error etc.

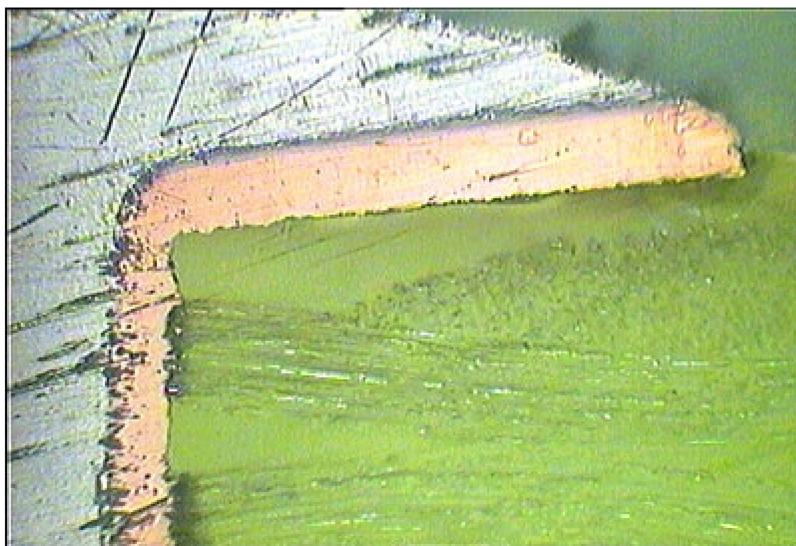


14) Material defects. May be bought in material defect or pre-preg fault or poor handling.

15) Severe back etch. Cause excessive time in solution.

16) Preferential resin attack during de-smearing. Cause incorrect solution make up or with plasma operation excessive time.

17) Pad lifting was originally seen during the introduction of multilayer boards with high z expansion; with lead-free soldering we may see it again



Many of the photographs come from the "***Printed Circuit Board Photo Album***" available to assist companies with their training and inspection documentation.

Bob Willis is a process engineer providing engineering support in conventional and surface mount assembly processes. He runs production lines for suppliers at exhibitions and also provides seminar and workshops worldwide. Bob has one of the largest collections of training videos, interactive CD-ROMs and training material in the industry. Bob will be presenting Master Classes at APEX in California, he will also be presenting classes at SMT Nuremberg in Germany for those engineers visiting the show. For further information on how Bob may be able to support your staff contact him via his web site **www.bobwillis.co.uk**

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