

Unlocking the Secrets of PCBs: A Metallographic Assessment of Vias

In the world of printed circuit boards (PCBs), the unsung heroes are often the smallest and least visible components – the vias (vertical interconnect accesses). These tiny vertical interconnections, responsible for transmitting electrical signals between layers of a PCB, are essential for ensuring the performance and reliability of today's complex electronics. But despite their importance, vias can be a significant source of failure if not properly designed, manufactured, and assessed. In this article, we'll explore the metallographic assessment of vias, a critical technique for uncovering defects, ensuring manufacturing quality, and maintaining the integrity of PCBs used in industries ranging from consumer electronics to aerospace and automotive.

Why Focus on Vias?

As electronic devices become smaller and more complex, PCBs have evolved to include more layers, finer traces, and higher-density designs. Vias serve as the electrical highways that connect these multiple layers. There are three primary types of vias:

1. **Through-hole vias:** Extend through the entire PCB, connecting the top and bottom layers.
2. **Blind vias:** Connect an outer layer to one or more internal layers without going all the way through.
3. **Buried vias:** Situated between internal layers, invisible from the outer surfaces.

When vias are not properly formed, they can introduce a host of issues that compromise the PCB's electrical performance, such as increased resistance, signal loss, or even complete circuit failure. In industries like automotive or aerospace, where reliability is non-negotiable, these defects can lead to catastrophic consequences.

The Role of Metallographic Assessment in Via Quality

Metallography is the study of the microstructure of metals and is an essential tool for analyzing the internal structure of PCB vias. By preparing cross-sectional samples of the vias, engineers can conduct a detailed inspection of critical aspects such as:

- Copper Plating Thickness and plating defects
- Via Wall Integrity
- Void Formation
- Cracks
- Misalignment with Internal Layers

This process helps identify potential manufacturing defects before they manifest as failures in the field. It's a proactive approach to ensuring the long-term performance and reliability of PCBs.

How Metallographic Assessment Works

To perform a metallographic assessment of vias, a sample PCB must be sectioned, polished, and analyzed under high magnification. The process is complex and requires precision to avoid damaging the fine structures of the PCB. Here's a breakdown of the steps:

1. **Sectioning:** A precision saw such as IsoMet 1000 or IsoMet high speed Pro is used to cut through the PCB, revealing a cross-sectional view of the vias. Sectioning must be precise and well controlled to ensure that the vias are not deformed during the process.



IsoMet 1000



Table Saw Attachment for IsoMet 1000



Figure 1. Illustrating sectioning of PCBA with the aid of table saw attachment on IsoMet 1000

2. **Mounting:** The sectioned PCB is encased in epoxy resin or an acrylic resin to strengthen the structure for grinding and polishing stages before examination. This step helps maintain the integrity of the delicate vias during further preparation. For PCB with multilayers and containing various vias, such as through holes, blind or buried vias, use of low viscosity resin with aid of a vacuum mounting system, SimpliVac, should facilitate resin impregnation into the vias and pore structures if present to better support them for subsequent grinding and polishing stages.



SimpliVac



Figure 2. Illustrating SimpliVac mounting system for PCBAs or PCB samples

Advanced techniques involve use of precision preparation tools such as PWB Met that facilitates direct mounting of PCB coupons using acrylic resins. The system allows multiple coupons to be mounted for subsequent precise grinding to vias centre point.



Figure 3. illustrating PWB met with PCB coupons mounted for targeted vias assessment

3. **Grinding and polishing:** The mounted sample is ground and polished using progressively finer abrasives to create a smooth, defect-free surface on a semi-automatic grinder and polisher such as EcoMet 30 or AutoMet 300. Using a PCB/PWB Met tool allows precise and accurate grinding and polishing to the centre

point of the Vias for full assessment of the vias. This ensures that the true microstructure of the via can be observed under a microscope without interference from surface irregularities.



