A New Technology for the Inspection of Contaminant Residues from the Formation of PCB Microvias

Masamoto Kishita
Shashin Kagaku Co Ltd.
Kyoto, Japan

Lionel Fullwood
Wong's Kong King Distribution Ltd.
Hong Kong

Introduction
The evolution of interconnection systems for Printed Circuit Boards has been extremely interesting.

The first connections were those generated in a copper foil on the surface of a single sided insulating substrate.

The first method providing connectivity between circuit patterns on both sides of an insulating layer was the use of rivets. When crimped correctly, these units allowed the development of multi-layered circuit patterns.

The introduction of electroless copper systems allowed this interconnection to be made chemically, and resulted in much more reliable electrical interconnects. The number of layers could be increased until the point was reached where reliability became a critical quality issue. It was not unusual to see finished product with 20, 30, 40, or more layers.

The problem inherent in the use of through hole technology is that a large portion of the 'real estate' of the circuit planes was used for connectivity requirements, thus reducing the density potential for the product.

Within the past decade, a new concept of interconnectivity has been introduced. The technology is called "Microvia Formation". By **IPC** definition in document IPC/JPCA-2315, microvias are those interconnection vias less than 150µ (0.006") in diameter. This paper relates to problems inherent in the formation of microvias.

The Problem
Every method presently available for the generation of microvias **other than plasma via formation** results in residues both on the surface of the substrate as well as in the formed via. As the via geometry has been constantly reduced, so the ability of the manufacturer to remove these residues has been diminished. A recent paper by one of the authors[1] has discussed this problem and its relationship to chemical Mass Transfer.

Figure 1 shows a microvia after plating that has residual smear from the formation process. This obviously will result in adhesion loss, and signal problems with the populated circuit board.

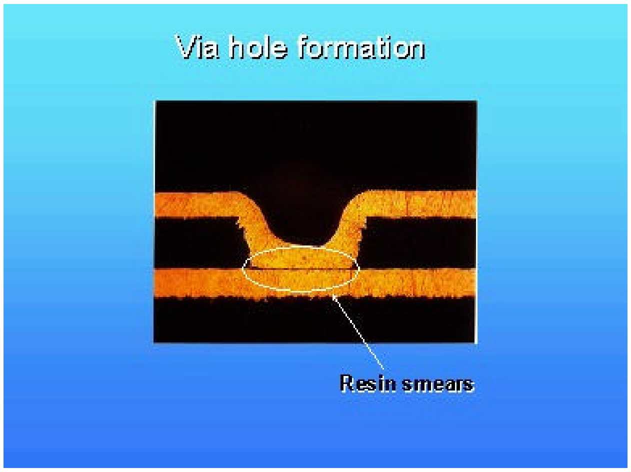

Figure 1 - Microvia after Plating that has Residual Smear from the Formation Process

Until now there has been no easy method to determine residual contaminants. One way has been to use Auger or EDX analysis of individual vias, mapping the hole surface to determine the level of cleanliness. Several examples of this technology can be seen later in this paper. However this is a destructive process, and is relatively expensive. Thus it was not possible to determine the cleanliness of a microvia, either after via formation, or after completion of the cleaning process, as an 'in-process' procedure.

The Solution
Recently the Shashin Kagaku Company Ltd. of Japan introduced its Model VH-600 machine. Its function is to detect contaminants in single or multiple build up microvia layers non-destructively. Please note that the unit measures one hole per 12 to 15 seconds, and so is a sampling tool, rather than a tool for verification of the complete substrate.

Figure 2 shows the process segments that can be analyzed using this technique.

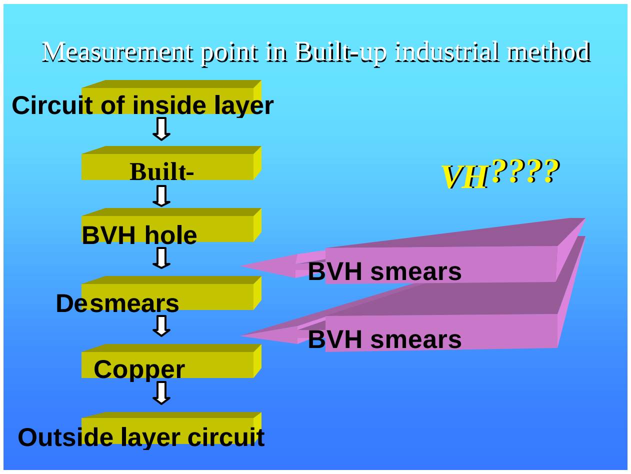

Figure 2 - Process Segments

It is now therefore possible to both check the actual via formation process as well as certify the desmear process.

