Live Demonstration: An Application for Layout Resilience Analysis of Silicon Dangling Bond Logic

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***Abstract*—This demonstration presents the *Operational Domain Explorer*, a PyQt6-based application designed for computationally efficient resilience analysis of *Silicon Dangling Bond* (SiDB) logic layouts. Leveraging novel algorithms, the tool significantly reduces the simulation load required for operational domain evaluations, supporting real-time, multi-dimensional visualizations and advancing SiDB layout reliability.**

I. Introduction

Silicon Dangling Bonds (SiDBs) constitute a promising alternative to the CMOS technology for computing at the nanoscale. They offer potential benefits in power efficiency and device miniaturization. However, SiDB layouts are inherently sensitive to environmental and fabrication-related variations in electrostatic properties, requiring robust evaluation methods to ensure reliable functionality. The *Operational Domain* is defined as the range of physical parameter variations within which SiDB layouts maintain correct logical operation. However, operational domains are notoriously computationally complex requiring tens of thousands of exponentially hard physical simulations.

This demonstration presents the *Operational Domain Explorer* application (as seen in Figure 1) that provides a platform for SiDB logic analysis with drastically reduced computational demand.[1] The work builds on previous research on SiDB operational domains, as detailed in [1].[2]

II. Demonstration Setup

For this demonstration, we will bring a laptop running the *Operational Domain Explorer*, a GUI-based tool developed in PyQt6, alongside supplementary materials to enhance the visualization and understanding of SiDB principles. A poster will illustrate the core concepts of SiDBs and their operational characteristics. Additionally, we will bring silicon wafers, fabrication instruments, and an atomic model to demonstrate the precision required in SiDB fabrication.

The *Operational Domain Explorer* demonstration will showcase its integration with simulation environments and its use of advanced algorithms to overcome traditional computational barriers. By relying on previously published methods for operational domain reconstruction, the tool reduces costly simulator calls by almost 95 %, enabling efficient multi-dimensional sweeps and delivering precise operational domain visualizations for SiDB layouts.

[1] Available at https://github.com/cda-tum/mnt-opdom-explorer/.
[2] Available at https://dl.acm.org/doi/10.1145/3611315.3633246.

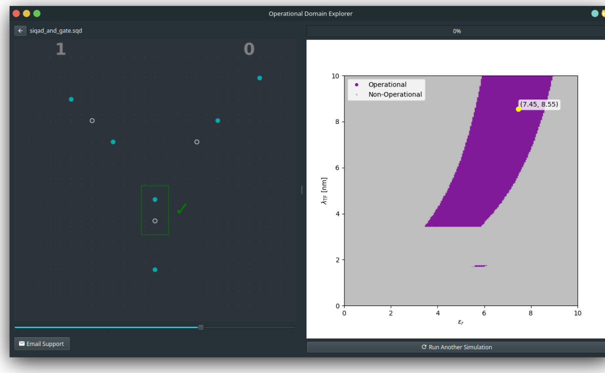

Figure 1: GUI of the *Operational Domain Explorer*.

III. Visitor Experience

Attendees will engage with the *Operational Domain Explorer* by manipulating parameters and observing the real-time updates to the operational domain visualizations. This interactive approach will allow visitors to directly experience the sensitivity of SiDB logic layouts to physical variations and the utility of advanced computational techniques for layout resilience analysis.

The demonstration emphasizes the computational advantages of the implemented algorithms in achieving rapid, accurate operational domain analysis. In particular, attendees will gain insights into the practical impact of these algorithms on the design and optimization of SiDB layouts, appreciating the value of this tool in advancing the reliability and robustness of emerging nanoscale logic technologies.

IV. Conclusion

The *Operational Domain Explorer* represents a significant advancement in the resilience analysis of SiDB layouts. By reducing the computational requirements traditionally associated with such evaluations, this tool empowers researchers and engineers to efficiently explore and optimize SiDB designs. This demonstration will give attendees a practical understanding of how operational domain visualization can inform robust layout design in SiDB-based nanotechnologies, addressing critical challenges as CMOS technology approaches its scaling limits.

References

[1] M. Walter *et al.*, “Reducing the Complexity of Operational Domain Computation in Silicon Dangling Bond Logic,” in *International Symposium on Nanoscale Architectures (NANOARCH)*, 2023.