Logical Diagnosis Solutions Must Drive Yield Improvement

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Introduction

Can automated solutions for logic diagnosis become a fundamental driver of yield improvement? or are they doomed to remain an “occasional entertaining diversion?” As we begin driving a transition in diagnosis from science projects to industrial solutions, we need to consider the differences between failure analysis (FA) and low yield analysis (LYA). We need to comprehend that this technology is critical, not just “nice to have.” And we need to drive development based on cutting edge research, supporting design features and validation in production silicon.

Failure Analysis vs. Low Yield Analysis

Diagnosis typically has two stages: logical defect location and physical defect analysis. Most diagnoses also fall into one of two categories: failure analysis (FA) and low yield analysis (LYA). The objective of FA is to find the defect in a given die. It may be a customer return, or a qualification stress failure. It may fail a manufacturing test or a customer application. Success is critical, and analysis may take weeks.

The LYA world is different from FA. The objective is to improve yield by identifying new, systematically repeating defect mechanisms and driving corrective action in the FAB. Unique and rare defects are not interesting. Chronic known problems (such as particles) are also of little value. Thus, by definition, there are many examples of interesting defect mechanisms in LYA, and it may be possible to “cherry-pick” highly accurate diagnoses with easy physical analysis. Also, defects caught in manufacturing fail well-understood tests.

LYA raises new problems as well. We either have to diagnose a statistically significant (i.e., large) number of defects, or find a way to identify interesting defects based on test results. Because of the cost of physical defect analysis, the ability to choose interesting defects up front is a critical LYA enabler. Also, the volume-based nature of LYA demands faster throughput times than FA requires.

The Need for Diagnosis

Memories have a limited ability to drive LYA. Their relative ease of use makes them a good first approach, but their usefulness tops out before process yields are high enough. Some critical logic defect mechanisms do not affect memory. The final stages of yield improvement are increasingly based on defects found in random logic.

However, finding defects in random logic is becoming exponentially more difficult. The physical techniques used in prior generations are fading away, as geometries fall below the wavelength of light and flip-chip designs limit physical access. Growing transistor counts and the complexity of new microprocessors has exponentially increased the time it takes to find a defect through manual deductive reasoning based on tester errors and probing.

With our need to find defects in random logic increasing and our ability to find such defects sharply falling off, we are approaching a crisis in LYA. Software-based automated solutions for logic diagnosis are critical.

Conclusions

We are closer to automated production-worthy solutions for high-volume manufacturing than ever before. Design for Test (DFT) techniques such as scan (particularly full scan) provide design hooks that enable more effective solutions, while advances in realistic defect behavior modeling and simulation at UC-Santa Cruz and elsewhere are improving both our accuracy and our ability to localize more difficult defect types.

We need to drive development based on cutting edge research. We need to judge proposed solutions on three criteria: accuracy, resolution, and throughput time for large designs. We must be advocates for enabling design features, and we must use prototype implementations in real factories to gather silicon data for continuous improvement and eventually for validation. Given a real commitment and a significant investment in research and development, the logic diagnosis problem is NOT hopeless!