NanoPoint: Applications for 2X and Beyond

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Abstract – As design rules shrink beyond 2Xnm the semiconductor industry has seen additional challenges that has reduced defect signal and increased optical noise sources. NanoPoint has shown significant advantages such as: enhancing defect-of-interest capture rates up to 8x, nuisance suppression up to 3x and unique design-based region-of-interest definition. Here, we introduce the basic concepts of NanoPoint and highlight some unique customer use cases that have utlized the power that NanoPoint offers.

I. Introduction

As the semiconductor industry moves beyond 2Xnm to 1Xnm and below, there have been unique challenges to provide inspection solutions to improve device yield. Generally, defects-of-interest (DOI) at one node become much smaller at the next node while the feature density increases. This results in the DOI optical signal at one node weakening and the surrounding optical nuisance increasing (see Fig. 1). Consequently, the DOI have become more difficult to detect. One approach to solve this issue has been *NanoPoint*.

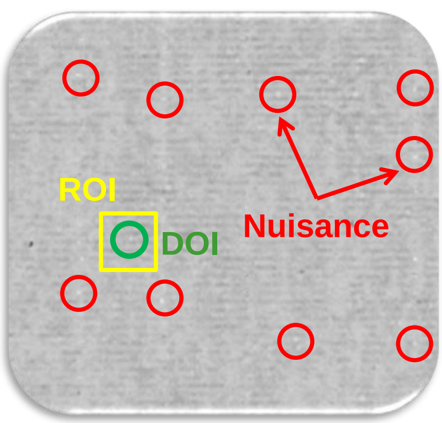

Fig. 1. A difference image of a candidate die and a reference die showing red Nuisance events, green defect-of-interest (DOI) and the desired region-of-interest.

The figure of merit that determines the ability for a detection system to detect a difference from the norm is the ratio of signal, *S*, to noise, *N*, must be greater than a limiting value, *R* (Eq. 1) [1].

$$\frac{S}{N} \geq R$$	(**Eq. 1**)

Typically, $1.2 \leq R \leq 5$ depending on the measurement method, system performance and the degree of certainty required. Hence, semiconductor device trends have decreased *S*, increased *N* and made it more difficult to detect the same (not to mention new) defects.

An approach to solve this issue is to define a region-of-interest (ROI) around the *expected* DOI locations and eliminate all the nuisance events surrounding it from the detection analysis (see Fig. 1, yellow box). This effectively translates the problem from expending enourmous engineering effort to increase the signal of the DOI and decrease the nuisance to identifying and accurately defining the ROI around the DOI. This is essentially what NanoPoint does.

II. Methods

To effectively identify ROIs, one must have access to what the expected features are: namely the device design. One could imagine doing computer simulations to vary the features over the expected tolerance for developing devices and attempt to predict the points that are most likely to fail first. In fact, the entire Electronic Design Automation (EDA) industry (>$6.5B in 2012) has developed tools for making device designs and simulate the expected performance [2]. Once those simulated points are produced, one could import them into an inspection tool and monitor how these points fail over time. Indeed, NanoPoint offers this functionality.

However, despite extensive simulations, DOI that are not expected still persist. Therefore, a complementary method that can define whole regions that are most likely to fail first is offered by NanoPoint using a feature called rule-based search (RBS). For example, one would expect that defects will happen wherever there are dense or isolated structures and we want to define inspection areas around these ROIs (see. Fig. 2).

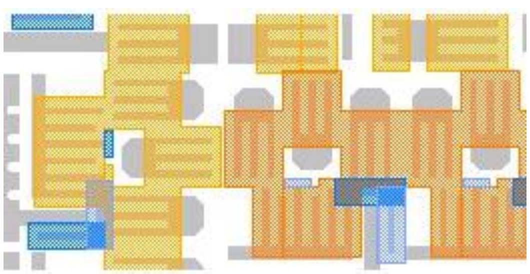

Fig. 2. An example of a device design (grey) with dense thin lines (orange and yellow) and isolated thin lines (blue) ROIs are defined with rule-based search (RBS).

This approach has been very effective in decreasing noise from the surrounding structures that are less likely to fail. Additionally, procedures to discover new defects, that have not been simulated, can be developed to further improve the detection sensitivity NanoPoint offers and further differentiate KT's products.

In particular, a two-pass NanoPoint flow has been introduced to identify so-called, *hotspots*, or points that have actually failed with a high probability (as opposed to simulated to fail). The first-pass involves defining ROI using RBS (e.g. dense thin lines, isolated thin lines, current layer design, edge of array and overlap of two layers) and inspecting those regions. We analyze the defects that have a high frequency of occurance around a particular design, using a feature called Design-Based Grouping (DBG), and identify defects that have systematically failed. For the second-pass, we then define these hotspots by using a feature called, Pattern Search, to find these exact patterns-of-interest across the entire design (ideally the whole die or reticle). We are then ready to show differentiated value using NanoPoint.

III. Results

KT customers have adopted NanoPoint worldwide where unique and interesting use cases have emerged. NanoPoint has been shown to enhance Broadband plasma (BBP) tool sensitivity and enable yield limiting defect detection that has been instrumental to its success.

One recent example is a contact layer that had huge color variation from the previous layer that made the tool less effective detecting defects. When ROIs were defined for all contacts using RBS, an 8x improvement in contact bridge detection and a nuisance rate reduction of 52% to 23% was achieved (Fig. 3).

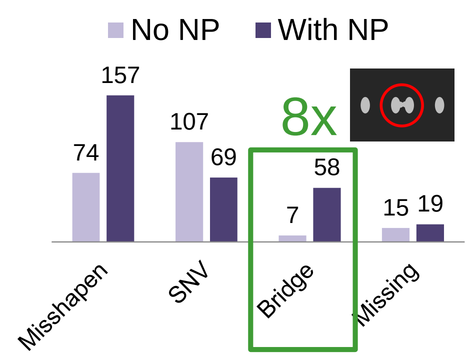

Fig. 2. The pareto for a contact layer NanoPoint (NP) evaluation showing an 8x increase in the key defect-of-interest (DOI), contact bridge, an increase in other DOIs (misshapen and missing contacts) and a reduction of SEM non-visual (SNV) nuisance events.

While uses of predefined rules (e.g. dense thin lines, etc.) have shown great value, custom rules, developed by KT Apps, have also shown great value (e.g. rules that enable defining ROIs around all line-ends, double vias or thin lines between thick lines have shown value). Custom rules have picqued the interest of customers and are in increasing demand. In our presentation, we will show more improvements achieved using NanoPoint and summarize new custom RBS rules customers have been requesting.

IV. Conclusion

In conclusion, we have introduced the basic concepts of NanoPoint, the common methods Application Engineers use NanoPoint to enhance BBP sensitivity and examples of how our customers are using NanoPoint. In particular, we will show DOI detection improvement up to 8X, nuisance reduction up to 3X and unique custom rules that our customers have requested.

Bibliography

[1] "Signal-to-noise Ratio," Wikipedia, May 2015. Available Online: http://en.wikipedia.org/wiki/Signal-to-noise_ratio[Accessed May 2015].
[2] "Electronic Design Automation," Wikipedia, May 2015. Available Online: http://en.wikipedia.org/wiki/Electronic_design_automation. [Accessed May 2015].