COMMON FAILURE ANALYSIS PROCEDURE for ELECTRONICS

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Applicable Products

- Printed Circuit Board (PCB)
- Printed Circuit Boards (PCBs)
- Printed Circuit Board Assembly (PCA)
- Printed Circuit Board Assemblies (PCAs)
- Electronic components [resistors, capacitors, transformers, oscillators, inductors, diodes, FET, integrated circuits (IC), ball grid arrays (BGA), etc.]
- Connectors
- Cables
- Finished Electronic Devices

Applicable Non-Destructive Analytical Techniques (NDA)

- Visual Examination
- Optical Microscopy
- Electrical Examination
- Ion Chromatography (IC)
- Fourier Transform Infrared Spectroscopy (FTIR)
- Scanning Electron Microscopy / Energy Dispersive X-Ray Spectroscopy (SEM/EDS)
- X-Ray Inspection
- Scanning Acoustic Microscopy (SAM)
- X-Ray Fluorescence (XRF)

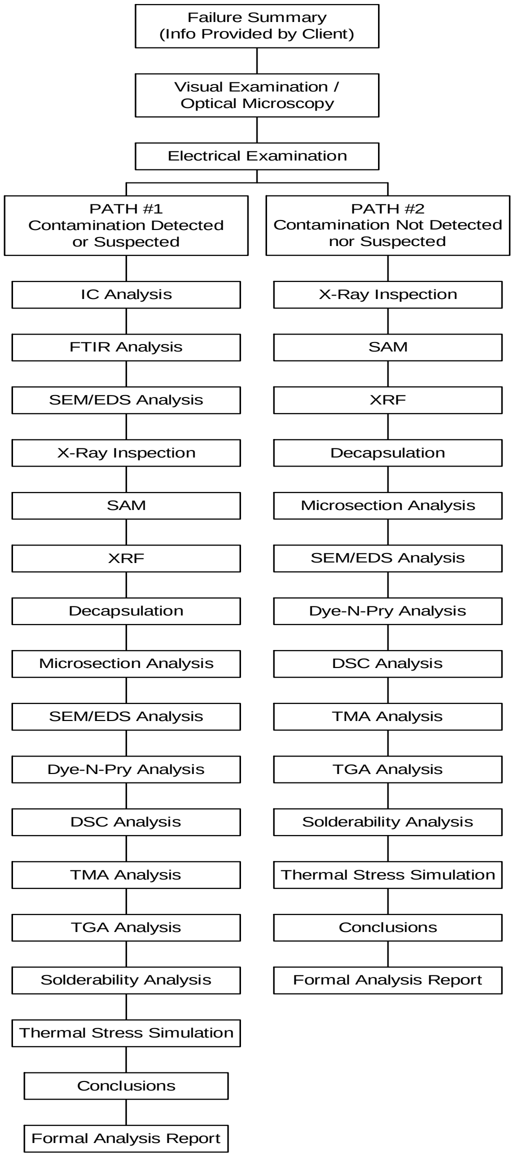
Applicable Destructive Analytical Techniques

- Decapsulation
- Microsection Analysis (Cross-section)
- Dye-N-Pry Inspection
- Differential Scanning Calorimetry Analysis (DSC)
- Thermomechanical Analysis (TMA)
- Thermogravimetric Analysis (TGA)
- Solderability Analysis
- Thermal Stress Simulation

Failure Analysis (FA)

All failure analysis is unique to the product and client involved. This procedure is meant as a guideline in conducting a failure analysis. The failure analysis scientist must rely on judgment, experience, knowledge, test results, and the information provided by the client to conduct a proper analysis. Certain steps of the following flowchart may be omitted if deemed unnecessary in order to save time and cost to the client. The client's needs and goals are the main concern.

Failure Analysis Flowchart



INITIAL INVESTIGATION

Failure Summary
In order to conduct as complete an analysis as possible, it is best to obtain representative "failed/defective" samples, representative "good" samples, representative components that comprise the "test" samples, representative process chemicals, and as much information as possible concerning the manufacturing of the product, the exact nature of the failure, failure detection, and environment in which failure was detected.

Obtain the client's exact needs and goals of this Failure Analysis. Determine if answers to specific questions are required.

Visual Examination / Optical Microscopy
Record the serialization and identification of all samples.

Using the various light sources, magnifications, and visual enhancement techniques, perform a detailed visual examination. Care should be taken to concentrate on areas identified by the client. Look at "good" and "bad" areas for comparison. All observation shall be recorded.

