Assessing the Reliability Risk of a Maverick Manufacturing Anomaly

William J. Roesch and Dave Littleton

TriQuint Semiconductor, Inc., 2300 N.E. Brookwood Parkway, Hillsboro, Oregon 97124-5300

Phone: (503) 615-9292 FAX: (503) 615-8903 EMAIL: broesch@tqs.com

Introduction

Compound semiconductor manufacturing processes occasionally experience an unusual event during wafer fabrication. Depending on the severity of the event and the coverage of the detection methods and control systems, the event could produce a wafer that has reliability outside of the normal population of wafers. If the anomaly produces some products which elude the normal detection methods, there might be a possibility that some samples would reach a customer before the event was discovered. In the unhappy situation of recalling this type of anomalous material, the customer will invariably ask "***What is the reliability risk*** of choosing to deploy the anomalous devices?" This abstract is intended to describe a methodology to answer that question, and demonstrate data obtained from an actual maverick event.

Purpose

The intent of this work is to provide information on:

1) Description of an actual maverick event.
2) Root cause investigation of a problem caused by the event. Followed by corrective action.
3) Application of various physical, electrical, and visual detection methods for discovering events.
4) Development of a suite of accelerated reliability stress tests to exacerbate a particular root cause failure mechanism.
5) Actual results of risk assessment and effectiveness of the approach.

What specific results were obtained?

This study is intended to answer questions about reliability risk of anomalous products using a relative measurement. Since there are several key variables in any particular occurrence, an actual case study will be used. During the course of this case study, at least six significant results were collected. These results include:

1) Magnitude of the maverick event.
2) Description of the effectiveness of detection methods (Figure 1 is an example).
3) Verification of corrective action.
4) Results of stress testing a 30,000 piece sample.
5) Measurement of the cumulative reliability risk over the projected lifetime of the product.
6) Determination of the size of the maverick population.

In addition to the specific items mentioned, the history of the specific example will be explained. Additional information, such as: the selection of reliability stress; the speed of gathering data in a high volume environment; and the advantage of utilizing specific reliability test structures to help make assessments; will be included. Examples of the special structures will be discussed. In particular, the physical shapes and sizes of features were varied in order to exacerbate the anomalous nature of manufacturing lots and how the delectability of defects can be enhanced using various structures. In fact, the effect of "amplifying" defects was utilized, and has been previously reported.[1]

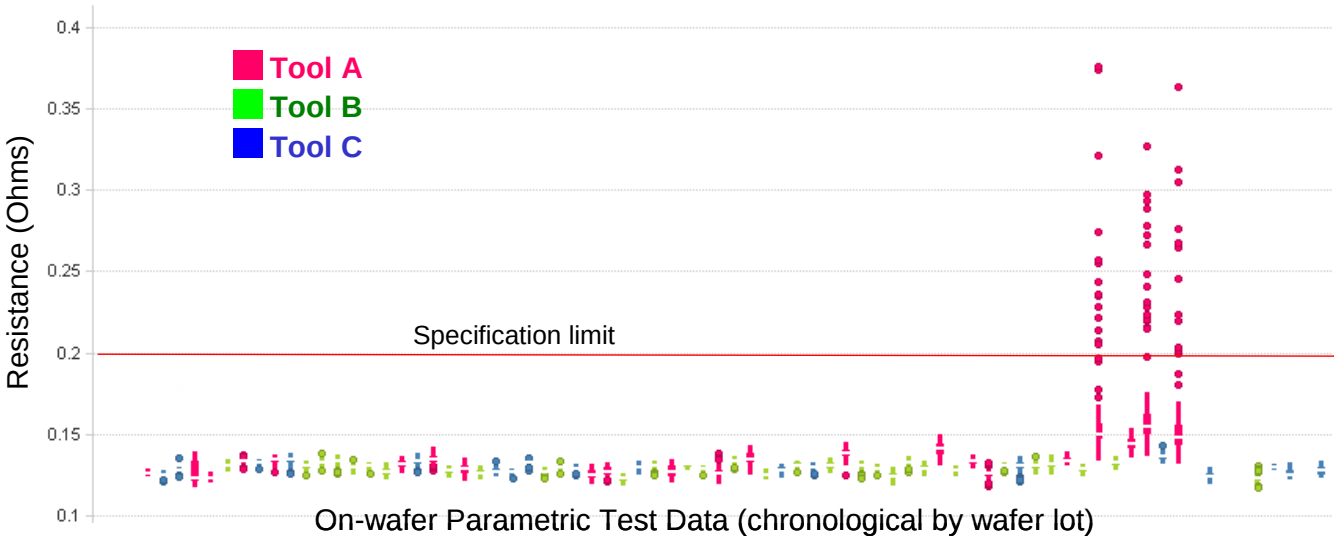

Figure 1. Initial detection of a manufacturing anomaly.

