IPC-9121A

Troubleshooting for Printed Board Fabrication Processes

Developed by the Printed Board Process Effects Handbook Task Group (7-24a) of the Process Control Management Committee (7-20) of IPC

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Users of this publication are encouraged to participate in the development of future revisions.

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Section 1 – Scope

1 SCOPE

This handbook provides problems, causes and possible corrective actions related to printed board manufacturing processes.

1.1 Purpose The purpose of this standard is to help designers, manufacturers and users of printed boards to troubleshoot fabrication processes to build electronics better.

1.2 Classification IPC standards recognize that electrical and electronic assemblies are subject to classifications by intended end-item use. Three general end-product classes have been established to reflect differences in manufacturability, complexity, functional performance requirements, and verification (inspection/test) frequency. It should be recognized that there may be overlaps of equipment between classes.

CLASS 1 General Electronic Products

Includes products suitable for applications where the major requirement is function of the completed assembly.

CLASS 2 Dedicated Service Electronic Products

Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end-use environment would not cause failures.

CLASS 3 High Performance/Harsh Environment Electronic Products

Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.

1.3 Use of "Lead" For readability and translation, the metallic element lead is always written as Pb.

1.4 Abbreviations and Acronyms See Appendix A for full spellings of abbreviations (including elements) and acronyms used in this standard.

1.5 Terms and Definitions Terms and definitions **shall** be in accordance with IPC-T-50 and 1.6.1 through 1.6.32.

1.6 IPC-9121 Format Example This document follows the general format seen below. In instances where there is no photo, a photo is not necessary or one could not be found. Potential test methods for discovery and verification are included in tables where applicable.

IPC encourages readers to submit process problems with photos as well as proposed causes and solutions to the IPC 7-24 Printed Board Process Effects Handbook Subcommittee. Submissions will be considered for document revisions.

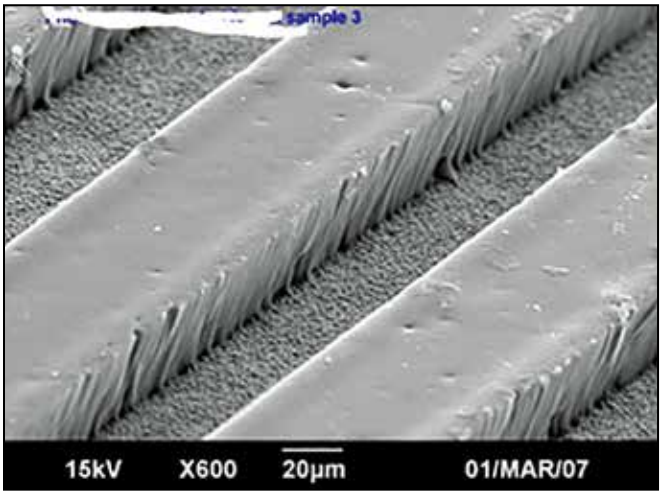

Figure 1-1 Photo Resist Under-Exposure

CAUSE	ACTION
UV source inadequate	Check exposure intensity/wavelength/duration
Expose intensity inadequate	Review, reinstated exposure control procedures
Expose time inadequate	Review, reinstated exposure control procedures
Oxygen exposure of photoresist prior to exposure	Review photoresist shelf life
Potential test methods (discover)	**Potential test method (verification)**
AOI (line/space reproduction) Etch-outs	AOI Periodic UV photometer and step tablet exposure checks

1.7 Guidelines for Effective Troubleshooting and Process Control One of the keys to effective problem solving is a structured routine that addresses key points each time a major problem is encountered. This section suggests steps to effectively find the cause of a problem and to solve it permanently. Refer to IPC-9191 for suggested methodology for statistical process control (SPC).

