Economics modelling and optimisation of MCM test strategies

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This paper presents a decision support system for the objective evaluation and optimisation of MCM test options, including boundary scan provision. The system is driven by a detailed cost model of the MCM manufacture and test process. The cost modelling can be extended to model partial scan provision.

Multi-chip modules (MCMs) are an exciting development in the design of complex systems, having many of the advantages of wafer scale integration combined with some ability to rework. They do, however, suffer from low system yield, largely due to test and quality assurance problems. Two major factors contribute to this problem. The use of bare die which have not been fully characterised and tested, and the lack of physical access at the module test stage. The use of known good die (KGD) addresses the first of those problems, but KGD are not always available and have a higher cost. The lack of physical access to the MCM for module test can be addressed by design for testability (DFT) methods such as boundary scan, either on the chips or on a smart substrate.

In either case, testability provision is not free. This expenditure needs to be set against the quality benefits in order to determine the optimum level of test provision. For example, faced with a set of KGD options of varying costs and quality levels, which one should be chosen for a particular application? The choice will be dictated by, among others, the system size, assembly quality, module test fault cover, ATE availability, reworkability and probability of collateral damage as a result of rework.

The authors have developed a decision support system for the objective evaluation of MCM test options. The decision support system is based on detailed economics models of the die procurement and test, and the MCM manufacture, test and rework process. This is a novel approach to MCM test planning, as it integrates a wide set of different decision variables into a coherent decision system, with the added advantage of the estimation of the financial impact of test decisions. Thus an objective evaluation is achieved, and the tools can be used for a range of applications, from initial project planning to detailed test strategy evaluation. The economics analysis has the advantage of translating engineering parameters into financial terms, without losing track of the product quality. It avoids problems of subjectivity and is clearly superior to ad hoc approaches. It also has the secondary advantage of encouraging data collection and process tracking, essential for the success of this method.

Although the tool was developed with the emphasis on test, it can be extended to evaluate decisions on manufacturing processes, equipment use, use of external design centres, etc. Initially, and to simplify the modelling, it was assumed that all die used conform to the IEEE 1149 boundary scan standard, and on that basis an analysis of KGD strategies was performed.

However, boundary scan can be used selectively to partition a design and provide access to critical areas, and it was important to include this capability in the cost modelling tool. Thus the scope of the modelling was extended to handle full, partial or no boundary scan. For example, the absence of boundary scan not only significantly increases diagnosis costs, but poses the problem of misdiagnosis and unnecessary repair. It also means that it is not possible to reuse KGD tests at the module level.

In addition to boundary scan evaluation, this analysis is especially useful in KGD procurement, to estimate the effect different levels of KGD quality will have on the final module. Current work is focusing on the modelling of varying rework scenarios, as well as the detailed modelling of collateral damage as a result of rework.

The applications of this method are not limited to test strategy evaluation, and can be extended to areas such as manufacturing, ATE use, software vs. engineering effort (as in the development of boundary scan continuity tests).

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