ANALYSIS

## From The Lab

**By Bob Neves**

# Testing Tiny Holes And Thin Dielectrics

## *(Part 1)*

You've just bought the latest laser-guided, plasma-driven, photo light speed gizmos to make those 2-mil holes you always wanted. You follow the (vendor) recommended manufacturing procedures to the letter. You hold your masterpiece up to the light and realize you can't even see the holes you just made… how are you going to test them?

Unfortunately, all of these small holes and thin dielectrics are going to force us to change the way we think about test and verification of manufacturing quality. The performance of these "latest" products also removes the safety margins we're used to. Although it seems like we are breaking new ground, there have been others who have been here before. The semiconductor industry is built upon these techniques, and I believe that we must take our direction from them. One thing that must go is the notion that these "new" PWBs will perform just like "old" ones (where have you heard that?). They will not! Properties like current carrying capacity, circuit resistance, dielectric constant, impedance, volume/surface resistivity, and electric strength will be different (maybe substantially different) than what we have become accustomed to with "conventional" technology PWBs. This means that the expectations of both you and your customer must change. In this month's column, I will write about those tiny holes, and next month I will talk about those thin dielectrics.

### *Cut, Mount, Grind, Polish, and Look*

The microsection is the test we have all looked to for the definitive answer to questions on plating and hole integrity. As hole sizes have shrunk, it has become increasingly difficult to get to the center of the hole (+/-10%) with standard microsectional techniques and test coupons. Getting to that magical center is important for an accurate measurement of plating thickness and other PTH attributes.

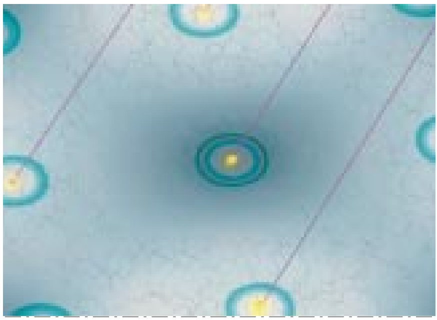
Microsectioning, for those of you unfamiliar with the technique, involves the successively finer grinding of the surface until you reach the center of the hole (see my May–July '96 columns for a detailed explanation). Making this all happen with a .020" hole is fairly easy as you have a center target of two mils. When your hole is two mils in diameter, and your target is two-tenths of a mil in depth, it is almost impossible to hit the center of a given hole.

To reliably hit the center of the microvia hole, a new test coupon needs to be designed which will give the microsection technician more opportunity to hit that magical center. I have detailed in Figure 1 the layout of a test coupon that will always yield a microsection with several holes visible at centerline in the microsection. This coupon design becomes large and impractical for hole sizes greater than 0.010" in diameter, but will work very well in the realm of microvias.

Using a microsection for plated through-hole analysis is not without its flaws. The statistical significance of a sampling plan which takes two points of a 360∞ hole from three of 10,000 holes on a printed board panel is almost laughable. In other words, if you don't see a problem in the microsection, you learn very little. However, if you do see a problem, the odds are that it is well distributed throughout the sample.

### *But Are They Reliable?*

There are some old as well as new reliability tests which can evaluate these tiny holes based upon the electrical and mechanical performance during temperature excursion. Reliability testing has become widely used despite historical impracticalities. New test technologies on the horizon will make reliability testing considerably more practical for both tiny holes and standard technologies. Here's a brief look at the old and the new.



*Thermal Shock*—The thermal shock test comes from MIL-STD-202 which has its roots in antiquity (I believe it may have been part of the Dead Sea Scrolls). This method utilizes a PWB coupon with an electrically interlocking pattern through which resistance is measured. This method subjects the test coupon to 100 cycles of externally induced thermal shock from -65∞C to 125∞C with a two minute transition and fifteen minute soaks at the extremes. The electrical resistance through the test coupon is monitored periodically during the cycle. Degradation of this resistance value is the key reliability factor evaluated. The samples are also typically microsectioned to evaluate the physical integrity of the plated through-hole after thermal excursion.

It is my understanding that the thermal shock method originally came from the need for a test which would simulate the environments that flight and space hardware would see when taking off from the desert (hot) and flying up (cold) into high atmosphere or space. There are others (Delco, Motorola, Bellcore, etc.) who have come up with reliability programs that rely upon the basic thermal shock philosophy. These programs typically vary from the MIL-STD-202 method due to specific product requirements and proprietary research and development.

*Thermal Cycling*—The thermal cycling test is a kinder, gentler, and substantially longer reliability test program. The key change that makes this test different than the thermal shock programs is the rate of change between

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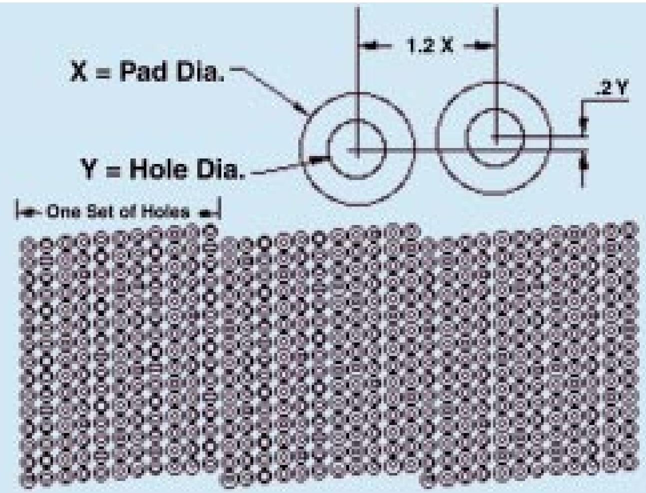

Number of columns in a set varies with hole diameter and pad size.
Minimum of three sets per coupon: Add microsection tooling holes as applicable.
Equations: Columns per set: $C = (6X / Y) - 1$ Width of each set: $L = (C)(1.2X)$

extremes. This rate can vary from 5∞C to 15∞C per minute which allows the product to adjust more gradually to the surrounding environment. The temperature extremes are also typically lower than the thermal shock test (≥55∞C and <95∞C) and typically relate more to an extension of the end-use application of the product.

*Current Induced Shock*—One of the most recent advances in the thermal shock arena is current induced shock. To summarize the technique, a special interconnecting test coupon is designed through which current is applied. This current can be controlled to heat the coupon up from the inside out at reasonably precise rates. This test coupon also includes circuitry by which the interconnection resistance is monitored continuously through a statistically significant number of holes. This technique has proven a repeatable way to gauge plated through-hole reliability economically, from both a cost and time standpoint. I believe that this technique has tremendous possibilities within our industry, and I will devote a future column entirely to this technique.

### *How Small Will It Go?*

This is the same question the semiconductor industry was asking years ago and, at a few microns, they are still thinking smaller. We shall follow suit! PWB products will continue to increase in density until the components that are mounted on them stop increasing in density. It is a paradigm that we must follow. We will find a way while materials, manufacturing procedures, product attributes, performances requirements, and test procedures will follow.