One-Shot DRC Within a Fine-Grain Physical Verification Platform for Advanced Process Nodes

May, 2013

To meet the challenge of nano-scale, deep sub-wavelength processes, innovative "***One-Shot DRC***" technique and a Fine-Grain Physical Verification (fgPV™) platform will be discussed. The benefits of such a system, we believe, will be enlightening, and will drive the future of DRC and LVS tools.

Abstract

As we continue to push the limits of nanometer scale silicon based semiconductor technology, the influence of neighboring device geometries and the need to add fill elements to compensate for chemical mechanical polishing (CMP) continue to grow and increasingly dominate physical design implementation. Yield and timing goals require dramatic increases in design rule complexity. Lithographic, electrical, chemical and mechanical effects are increasingly checked. The increase in the number of rules and data volume with every new process technology is raising accuracy, runtime and scalability issues. In addition, while the use of hierarchical DRC processing has been an asset in the past, more recently the traditional use of hierarchy has not helped with runtimes. Now, with more complex rules span multiple levels of hierarchy, accuracy issues are sprouting up as major concerns with hierarchical approaches. Without question this is certainly a major concern going forward with 28nm and below.

We will attempt to bring to light the needs of DRC analysis for deep sub-wavelength process nodes such as 28nm and below.

Today's Challenges in Physical Verification

Existing DRC tools are based on software architecture and rules language developed in the mid 1990's, when none of today's process problems even existed. Today's challenges in physical verification include:

- Geometries are much smaller than wavelength of light used to create the mask patterns
- Explosion in number of rules and parameters
- Complex rules that span multiple layers
- Proximity effects
- Increasing use of metal fill
- Growth in design density and complexity

The Role of Hierarchy

Hierarchical processing was the innovative capability introduced in the early 90's to combat the limitations of DRC tools in processing large layouts in a reasonable time-frame. The hierarchical approach took advantage of repetition in design by checking a cell area only once and then applying the results to all instantiations of that cell. As design densities started growing rapidly, the runtimes started growing exponentially as shown in Figure 1. The use of hierarchical processing helped maintain those runtimes in the linear region of the curve by storing and solving the DRC problem for a specific cell that was repeated many times. Today, in the world of sub-wavelength nanometer design, except for memory designs, most instantiations of

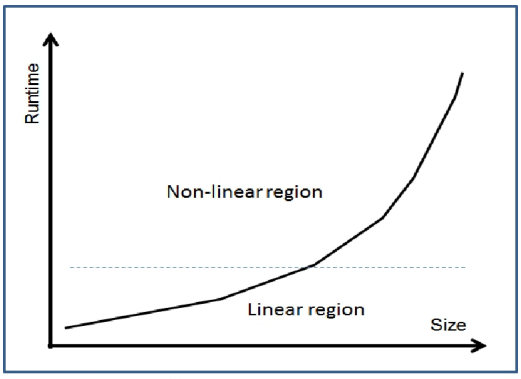


Figure 1.Runtime Performance

repeatable structures such as individual standard cells may have to be verified because of proximity effects and specific DFM-related checks, which are location-specific. In other words, hierarchical processing is not applicable for almost all circuits except highly structured sections of a memory layout. How do the DRC tools that totally rely on hierarchy perform? With respect to run times, performance is very poor. Accuracy has been a more recent issue, especially with the complex process checks. The net impact to customers of current DRC tools is,

- Exponential and un-predictable runtimes
- Over and under-checking of designs

An innovative new DRC tool is needed that offers the required accuracy along with speed and capacity for the current and emerging nano-scale processes.

POLYTEDA's Innovation: One-Shot DRC

POLYTEDA leverages its strength in semiconductor physics and the latest advances in computer science to create a unique ***One-Shot DRC*** processing technology. One-Shot DRC Processing™ is a proprietary architectural innovation in DRC processing technology that is the foundation of POLYTEDA's verification platform, fgPV™ (Figure 3) and the product, PowerDRC™.

