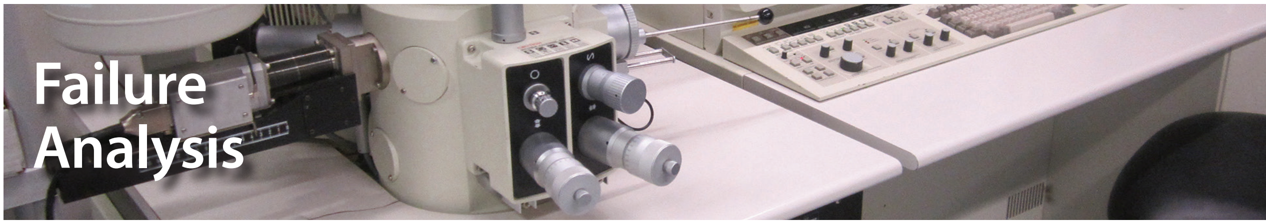

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Utilizing Failure Analysis as a Key Instrument in Developing Robust Microelectronic Assemblies

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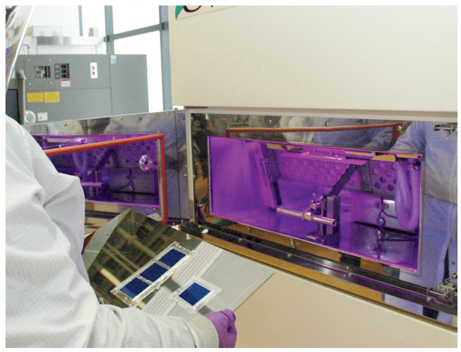
IN THE WORLD OF MICROELECTRONICS new product development, failure analysis is a tool that can reduce costs and accelerate time to market. Failure analysis can be used to achieve a better understanding of the behavior of a product after being stressed by the conditions of its application environment. In a thoughtful design, the environmental conditions in which a product is intended to function need to be considered carefully. Once these conditions have been determined, a life test profile is defined in order to simulate the environmental conditions in which the product will need to survive. When the life test profile is completed, a functional test is performed to evaluate whether the product is still operating according to customer specifications. The next step is to perform destructive and/or non-destructive analysis of the product to identify its strengths and weaknesses. Analysis should always be conducted regardless of whether or not there is a confirmed failure. Finally, the lessons learned from the analysis must be fed back to the product design team to improve the product, lower the cost, or both.

Environmental Conditions

The environmental conditions for any product are requirements driven by the customer. An automotive application for example, will have a different set of requirements than a part with an aerospace application. The end user or customer typically has a good understanding of how the part will be used and the environment in which it must survive. High temperature endurance, low temperature endurance, and UV exposure are examples of tests that are used to replicate common environmental conditions.

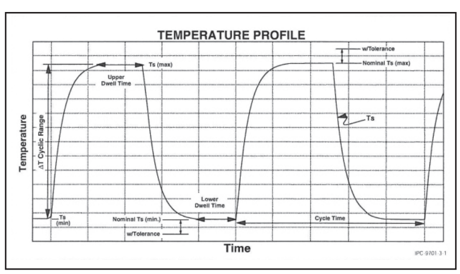
Life Test Profile

A life test profile is developed by the customer in an effort to simulate the environmental conditions to which the part will be subjected during use. These tests, or series of tests, are intended to accelerate the life exposure of the product and can sometimes be harsher than the actual operating conditions of the product. For example, air to air thermal shock exposure is



Super UV Test Chamber.

Thermal Shock and Thermal Cycle Chambers.



Sample Thermal Cycle Test.

a commonly performed test that can stress a mechanical package to premature failure. The life test profile includes tests that represent both actual environmental conditions and accelerated environmental conditions in order to create learning about failures, potential failures, or both.[1]

Functional Test

Functional tests can vary widely and are driven by the operating requirements of the product. This can include visual inspection, measurements taken after the life test profile, and/or measurements taken during certain tests. In the case of a pressure sensor, the functional test will typically include current draw, output as a response to applied pressure (characteristic curve), and a leak test. In many cases, monitoring the sensor output function throughout testing is required to determine the exact moment of failure—if and when it occurs. There is also typically a mechanical package inspection requirement to determine if any physical damage to the package occurred as a result of the life test profile.