If contamination is observed or suspected, and could cause the type of failure described, the Failure Analysis should follow Path #1. If contamination is not observed nor suspected, or could not cause the type of failure described, the Failure Analysis should follow Path #2.

Take representative overview photographs of the samples submitted. Take close-up photographs of any anomalies or areas of concern.

As a minimum, attempts should be made to answer the following questions:

1. Is there any visual confirmation of the client's problem?
2. Are other areas affected?
3. Do all samples exhibit the same condition?
4. How much/many areas are affected?
5. What did it look like, in layman's terms (color, shape, size, etc.)?
6. Does the condition have a technical name?
7. Were defects, other than those mentioned by the client, observed?

Electrical Examination
Conduct this test if the mode of failure is electrical in nature.

The examination should primarily center on the areas specified by the client and/or suspect areas identified by the Visual Examination.

Measure any pertinent electrical parameter on the "failed" samples (such as insulation resistance, contact resistance, capacitance, conductance, etc.). Compare this data to measurements taken on "new" samples and/or information received from the client. Attempt to isolate any anomalous conditions. Record all data.

As a minimum, attempts should be made to answer the following questions:

1. Is there any electrical confirmation of the client's problem?
2. What type of problem would these electrical conditions create?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Does the condition have a technical name?
7. Were defects (other than those mentioned by the client) observed?

PATH #1

Ion Chromatography (IC) Analysis
Conduct this test if high ionic levels could contribute to the mode of failure.

If possible, compare ionic levels of "good" to "failed" samples. If not, as few industry standards exist, compare ionic levels of the "failed" samples to what experience would dictate as high ionic content. Compare ionic levels of the "failed" samples to the ionic content of any process chemicals or suspected sources of contamination. Record all data.

As a minimum, attempts should be made to answer the following questions:

1. Was ionic contamination detected?
2. Could these ionic levels contribute to the client's problem?
3. What type of problem would these ionic levels create?
4. Are other areas affected?
5. Do all samples exhibit the same condition?
6. Would a manufacturing defect, process problem, or field environment cause such a condition?

Fourier Transform Infrared Spectroscopy (FTIR) Analysis
Conduct this test if organic contamination could contribute to the mode of failure.

If possible, compare "good" and "failed" samples or "good" and "failed" areas. Compare spectra of the "failed" samples to the spectra of any process chemicals or suspected sources of contamination. Record all data. Print and supply all FTIR spectra and reference spectra.

As a minimum, attempts should be made to answer the following questions:

1. Was organic contamination detected?
2. What was the organic material detected?
3. Could this organic contamination contribute to the client's problem?
4. What type of problem would this organic contamination create?
5. Are other areas affected?
6. Do all samples exhibit the same condition?
7. How much/many areas are affected?

Scanning Electron Microscopy / Energy Dispersive X-Ray Spectroscopy (SEM/EDS) Analysis
Conduct this test if elemental or inorganic contamination could contribute to the mode of failure.

If possible, compare "good" and "failed" samples or "good" and "failed" areas. Record all data. Compare spectra of the "failed" samples to the spectra of any process chemicals or suspected sources of contamination. Take representative photographs to show general structure of the areas in question. Take close-up photographs of any anomalies or areas of concern. Print and supply all EDS spectra and reference spectra.

As a minimum, attempts should be made to answer the following questions:

1. Was elemental contamination detected?
2. Could this elemental contamination contribute to the client's problem?
3. What type of problem would this elemental contamination create?
4. Are other areas affected?
5. Do all samples exhibit the same condition?
6. How much/many areas are affected?

X-Ray Inspection
Conduct this test if internal anomalies could contribute to the mode of failure. X-Ray Inspection can be used to examine for extraneous metallic contamination, solder joint defects, broken metallic connections, voiding, cracking, etc.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Take representative X-Ray images to show general structure of the areas in question. Take close-up images of any anomalies or areas of concern. Print and supply all X-Ray images.

As a minimum, attempts should be made to answer the following questions:

1. Do the internal structures of the “good” and “failed” samples look similar?
2. Could any observed differences between the “good” and “failed” samples contribute to the client’s problem?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Were defects (other than those mentioned by the client) observed?

Scanning Acoustic Microscopy (SAM)
Conduct this test if internal anomalies could contribute to the mode of failure. SAM is primarily used to examine electronic components for delamination, internal voiding, etc.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Take representative images to show general structure of the areas in question and any anomalies or areas of concern. Print and supply all SAM images.