In addition to the physical design of special test structures, several environmental stress methods were applied during this study, as shown in Figure 2. In particular, the use of solder reflow simulations, liquid-to-liquid thermal shock, and unbiased humidity methods were found to have particularly interesting results. By applying a spectrum of stress to actual devices and by utilizing various experimental structures, multiple successful results were obtained. Remarkable similarities to historical events have been discovered. [2]

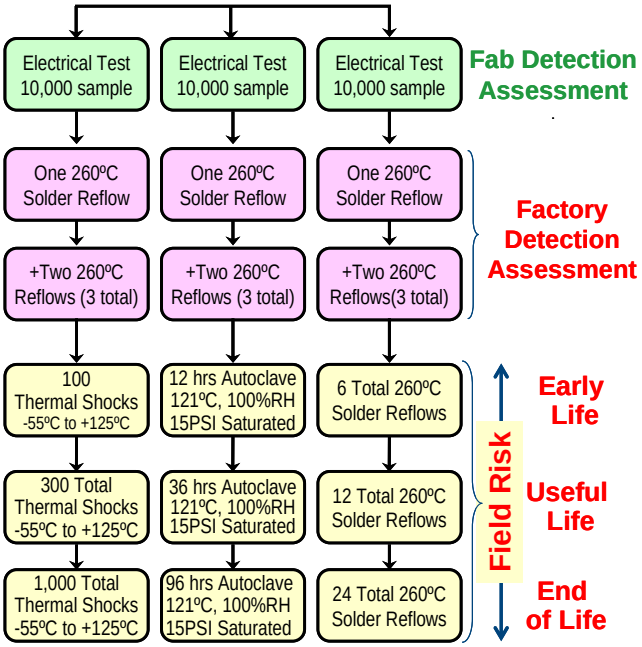

Figure 2. Initial risk assessment test plan.

How Compound Semiconductor manufacturing technology was advanced?

As a result of detailing an actual event, Compound Semiconductor manufacturing technology can be advanced because:

1) The specific root cause of a maverick anomaly will be explained.
2) Various detection methods will be compared, so that new escape points can be considered.
3) Various accelerated stress methods will be compared, and the overall method will be evaluated for one specific type of Fab defect.
4) The effectiveness of Process Control Monitor structures will be compared to enhanced structures.
5) Ideas about how to handle a maverick event will be shared.

Results

As a result of the methodology applied in this example, the question of reliability risk can be answered as shown in Figure 3. Although this data is for a specific lot with a population of affected devices, the relative risk is now known for any lot, regardless of the population affected. Because of the intermittent nature of the anomaly discussed in this example, there was considerable variation in the defective population from wafer-to-wafer and from lot-to-lot. However, once the relative ratio of fallout was determined, the ratio of risks at each point in the lifetime of an affected population is likely to apply.

In particular, the results in Figure 3 clearly indicate that the highest reliability risk exists at the Customer's factory. Figure 3 also shows the defect was detectable at the Fab, albeit at a very low level. Determining these relationships between quality and reliability are essential in any customer protection strategy.

The full manuscript and presentation will include all the findings and results described here.

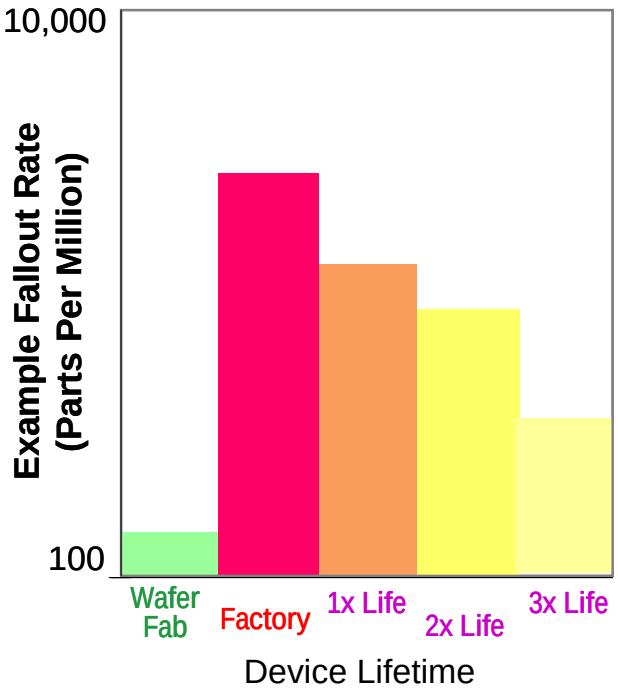

Figure 3. Customer fallout risk assessment based upon multiple accelerated stress tests of 30,000 sample devices from a known maverick lot.

Keywords: outlier, excursion, escape, defects, metallization, screen, detection, prediction.

References

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2. W.J Roesch, "Thermal Excursion Accelerating Factors," GaAs REL Workshop, pp.119-126, 1999.