An Overview of CMOS VLSI Failure Analysis and the Importance of Test and Diagnostics

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Abstract

This paper reviews the logic failure analysis process and the critical need for design-for-diagnostics. The use of flip-chip packaging will render hardware-based diagnostic techniques from the front side of the die obsolete, e.g., liquid crystal, electron beam testing, and photon emission microscopy. Two primary solutions are discussed: software-based diagnostic methods, e.g., scan, and the adaptation of hardware techniques to the backside of the die.

The Failure Analysis Process

Quickly determining the root cause of failure and implementing corrective action is essential and often critical. Significant cost and time savings are attained. The following failure analysis process provides thorough electrical and physical data for faults identified:
- electrical verification and characterization
- coarse localization
- de-processing
- fine localization and defect electrical characterization
- inspection and physical characterization

The Critical Role of Diagnostics

In the above process, coarse localization is the most critical step. Without knowing where to look, the process cannot continue and there are no alternatives.

Two basic approaches exist: software techniques using test data, and hardware techniques which observe various physical phenomena associated with the defect or which measure the chip’s response to outside physical stimulus, e.g., optical or electron beam radiation or heat.

Two key pre-existing conditions are necessary to enable the use of these methods. For most software techniques, a design-for-diagnostics approach during product development is required. For hardware techniques, access to the front side of the die while under test must be possible.

![Fig. 1: Diagnostic Options for Failure Analysis](image)

Figure 1 shows that when front side access is impeded, software diagnostics or backside hardware techniques are the only options. Backside diagnostic capability is very limited however. Infrared optical techniques are the only promising option, and they may be limited in the defect mechanisms they can find.

Software techniques on the other hand can be capable of diagnosing a broad range of faults, independent of the mechanism responsible.

Conclusion

Once fully developed, backside hardware techniques will play a key role in localizing certain logic fails. However, software diagnostics must be developed as the primary method, both as a complement to hardware techniques and as a supplement in cases where these are inadequate.