As a minimum, attempts should be made to answer the following questions:

1. Do the internal structures of the “good” and “failed” samples look similar?
2. Could any observed differences between the “good” and “failed” samples contribute to the client’s problem?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Were defects (other than those mentioned by the client) observed?

X-Ray Fluorescence (XRF)
Conduct this test if plating/coating anomalies could contribute to the mode of failure. XRF can be used to measure the plating thickness of electronic materials.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Measure the plating thickness. Record all data.

As a minimum, attempts should be made to answer the following questions:

1. Are plating thickness measurements within tolerance?
2. Are there variations from sample to sample or within the same sample?
3. Could this thickness contribute to the client’s problem?
4. Are other areas affected?

Decapsulation
Conduct this test if internal anomalies could contribute to the mode of failure. This technique is primarily used on electronic components.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Perform Visual Examination and Optical Microscopy after decapsulation. Take representative images to show general structure of the areas in question and any anomalies or areas of concern. Print and supply all images.

As a minimum, attempts should be made to answer the following questions:

1. Do the internal structures of the “good” and “failed” samples look similar?
2. Could any observed differences between the “good” and “failed” samples contribute to the client’s problem?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Were defects (other than those mentioned by the client) observed?

Microsection Analysis

Conduct this test if internal anomalies could contribute to the mode of failure. This technique is useful for almost all test samples.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Prepare the microsections and evaluate to any applicable specification. Examine for any type of subsurface anomalies.

Take representative photographs to show general internal structure of the samples submitted. Take close-up photographs of any anomalies or areas of concern.

As a minimum, attempts should be made to answer the following questions:

1. Are there any subsurface conditions that could contribute to the client’s problem?
2. Are other areas affected?
3. Do all samples exhibit the same condition?
4. How much/many areas are affected?
5. What did it look like, in layman’s terms (color, shape, size, etc.)?
6. Does the condition have a technical name?
7. Were defects (other than those mentioned by the client) observed?

Scanning Electron Microscopy / Energy Dispersive X-Ray Spectroscopy (SEM/EDS) Analysis

Conduct this test if higher magnification examination or elemental identification is needed of the microsections and/or decapsulated samples.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Record all data. Take representative photographs to show general internal structure of the samples submitted. Take close-up photographs of any anomalies or areas of concern. Print and supply all EDS spectra and reference spectra.

As a minimum, attempts should be made to answer the following questions:

1. Did higher magnification examination of the microsections show anything additional to optical examination?
2. Did the elemental identification add any additional information, clues, or conclusion?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Were defects (other than those mentioned by the client) observed?

Dye-N-Pry Analysis

Conduct this test if solder joint cracking is suspected. This technique is primarily used on BGAs where the solder joints are not readily visible but it can be applied to any component type.

After prying, inspect all joints for cracks. Record all data. Diagram solder joints and indicate any that have defects.

As a minimum, attempts should be made to answer the following questions:

1. Where joint defects located in the area of concern?
2. Are other areas affected?
3. Do all samples exhibit the same condition?
4. How much/many areas are affected?
5. Were defects (other than those mentioned by the client) observed?

Differential Scanning Calorimetry (DSC) Analysis

Conduct this test if the glass transition temperature (Tg), degree of cure (ΔTg), or melting point of the sample could contribute to the mode of failure.

If possible, compare “good” and “failed” samples. Record all data. Print and supply all DSC thermograms.

As a minimum, attempts should be made to answer the following questions:

1. What were the thermal properties of the samples?
2. Could these properties contribute to the client’s problem?
3. What type of problem would these properties create?
4. Do all samples exhibit the same condition?

Thermomechanical Analysis (TMA)

Conduct this test if mismatched or unexpected coefficient of thermal expansion (CTE) or softening point could contribute to the mode of failure. Additionally, the time to delamination (T260 or T288) of the material can be examined.

If possible, compare “good” and “failed” samples. Record all data. Print and supply all TMA thermograms.

As a minimum, attempts should be made to answer the following questions:

1. What was the CTE, T260, T288, or softening point of the samples?
2. Could these properties contribute to the client’s problem?
3. What type of problem would these properties create?
4. Did the material delaminate sooner than expected?
5. Do all samples exhibit the same condition?

Thermogravimetric Analysis (TGA)

Conduct this test if thermal decomposition of the sample is suspected or if the decomposition temperature (Td) of the material is in question.

