

# Are There Economic Benefits in DFM ?

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## ABSTRACT

A fabless company perspective is presented on the roles of the foundries, design entities and EDA providers in the DFM arena, and the requirements for measurement of the economic benefits of DFM

## Categories and Subject Descriptors

B.7.1 , B.7.2

## General Terms

Management, Measurement, Design, Economics

## Keywords

DFM, Design for Manufacturability, Foundries, Fabless

## 1. INTRODUCTION

Design for Manufacturability – DFM – has become a very hot ‘buzz word’ but is somewhat ambiguous to a fabless semiconductor design company. Traditionally yield was the foundry’s responsibility - the design house was expected just to produce a DRC clean design. The use of new materials and sub wavelength lithography in advanced manufacturing processes has precipitated a whole new class of softer design guidelines and recommendations, intended to address the design-process interactions. The engineering decisions required to implement these guidelines and disposition the associated trade offs among all other design project considerations, typically represent a new discipline for most fabless design teams. One of the key issues faced by such teams is that whereas the costs of implementation of a given DFM guideline can be estimated using the existing design infrastructure, there is no practical way of estimating the associated benefits. In this environment, implementation of DFM practices therefore becomes a matter of opinion, rather than a hard engineering decision.

## 2. Fabless Role in the DFM Spectrum

DFM, by definition, spans the whole spectrum of activities between the ‘design’ realm and the ‘process’ realm. At the same time all DFM technologies require some process specific input, and are deployed at some phase of design. In order to delineate the appropriate role that a fabless entity should assume, the DFM spectrum is arbitrarily segmented into four separate groups.

These are

- Process Characterization – focus on test vehicle design and process characterization and data extraction;
- Models and Simulators – focus on specific models, and the associated simulation methodologies and tools, such as lithography simulators, CMP simulators, and SPICE and RC corner models,
- Polygon Transformations – focus on the methodologies, rules and tools used to ‘polish’ a layout and optimize it for manufacturability at the post GDS 2 level,
- Design Flow Transformations – focus on implementation of manufacturability awareness higher up in the design flow, prior to polygon level implementation.

From a fabless entity perspective, the first two segments should be provided by the foundry. Whereas many DFM entities approach a fabless company, such as Qualcomm, to champion a given tool or methodology, the fabless entity would, in fact, prefer to access this class of technologies from the foundries – but with one caveat : the technology should be foundry-independent. Consequently the “Design Kit” model used for managing all other process characteristics is appropriate, and should be expanded to encompass the models required to power this class of DFM tools. That would allow the fabless user to select the desired DFM solution on terms that it is familiar with – such as simulation performance, capacity or integration attributes.

The third segment – DFM associated with Polygon and Design transformations – is jointly in the realm of the foundry and the fabless semiconductor design company. The fourth segment – Design Flow Transformations – is clearly the realm of the fabless design houses. However, in the absence of some metric, it is difficult for a design team to ascertain the value and benefit from any one of the competing DFM solutions. Consequently, the DFM technologies of this class that are being adopted, are mostly selected by virtue of their integration into a given design flow, rather than due to the benefit delivered by the given tool or methodology.

## 3. DFM – a Solution in a Need of a Metric

Ultimately, it is clear that the benefit of a DFM tool is in terms of die cost, or product yield. The problem with using product yield as a metric for DFM benefit is that product yield data is not available at the time DFM decisions are made. The time when a DFM decision is made and product yield measurement is available can be separated by a year or more. In addition, direct yield measurement is convoluted and it is difficult to separate the variables and determine the benefit derived from a given DFM

design decision. On the other hand, use of yield modeling and simulation is somewhat controversial; the calibration accuracy is arguable, and prediction of the future performance subjective. Finally yield is directly connected to the economics of the business, and is therefore often obscured.

Consequently use of product yield to make decisions about the benefit of DFM is not practical and a more useful metric of DFM benefit is needed.

It is suggested that a relative, arbitrary and normalized metric be defined, based on measures or design statistics that are intuitively obvious. It is, for example, relatively uncontroversial that the failure rate of a redundant via is much better than that of a single via – hence a simple count of single vias is an indication of the manufacturability of a given design. It is suggested that these individual metrics can be combined in a simple numerical way to produce a ‘DFM Score’ which can rate the manufacturability of a given design. The exact relationship of this relative ‘score’ and actual product yield may be unknown, but it should be relatively clear that a given design with better score will probably yield more than the one with lower score.

The availability of a metric is more valuable than the absolute accuracy of that metric. In practice, a design team can start implementation of DFM technologies only when some metric is defined. They can use these “DFM Scores” to select the tools and methodologies, and to optimize the designs. Management can use the DFM Scores to motivate the design teams. As these practices become more established, the industry can then focus on tuning and improving the accuracy of the DFM metrics.

#### 4. DFM Score Structure?

Some DFM transformations are focused on optimizing the cost of design, whereas other DFM transformations are targeted to optimize the cost of die. Therefore, it is suggested that there should be two separate metrics.

- “Cost of Design” DFM Score – targeted to assess the efficiency of implementation of a given DFM transformation. For example, it is possible to insert features in a layout, at P&R stage, such that the number and complexity of OPC actions is minimized. Thus, one measure of DFM awareness of a P&R tool could be the number of end-of-line instances

that require insertion of hammer heads at OPC. Similar transformations could be implemented at the post GDS polygon polishing stage – but with a different efficiency. A normalized DFM Score could be produced by counting the frequency of occurrence of known undesirable layout constructs at various stages of the design, and as a result of application of various tools

- “Cost of Die” DFM Score – targeted to assess the relative friendliness of a design to manufacturing process considerations. A count of features such as redundant vias and critical areas can be used to produce a relative DFM Score, and this score can then be used to rate a design.

#### 5. Summary and Conclusion

It is clear that with advanced process technologies, design teams must take more responsibility for yield. The problem is that at this time there is no practical way of implementing the transformations required to optimize the yield because the costs and benefits cross disciplinary boundaries and are difficult to measure. This is exacerbated by the fabless business model where the cost and benefits can cross corporate boundaries as well.

It is concluded that in practice, genuine DFM practices can be deployed by design teams only when they have a way of evaluating and trading off the benefits. This ability to measure the benefits requires that:

- (a) The foundries provide the necessary process models in a Design Kit form – even allowing all the encryption desired to protect proprietary IP – such that the design teams can assess various DFM technologies based on attributes that are familiar to them, and
- (b) The industry develops a set of metrics – and it is recommended that these metrics be divorced from direct product yield measurements – that can be used to score the DFM attributes of a given design