Technical Principles Involved

The principle utilized is interference radiometry. This allows for film thickness measurements of residual surface contaminants.

Led light is projected onto the surface of the hole.

If there is a film of material on the surface of a substrate, then there are two reflective exit light paths (Figure 3). One is from the surface of the layer of residue. The second is from the back side of the layer. These two exit beams have a phase gap that varies by wavelength. In practice, several wavelengths are emitted, producing a 'pigmented' appearance to the film.

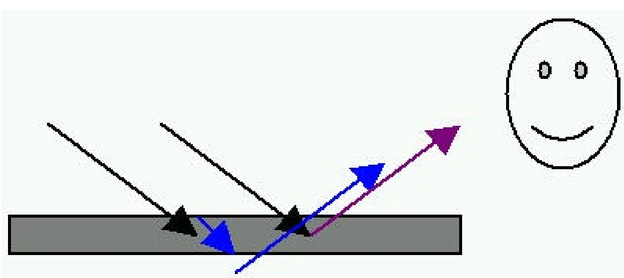

Figure 3 – Projected Light

The system only works well when the background is capable of reflectance rather than absorbance. Absorbance eliminates the generation of interference patterns (Figure 4).

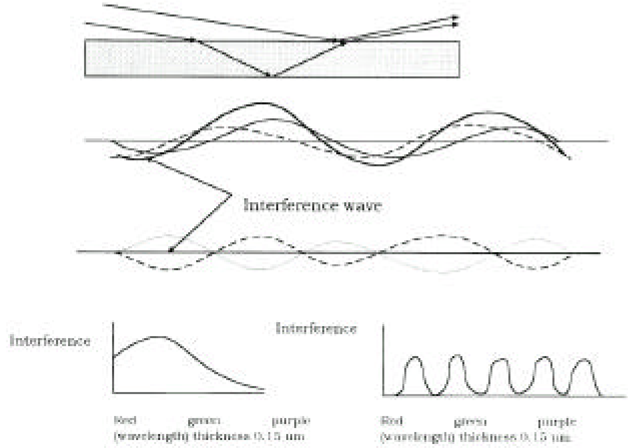

Figure 4 - Interference Patterns

This principle is then applied to residues from microvia formation. It can provide information from both the surface and the actual via itself. This therefore provides a valuable tool in determining the quality of both the via formation, as well as the de-smearing process.

Simple Instrumental Schematic

The basic schematic in Figure 5 describes the equipment set up. LED lights are provided for illumination, because of their long life and stable lumens output.

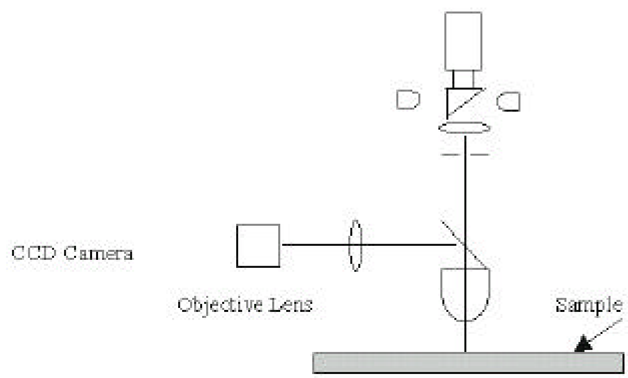

Figure 5 – Basic Schematic of Equipment Set Up

Operating Procedures

The target hole is located under the optics of the equipment, and is illuminated with white light.

The system incorporates an image processing system, and then automatically focuses the hole itself.

The operator then activates the LED function that then scans the hole with 10 different colors. Figure 6 demonstrates what could be exp ected as raw data. It should be noted that if the entire reflection rate is under about 30%, then the substrate does not have sufficient reflectance, and cannot be analyzed.

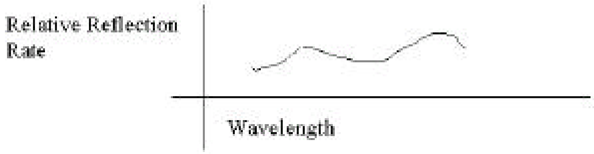

Figure 6 – Raw Data

Please note that if the substrate surface is relatively rough, there is the potential for diffused reflection waves to be included in the spectral response. It is therefore necessary to further analyze the data as shown in Figure 7.