Figure 4. Illustrating EcoMet 30 semi-automatic grinder polisher

4. Imaging and Analysis: High-resolution optical microscopy is generally used to examine the cross-sectioned vias. The detailed images reveal any defects, such as cracks, voids, wicking, hole defects, insufficient copper plating among others.

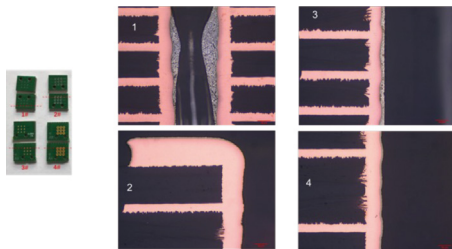


Figure 5. Shows various polished PCB Vias illustrating some defects; wicking, and uneven plating.

Common Defects Uncovered by Metallography

1. Insufficient Copper Plating: One of the most common defects found in vias is insufficient copper plating, which can lead to increased electrical resistance and a higher risk of mechanical failure. If the copper layer inside the via is too thin, it may not provide adequate conductivity, causing signal degradation or failure under thermal or mechanical stress.

Remedial action: Ensure that plating processes are carefully controlled and optimized to achieve uniform copper deposition throughout the via.

2. Voids: Voids are air pockets or gaps within the copper plating of the via. These can occur due to trapped air or outgassing during the manufacturing process. Voids act as weak points and can cause failure during thermal cycling or mechanical flexing.

Remedial action: Improve cleaning and surface preparation techniques before the copper plating process to minimize void formation.

3. Cracking: Cracks in vias are typically caused by mechanical or thermal stress. They can occur during the manufacturing process or over time due to the expansion and contraction of materials under thermal cycling. Cracks can lead to intermittent connections or complete failure.

Remedial action: Use materials with compatible coefficients of thermal expansion (CTE) and optimize the design to minimize stress concentrations around vias.

4. Misalignment with Internal Layers: Vias must align perfectly with internal layer pads to ensure proper electrical connectivity. Misalignment can lead to open circuits or partial connectivity, resulting in unreliable performance.

Remedial action: Regular calibration of drilling and imaging processes during PCB fabrication can help ensure accurate alignment of vias with internal layers.

Real-World Impact of Via Failures

Via failures can have severe consequences, particularly in industries where performance and reliability are critical. For example, in automotive electronics, a failure in the control system could lead to loss of vehicle function, creating a serious safety hazard. Similarly, in aerospace applications, the failure of even a single via could disrupt communication systems or flight control, with potentially catastrophic results.

In consumer electronics, while the stakes may not be as high, via failures can lead to costly product recalls, brand damage, and reduced customer satisfaction. In short, understanding and mitigating via defects is vital to the long-term success of any electronic product.

How to Stay Ahead of Via Defects

For manufacturers, a proactive approach is essential. Regular metallographic assessments can help identify potential problems before they affect product performance. By embedding metallographic analysis into the quality control process, companies can significantly reduce the risk of field failures and improve overall product reliability.

Here are some steps to consider:

- **Invest in state-of-the-art equipment:** Good sample preparation equipment coupled with good optical microscopes will enable precise analysis of even the smallest vias.
- **Train your team:** Ensure that engineers and technicians are skilled in metallographic techniques and can interpret results accurately.
- **Implement continuous improvement:** Use insights from metallographic assessments to refine manufacturing processes and materials selection, ultimately enhancing PCB performance.

Why Metallography Matters for Via Integrity?

Vias are the lifeblood of PCBs, transmitting critical electrical signals through the layers of modern electronic devices. Through metallographic assessment, manufacturers can uncover hidden defects that would otherwise go unnoticed until it's too late. By addressing these issues early, companies can ensure that their products meet the high standards of reliability and performance demanded by today's consumers and industries.

In the end, paying attention to the details—like the integrity of your PCB vias—can make all the difference in delivering a product that not only works but thrives in the real world.

By incorporating a proactive approach to via assessment through metallography, you can take the quality and reliability of your electronics to the next level.



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