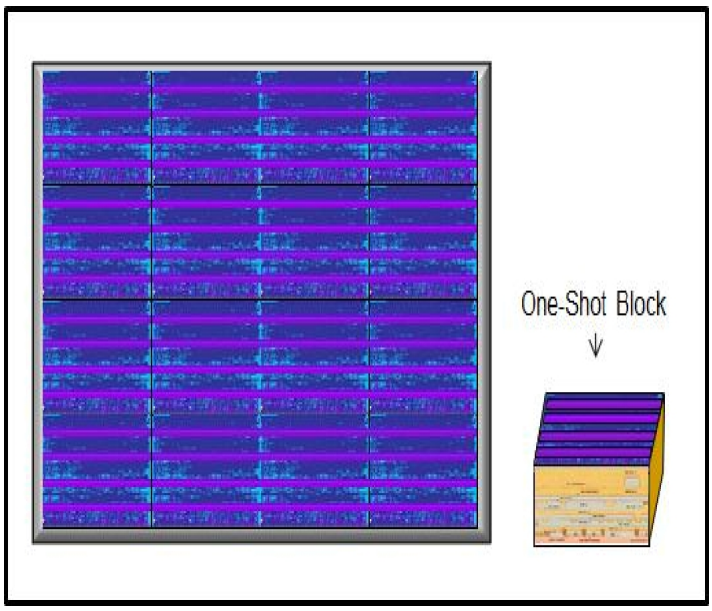


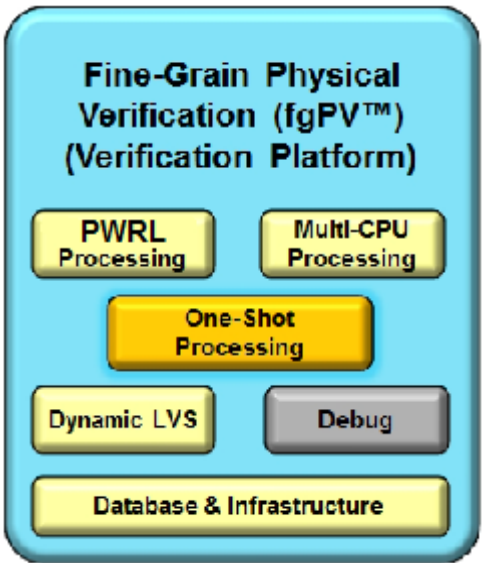
Figure 2. One-Shot DRC

At a high level, one-shot processing takes a block of layout and processes all layers and the rules associated with those layers in one shot. An innovative windowing capability enables the processing to be memory-efficient. That delivers accuracy and performance that are better and faster than today's hierarchical tools. One-shot processing is also unique in allowing runtimes to be predictable. Unlike hierarchical tools, PowerDRC's processing is not limited by factors like complex rules that span hierarchical boundaries. This leads to better accuracy. PowerDRC™ can process more design variables per square nanometer than any other DRC tool thereby maximizing physical verification per square nanometer (***Maximum PV/nm²***).

Fine-Grain Physical Verification (fgPV™) Platform

While the new One-Shot DRC processing works well for all process technologies, we believe it is essential for 28nm and smaller geometries. One-Shot DRC is the foundation for POLYTEDA's verification platform, fgPV™. Key components of fgPV™ platform (Figure 3) are:

- One-Shot processing
- Multi-CPU processing
- PWRL (pronounced Power-L) rule language to best handle the simple and complex checks



PowerDRC™ and PowerLVS™ are the respective DRC and LVS products from POLYTEDA, which are both based on One-Shot DRC and fgPV™ platform. PowerDRC™ offers the unique benefits of:

- Unsurpassed Accuracy
- Faster performance, delivering
- Maximum PV per CPU (PV/CPU) in runtime
- Predictable runtimes, directly proportional to the number of physical objects
- Scalable capacity over single & multi-CPU platforms for any layout
- Best defense against Over and Under-Checking

Figure 3. Fine-Grain Physical Verification technology platform

The smaller the process geometry, the greater is the gap between PowerDRC™ and other hierarchical

DRC tools, and the gap continues to grow.

Shrinking geometries pack more devices into a smaller area; more devices move "into the neighborhood" of the immediate area being analyzed, and nearest neighbor comparisons become the norm. Since all layers are processed in one shot, however, reducing device size does not shrink some of the distances over which design effects occur because those are based upon fundamental physics. Therefore, more rules and many new parameters related to those rules are generated for the nano-scale nodes, creating a need to process more design effects per square nanometer. One-Shot processing is better suited for the advanced process nodes than any hierarchical processing technology that handles a few layers at a time. The One-Shot DRC processing engine also has a close to linear relational dependency between run time and input data size. Therefore, there is no need to rely on hierarchy to manage performance. The speed of DRC processing is directly proportional to the number of objects being processed and is constant for a given style of layout and process node. In other words, the performance is predictable.

Utilization of Multi-CPU Architecture

POLYTEDA's fgPV platform is capable of fully leveraging the One-Shot DRC processing technology for practically delivering linear runtime response across a larger farm of CPUs. The One-Shot packages created by the system can be dynamically and efficiently scheduled across a large number of available processors, thereby extending the advantage, maximum PV/CPU.

PWRL for Standard and Complex Rules

PWRL, a key component of the fgPV™ physical verification platform encapsulates advanced, complex rules into simpler syntax; While the PWRL syntax mirrors the well-known syntax used all these years in rule deck creation, it also efficiently encodes factors that are not considered at higher process nodes. This powerful, flexible and expressive language facilitates and eases the implementation of standard as well as advanced foundry rules in rule deck syntax. One-Shot DRC processing enables near-simultaneous execution of these complex rules to deliver the required accuracy and performance.

Conclusion

Clearly, the time has come for an innovation in physical verification. POLYTEDA's ***One-Shot DRC*** technology as the key component of its ***Fine-Grain Physical Verification ™*** platform offers the required accuracy, runtimes and scalability of both runtimes and design capacity for the most advanced process technologies. While the technology is an asset at any process node, it has the capabilities ***that are necessary for the most advanced process nodes, today and tomorrow***.