1. Before beginning a detailed troubleshooting project, use common sense in defining the problem.
   - Verify there is a problem.
   - Observe the defective product and compare it to the standard.
   - Identify the standard process and product and then determine any present deviation from the standard or any change in the product.
2. Establish whether operating procedures were followed and whether an assignable cause can be quickly identified as the reason for the problem.
   - Only continue into more detailed analysis if the initial questions do not lead to an obvious answer.
   - Even if the answer appears to be obvious, confirm the answer by operation of the process before closing the project.
3. Develop a clear, concise problem statement that quantifies the problem whenever possible and reduces the scope of the investigation to a manageable size.
4. Gather all pertinent data and facts.
   - Use statistical process control (SPC), historical data, records, logs, etc.
   - This includes temperature charts, analysis records, maintenance logs, etc.
5. Perform a causal analysis:
   - Producing out-of-specification parts requires immediate action (i.e., shut down the process).
   - Out-of-control processes require determination whether the process can continue to operate.
   - Severe process variation requires evaluation of the severity and effect of the problem on the final product.
6. Develop an action plan which includes the procedures for addressing products produced during out-of-specification or out-of-control conditions. The plan should also indicate who should make those decisions. These issues include but are not limited to:
   - Disposition of the defective material (repair, scrap, replace, etc.).

- Checking the effect on scheduled delivery.
- Informing the effect on scheduled delivery.
- Request for nonconformance authority or Material Review Board (MRB) action.
- Establish a corrective action plan to reduce or eliminate the likelihood of recurrence.

7. Conduct a Measurement System Evaluation, which is a means used to detect and identify the problem. This includes not only the measuring apparatus, but also:

- The sampling method.
- The operator (and his/her instructions).
- Accuracy and calibration of equipment.
- Environmental factors (e.g., lighting, temperature, and relative humidity (RH))

8. The variation inherent in the measurement of attribute data and responses that are subjective in nature can be addressed. The evaluation is more complex in nature, but it is still an essential part of the analysis of the problem. IPC-9191 discusses this subject in greater detail.

1.8 Parameter Analysis The purpose of parameter analysis, as detailed in IPC-9191, is to establish cause-effect relationships and to identify, isolate and rank major sources of variation. Common sources are:

- Positional variation (within a piece).
- Cyclical variation (piece to piece).
- Temporal variation (over time).

1.8.1 Brainstorming The development of a cause-and-effect diagram by a cross-functional problem-solving team is critical to the identification of variables to be studied. Care should be taken to include representatives of the disciplines that are part of the process being studied, such as engineering, quality, manufacturing operators, analysis laboratory, etc.

Identify all possible causes of the problem, including process steps, raw materials, materials handling, inspection and personnel (i.e., ‘‘fishbone’’ diagram for root cause analysis). The ranking of these factors by the problem-solving team should be used to establish those factors that will be studied experimentally. The problem-solving team should, at a minimum, include manufacturing engineers, quality engineering and operators who are intimate with the process. The team should take care to openly consider new ideas on the problem.

Situations may occur in which the formation of a brainstorming team is inappropriate. Only someone with troubleshooting experience should make the decision to approach a problem alone. Considerable time and effort can be wasted by failure to get input from all knowledgeable sources.

1.8.2 Process Audit Process an audit by reviewing the entire operation (e.g., documentation, transfer, handling, processing, etc.). Identify current conditions and compare to the standard. Define process windows. An audit is best conducted by someone not directly involved in the day-to-day operation of the process.

1.8.3 Initial Capability Study Initial capability studies are ideally done before the process is accepted for production. This means creating a match between the process and the product, and it results in a process control window that is capable of producing the product.

One approach to troubleshooting that quantifies improvement for reporting to management involves a capability assessment. IPC-9191 discusses in greater detail the generation of capability indices. This step promotes a clear understanding of the process matrices, but it requires time and resources.

1.8.4 Optimization This step includes the variety of techniques used to isolate factors that affect the response being studied. The most important technique is to alter one-factor-at-a-time change. Comparison of the output at both settings is mandatory to establish the real effect of the process change. Outside factors that are not controlled when a new factor setting is evaluated can cause incorrect conclusions to be drawn.