

The Microsection: A Work of Art (Part 3)

By Bob Neves



Bob Neves has spent the last ten years as the director of technical services for Microtek laboratories, an independent test facility. Prior to his tenure at Microtek, Bob worked in quality management and engineering in PWB manufacturing. He currently serves as the IPC's Rigid Board General Committee chairman, Rigid Board Test Method Task Group chairman, laboratory Qualifications (IPC-QL-653) Committee chairman, Member of DESC's Tiger Team for MIL-P-RRRRR (MIL-PRF-31032). Member of Blue Ribbon Committee for MIL-S-XXXXX (MIL-PRF-5X) and Convenor of IEC TC52 Working Group 10 Printed Wiring Test Methods.

Microsectional evaluation of the PWB is where information on plated-through hole and reinforcement material quality is assessed. Although evaluation is more straight-forward than microsectional preparation, the skill and knowledge necessary to properly evaluate a PWB microsection can be obtained only through experience and education. The IPC is an excellent source for training and educational materials as well as for providing technical workshops on the subject of microsectional evaluation of PWBs. IPC-VT-30/31 is the IPC's video training series on microsectional evaluation, and IPC-VT-30/31SS is the slide set that complements it. The IPC has also recently released IPC-CD-30/31, an interactive training CD-ROM on microsectional evaluation. The IPC can be reached at 847-509-9700.

This column will not directly deal with actual evaluation techniques, but will concentrate on the tools and techniques that are commonly overlooked during evaluation.

The Optical Microscope

The optical microscope is used to magnify images through a series of at least two convex lenses, one near the specimen (3X-100X) and one near the observer's eye (3X-25X). The path the light takes through a microscope can also be routed through various prisms and lenses to allow proper eye and sample orientation, split the light to a camera or second observation port, or to introduce light into the viewing path. Microscopes come either upright or inverted (metallurgical). Either type will work for PWB observation, but when using an upright scope, the sample must be leveled to assure that the focus is uniform across the field of view. Inverted or metallurgical microscopes inherently level the surface by allowing the sample to sit upside-down on a flat stage.

Microscope objectives and eyepieces can be acquired with a variety of optical ratings. These ratings are a function of the objective or eyepiece magnification, optical working distance, optical correction, filter and light compatibility, field of view, etc. The quality and diversity of optics are constantly changing, so careful consultation must be made with the microscope manufacturer to assure that you have the correct optics for your observation needs. The placement of focusing and sample movement knobs, filter adjustments and eyepieces must be carefully considered, as a typical technician will spend many hours each day at the scope and operator fatigue can be a real problem.

Damage can occur to the optics system from exposure to dust, excessive heat and corrosive vapors. Dust is the great-

est enemy of your optics, so keep your scope covered when not in use. It collects in the objectives, eyepieces, lenses and illumination sources, reducing light while introducing distortion to the light path. The vapor from the etchant used for PWB microsections can also be destructive to our optics. It is a good idea to ensure that the PWB microsection surface has been thoroughly cleaned and is free from residual etchant.

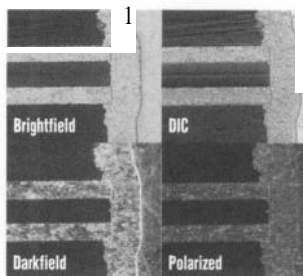
As you increase microscope magnification, the ability to obtain a depth of focus is subsequently reduced. Certain lenses and filters can improve this focusing depth, but the operator must be aware that features readily apparent at low magnifications may become difficult to see at higher magnifications.

The Problem with Light

By definition, an optical microscope uses the effects of light on surfaces to create an image of the area under observation. The area, evenness, color and intensity of the light source will directly affect the quality of your microscope observation. The first step in any microscope lighting system is the proper alignment of the bulb filament. If the filament is misaligned, the uneven image of the filament can produce diffraction fringes on the sample. The simplest method to align the filament is to view a piece of white paper using the lowest magnification available on your scope. Adjust the movement of the filament until you get a uniform brightness on the white paper.

Many microscope operators assume that more light is better so they adjust the power on their bulbs to maximum. Quite the contrary can be true. The power for lighting systems on microscopes is typically rated in volts. The more voltage applied to the bulb, the higher the intensity and color temperature. Higher light intensity can "wash out" surface features and reduce the contrast of the image. Most light sources are either halogen or tungsten, with halogen providing higher color temperature (3400K at 12V compared to 2800K at 7.5 for tungsten) and approximately four times the luminescence. Color temperature has the greatest effect upon photography as various films perform best under certain color temperature conditions. Most microscopes provide filter(s) for color temperature compensation which will allow the matching of film to the light source. If the proper adjustment for color temperature is still too bright for proper observation, the volume of light entering the path can be adjusted with neutral density filters which reduce light without affecting color temperature.

The field diaphragm "F" and aperture diaphragm "A" settings on a microscope are often overlooked, but when



Properly adjusted can dramatically improve viewing quality. The field diaphragm is used to restrict the illumination range, which will in turn reduce flare and residual reflected light. The field diaphragm should be "stopped down" to just beyond the field of view for a given objective. This will maximize the contrast of features within the sample. The aperture diaphragm is attached to the condenser lens and is used to control resolving power, contrast and depth of focus. As the aperture diaphragm is "stopped down," brightness is decreased while depth of focus and contrast is increased. If the aperture setting is "stopped down" too far, a diffraction image or white fringe will appear, giving false resolution to the image.