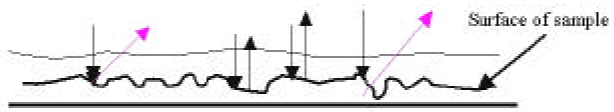

Figure 7 - Measurement Patterns for Rough Surface

As shown in Figure 7, light reflected from the relatively flat peaks, as well as somewhat flat valleys, provide a normal response. However light reflecting off the sidewall of the slope will reflect at different angles, depending on the degree of the slope. Thus reflection rates are higher from these areas.

To compensate for this, the software uses white light to identify pixel positions from these areas, and saves this data. A system algorithm then provides a base waveform for the substrate, and then is able to use this base waveform when processing the interference patterns from the LED light. Finally the system then calculates the approximate film thickness in this area, annulling the effect of the surface irregularities.

Machine set-up

The system has a profile display menu built in to the Operating System.

The operator has the option to select only two colors, providing only the actual surface, plus the residual material. In practice, this is usually not sufficient information, and the operator will normally select 4 or five levels of contamination.

The machine is capable of seeing smear thickness from 0.5 to 2.0µ.. It would therefore be possible to choose a background color, and a different color for 0.5, 1.0, and 2.0µ.

In Figure 8, green is background, and red the thickest residue deposit.

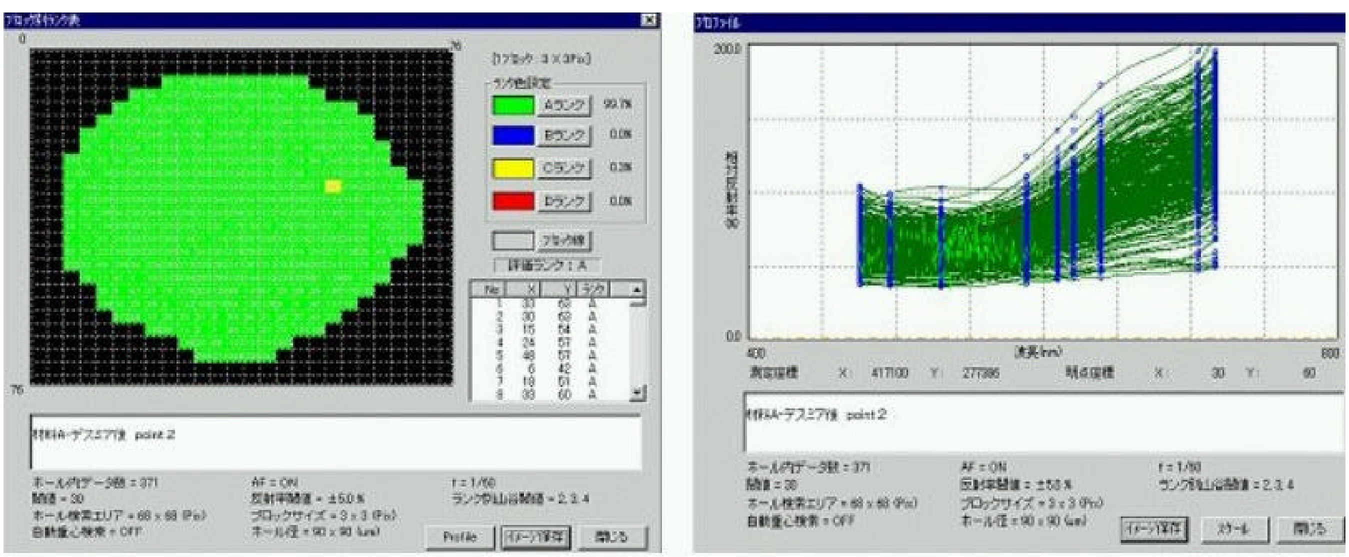

Figure 8 - Before De-smear

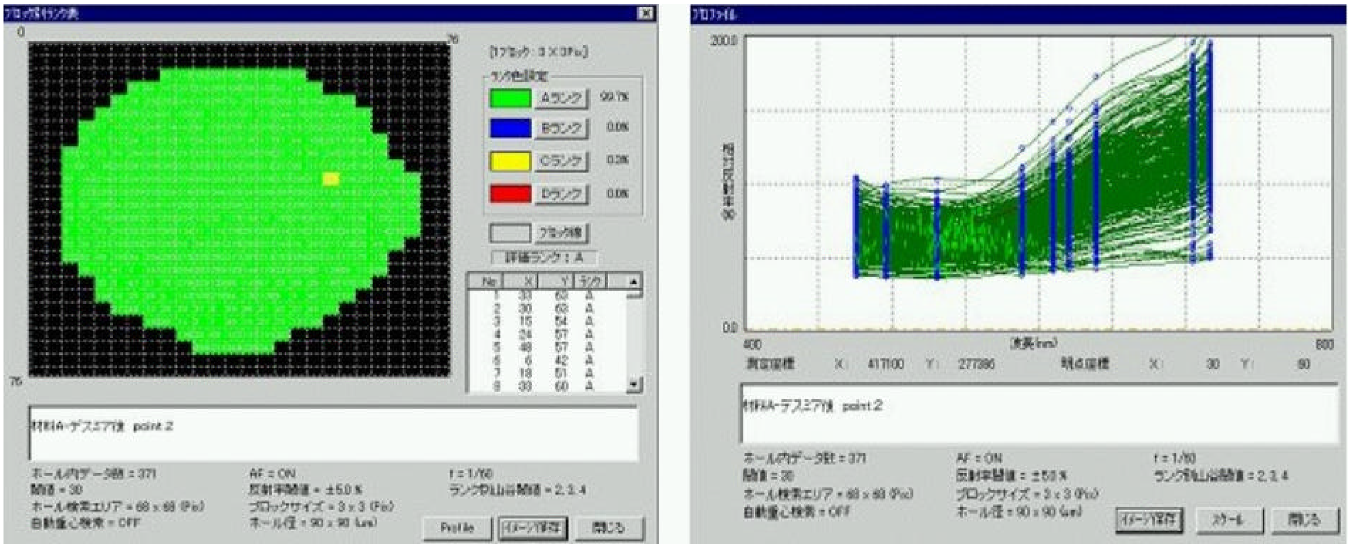

Figure 9 - After De-Smear

Figure 10 show firsts the surface and capture land, using a Scanning Electron Microscope. Relative magnification is indicated in the figure. Hole quality before and after the de-smear operation are provided.

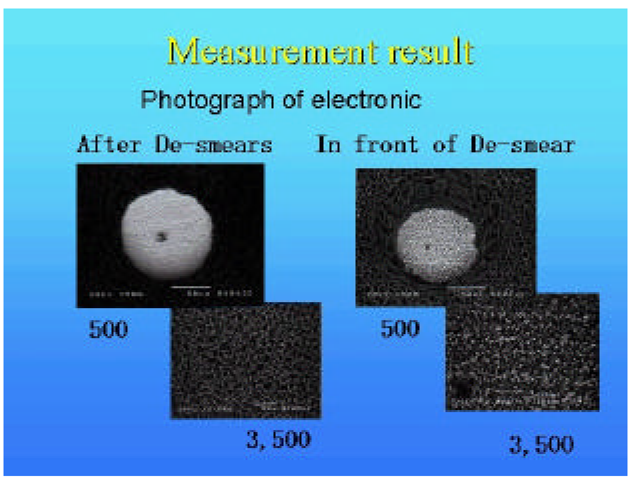

Figure 10 – Measurement Results

Figure 11 shows the profile and scatter graph of the same holes using the "detection equipment". It is felt that these two pictures provide verification of the value of this piece of equipment.

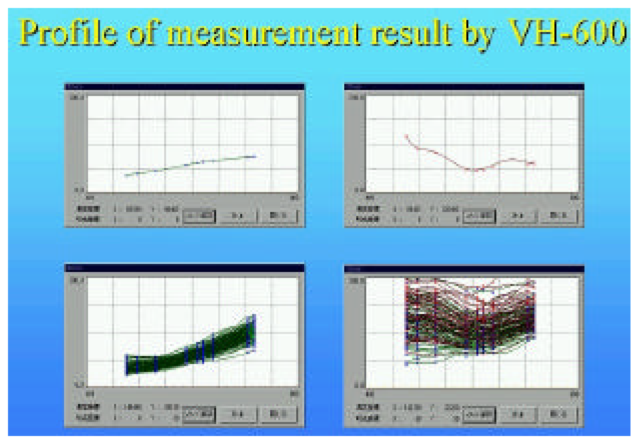

Figure 11 – Profile and Scatter Graph

Please note that the equipment is also very useful for the evaluation of silicon surfaces, but this information is outside the purview of this presentation.

In conclusion, there is now a powerful new tool for the analysis of microvias, both after formation and also after the de-smear process.

References

1. *The Laws of Chemistry Intrude on Fine Line Wet Processing Operations:* IPC Fall Meeting, 2001. Authors: Lionel Fullwood and Patrick Li.