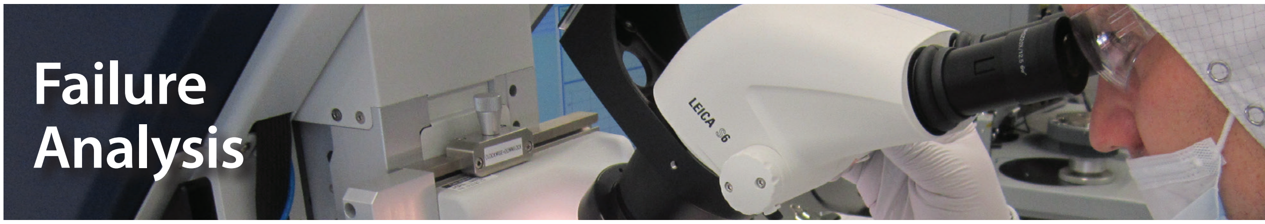
Destructive / Non-Destructive Analysis

If a functional failure does occur from the life test profile, analysis should be performed to determine the root cause of the failure. Non-destructive analysis techniques include optical microscope inspection, 3D X-ray, and acoustic microscopy. Destructive disassembly follows which could include shear/pull testing, cross sections, scanning electron microscopy (SEM), optical microscopy, and elemental surface analysis such as emission dispersive spectroscopy (EDS).

If all of the parts on test survive the entire life test profile without a failure, a complete post-test analysis should still be conducted in order to determine if there are any parts near failure or areas for improvement. Additionally, it is recommended that non-destructive analysis techniques should be used to capture images of parts before the life test profile, so that there is a base line for comparison once testing is complete. In some instances, design and process improvements can be identified by uncovering potential weaknesses after the life test profile, even without a demonstrated failure.

Lessons Learned

In this stage of the new product development cycle a complete "lessons learned" review is in order. It is important to use all collected data to drive design and process improvements. This



Failure Analysis

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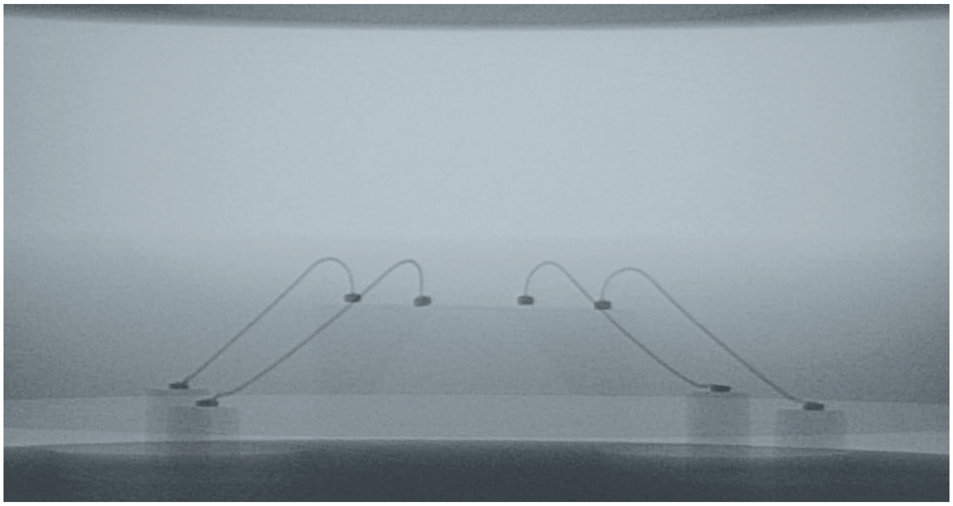
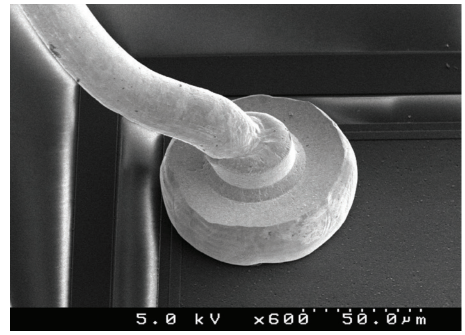


X-ray of Die and Wire Bonds.



Fatigued/Deformed Wire Bond.

3D X-ray System.

Scanning Electron Microscope.

aligns with proven new product development strategies such as: test early, test often and concurrent engineering. The idea is to create early learning using failure analysis results in order to implement improvements before freezing the product design. The results of this "lessons learned" review drive action in the form of a Risk Analysis, PFMEA, DFMEA, other six sigma techniques and quality methods.[2]

Failure analysis is an effective tool for the development of any new product. It can be used to understand the behavior of a part in the given application environment. A life test profile evaluates the effects of the environmental conditions against the design objectives and a developed manufacturing process. Functional testing and non-destructive/destructive analysis provides the lessons learned where immediate inputs to the new product development cycle can reduce development costs and time to market. ◆

William Boyce is the Engineering Manager at SMART Microsystems. He has served in senior engineering roles over the last 19 years with accomplishments that include manufactured automotive sensors. He also led new product development teams that created over $25 million in new revenue per year. He is certified in EIT and Six Sigma Green Belt and is an industry recognized expert in Al wire bonding. Additionally, he designed and led the metrology lab and machine shop at Sensata.

References

[1] "Environmental Test Strategies for MEMS Sensors Product Development", MEPTEC Report, Spring 2017, Volume 21, Number 1.

[2] "Engineering that Begins with the End in Mind", MEPTEC Report, Spring 2016, Volume 20, Number 1.

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