Viewing it in a Different Light

Many people use the buzzwords for optical microscope lighting conditions while trying to dazzle or baffle (you know the terms). I will try to provide the four major categories of lighting conditions with a concise description of each. I have included a figure which contains four views of the same sample.

"Brightfield" is the most common way to adjust lighting on a microscope. In brightfield mode, all of the light is projected directly at the sample surface through the chosen optics and filters. Brightfield observations are a direct reflection from the sample surface which produces interference patterns at discontinuities giving contrast to the reflected image. Brightfield illumination is also the basis for both polarization and differential interference contrast filters.

"Polarized" lighting uses the inherent properties of a polarizing filter which only allow light that is aligned with the gratings of the filter to pass through. This has the effect of eliminating all "non-conforming" light, while proportionately decreasing illumination. I'm sure everyone has taken the polarized glasses from Disneyland's Captain E.O. and crossed them at 90-degree angles, blocking out all light. This effect is due to the fact that the columnized light which makes it through the first filter is totally stopped by the second filter aligned in the opposite direction. If you change some of the light between the first and second filters by "interfering" with it, all of the light except for the "interfered with" light gets blocked. An optical microscope uses this principle for its light polarization. The first polarizing filter on the microscope is placed in the light path between the incoming light and the sample, allowing only columnized light to hit the sample. This light then reflects back from the sample to the observer after passing through a second adjustable polarization filter. This has the effect of blocking the light reflecting off flat surface features while allowing light "interfered with" by surface discontinuities to pass

through the second filter because it is columnated differently.

Differential Interference Contrast filtering comes in several "flavors" (DIC, NIC, Namarski). The easiest way to describe the effect produced by this filtering system is to take you back to our Captain E.O. analogy. The 3D effect produced with the polarizing glasses uses light which has been separated into two images to give the visual effect of depth from a flat image. This is what the spacing between our eyes does naturally when we perceive a 3D object. Differential Interference Filters use the polarizing filters described above with an added twist. An extra lens is added to the light path near the sample which bends and tweaks (pardon the professional term) the light to give a similar 3D effect. This can allow the operator to get a depth of focus which is much better than standard Brightfield observations. It can also allow you to see into nooks and crannies which previously appeared



as the infamous dark, lines in your field of view. Too much Namarski can also be bad. When pushed to an extreme, these filters can also make you see (false) images which are not there. so be careful!

Don't Be Afraid of the Dark(field)

Darkfield is, as its name suggests, anti-Brightfield. In darkfield mode, all light going directly to the sample surface is blocked out or re-channeled so that light only hits the sample surface at an oblique angle. When this light hits "flat" areas on the sample surface, it bounces off at an oblique angle and is not reflected toward the observer. When the oblique light hits a surface discontinuity, some of it is reflected back to the observer. This gives a similar effect to the polarizing filters, but can give a different view which can shed more light (literally) on surface discontinuities.

Microscope Measurement

Accurate measurement of surface features through the microscope is possible by using a scale which is placed in the field of view. This measurement tool can take the form of a fixed

scale at the eyepiece, a variable filar micrometer at the eyepiece, or video micrometer attached to a video system and projected onto the screen. Calibration of microscope scales or micrometers is accomplished by using a calibrated glass scale with graduations at very fine intervals (0.01mm, typically). This glass scale is viewed and measured through the microscope at all of the magnifications and a relationship between the measurement tool and the glass scale is developed.

A Picture Is Worth....

The Polaroid" camera revolutionized the still picture and is still in use today on many microscope systems. The Polaroid picture is easy to use and provides a quick picture developing time (=60 sec.). It comes in many iterations and formats, but typically has a high cost per print.

The 35mm camera has some distinct advantages and disadvantages. Such pictures inherently provide a permanent record (negatives) of the photographs shot. You would be surprised at how many necks have been saved by being able to reprint an MIA picture. The 35mm is very cost effective and has the benefit of being able to produce slides and large format photographs from negatives. The downside is that you have to develop it before you know what you have. If you botch a picture, it will be awhile before you know it.

Recent advances in electronics have allowed the use of high resolution video cameras and monitors to view microsectional specimens. Although the resolution of these systems is not as good as looking through the eyepiece, it is a good tool for evaluation and group viewing of the sample surface. Printers are available which will capture the video image, providing an impressive print in about 45 seconds.

If you have a video system, the next step is to capture images to a computer using special commercially available PC card and software packages. Capturing an image to a computer allows the photographs to be placed directly into a test report or presentation, and allows the quick transmission of images between different sites using e-mail and the Internet. We have set up a system at our lab with which we can capture the images directly into our test reports and then e-mail them to our customers so they can look at color pictures of the samples on their own computer screen. That sure beats a copied-faxed picture!

Microsection "artists" are created through education and training (natural ability helps too). Be patient and take the time to evaluate your work and the work of others. Be critical in a positive way. Don't hesitate to experiment with new materials and processes. Think "continuous improvement" and take the first steps to create your own microsectional work of art.