If possible, compare “good” and “failed” samples. Record all data. Print and supply all TGA thermograms.

As a minimum, attempts should be made to answer the following questions:

1. Was the Td as expected?
2. Could the material decompose at process or end-use temperatures?
3. What type of problem would the Td create?
4. Do all samples exhibit the same condition?

Solderability Analysis

Conduct this test if the solderability of the samples is in question.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Record all observations.

As a minimum, attempts should be made to answer the following questions:

1. What was the percentage solderability of the samples?
2. Could this percentage solderability contribute to the client’s problem?
3. What type of problem would this percentage solderability create?
4. Do all samples exhibit the same condition?

Thermal Stress Simulation

Conduct this test if the samples inability to withstand normal thermal processing could contribute to the mode of failure.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Perform visual Examination and Microsection Analysis after Thermal Stress. Record all observations.

As a minimum, attempts should be made to answer the following questions:

1. Do the samples exhibit any external or internal anomalies after Thermal Stress?
2. Are these anomalies similar to the mode of failure?
3. What type of problem would these anomalies create?
4. Do all samples exhibit the same condition?

PATH #2

X-Ray Inspection

Conduct this test if internal anomalies could contribute to the mode of failure. X-Ray Inspection can be used to examine for extraneous metallic contamination, solder joint defects, broken metallic connections, voiding, cracking, etc.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Take representative X-Ray images to show general structure of the areas in question. Take close-up images of any anomalies or areas of concern. Print and supply all X-Ray images.

As a minimum, attempts should be made to answer the following questions:

1. Do the internal structures of the “good” and “failed” samples look similar?
2. Could any observed differences between the “good” and “failed” samples contribute to the client’s problem?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Were defects (other than those mentioned by the client) observed?

Scanning Acoustic Microscopy (SAM)

Conduct this test if internal anomalies could contribute to the mode of failure. SAM is primarily used to examine electronic components for delamination, internal voiding, etc.

If possible, compare “good” and “failed” samples or “good” and “failed” areas. Take representative images to show general structure of the areas in question and any anomalies or areas of concern. Print and supply all SAM images.

As a minimum, attempts should be made to answer the following questions:

1. Do the internal structures of the "good" and "failed" samples look similar?
2. Could any observed differences between the "good" and "failed" samples contribute to the client's problem?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Were defects (other than those mentioned by the client) observed?

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Conduct this test if plating/coating anomalies could contribute to the mode of failure. XRF can be used to measure the plating thickness of electronic materials.

If possible, compare "good" and "failed" samples or "good" and "failed" areas. Measure the plating thickness. Record all data.

As a minimum, attempts should be made to answer the following questions:

1. Are plating thickness measurements within tolerance?
2. Are there variations from sample to sample or within the same sample?
3. Could this thickness contribute to the client's problem?
4. Are other areas affected?

Decapsulation
Conduct this test if internal anomalies could contribute to the mode of failure. This technique is primarily used on electronic components.

If possible, compare "good" and "failed" samples or "good" and "failed" areas. Perform Visual Examination and Optical Microscopy after decapsulation. Take representative images to show general structure of the areas in question and any anomalies or areas of concern. Print and supply all images.

As a minimum, attempts should be made to answer the following questions:

1. Do the internal structures of the "good" and "failed" samples look similar?
2. Could any observed differences between the "good" and "failed" samples contribute to the client's problem?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Were defects (other than those mentioned by the client) observed?

Microsection Analysis
Conduct this test if internal anomalies could contribute to the mode of failure. This technique is useful for almost all test samples.

If possible, compare "good" and "failed" samples or "good" and "failed" areas. Prepare the microsections and evaluate to any applicable specification. Examine for any type of subsurface anomalies.

Take representative photographs to show general internal structure of the samples submitted. Take close-up photographs of any anomalies or areas of concern.

As a minimum, attempts should be made to answer the following questions:

1. Are there any subsurface conditions that could contribute to the client's problem?
2. Are other areas affected?
3. Do all samples exhibit the same condition?
4. How much/many areas are affected?
5. What did it look like, in layman's terms (color, shape, size, etc.)?
6. Does the condition have a technical name?
7. Were defects (other than those mentioned by the client) observed?

Scanning Electron Microscopy / Energy Dispersive X-Ray Spectroscopy (SEM/EDS) Analysis

Conduct this test if higher magnification examination or elemental identification is needed of the microsections and/or decapsulated samples.

If possible, compare "good" and "failed" samples or "good" and "failed" areas. Record all data. Take representative photographs to show general internal structure of the samples submitted. Take close-up photographs of any anomalies or areas of concern. Print and supply all EDS spectra and reference spectra.

As a minimum, attempts should be made to answer the following questions:

1. Did higher magnification examination of the microsections show anything additional to optical examination?
2. Did the elemental identification add any additional information, clues, or conclusion?
3. Are other areas affected?
4. Do all samples exhibit the same condition?
5. How much/many areas are affected?
6. Were defects (other than those mentioned by the client) observed?

Dye-N-Pry Analysis

Conduct this test if solder joint cracking is suspected. This technique is primarily used on BGAs where the solder joints are not readily visible but it can be applied to any component type.

After prying, inspect all joints for cracks. Record all data. Diagram solder joints and indicate any that have defects.

As a minimum, attempts should be made to answer the following questions:

1. Where joint defects located in the area of concern?
2. Are other areas affected?
3. Do all samples exhibit the same condition?
4. How much/many areas are affected?
5. Were defects (other than those mentioned by the client) observed?

Differential Scanning Calorimetry (DSC) Analysis

Conduct this test if the glass transition temperature (Tg), degree of cure (ΔTg), or melting point of the sample could contribute to the mode of failure.

If possible, compare "good" and "failed" samples. Record all data. Print and supply all DSC thermograms.

As a minimum, attempts should be made to answer the following questions:

1. What were the thermal properties of the samples?
2. Could these properties contribute to the client's problem?
3. What type of problem would these properties create?
4. Do all samples exhibit the same condition?

Thermomechanical Analysis (TMA)

Conduct this test if mismatched or unexpected coefficient of thermal expansion (CTE) or softening point could contribute to the mode of failure. Additionally, the time to delamination (T260 or T288) of the material can be examined.

If possible, compare "good" and "failed" samples. Record all data. Print and supply all TMA thermograms.

As a minimum, attempts should be made to answer the following questions:

1. What was the CTE, T260, T288, or softening point of the samples?
2. Could these properties contribute to the client's problem?
3. What type of problem would these properties create?
4. Did the material delaminate sooner than expected?
5. Do all samples exhibit the same condition?

Thermogravimetric Analysis (TGA)

Conduct this test if thermal decomposition of the sample is suspected or if the decomposition temperature (Td) of the material is in question.

If possible, compare "good" and "failed" samples. Record all data. Print and supply all TGA thermograms.

As a minimum, attempts should be made to answer the following questions:

1. Was the Td as expected?
2. Could the material decompose at process or end-use temperatures?
3. What type of problem would the Td create?
4. Do all samples exhibit the same condition?

Solderability Analysis

Conduct this test if the solderability of the samples is in question.

If possible, compare "good" and "failed" samples or "good" and "failed" areas. Record all observations.

As a minimum, attempts should be made to answer the following questions:

1. What was the percentage solderability of the samples?
2. Could this percentage solderability contribute to the client's problem?
3. What type of problem would this percentage solderability create?
4. Do all samples exhibit the same condition?

Thermal Stress Simulation

Conduct this test if the samples inability to withstand normal thermal processing could contribute to the mode of failure.

If possible, compare "good" and "failed" samples or "good" and "failed" areas. Perform visual Examination and Microsection Analysis after Thermal Stress. Record all observations.

As a minimum, attempts should be made to answer the following questions:

1. Do the samples exhibit any external or internal anomalies after Thermal Stress?
2. Are these anomalies similar to the mode of failure?
3. What type of problem would these anomalies create?
4. Do all samples exhibit the same condition?

EVALUATION
(PATH#1 or PATH #2)

Conclusions
Compile all test/analysis data. Compare these results to the information obtained from the client. Based on the analysis results, scientist's experience, and the information provided by the client, form an opinion as to the possible cause(s) of the failure. Attempt to limit the conclusions to one or two possible causes, if possible. Recommend any possible corrective actions, preventative actions, or repairs for this failure mode. Answer any specific questions the client may have had. Compile any supporting literature that would be useful to the client.

Formal Analysis Report
Present all data, photographs, spectra, thermograms, and information in a Formal Analysis Report.

For more information concerning these topics or any other testing needs, please contact us at (410) 584-9099, (303) 683-4806, (847) 934-5300, or info@tracelabs.com. Visit us on the web at www.tracelabs.com.