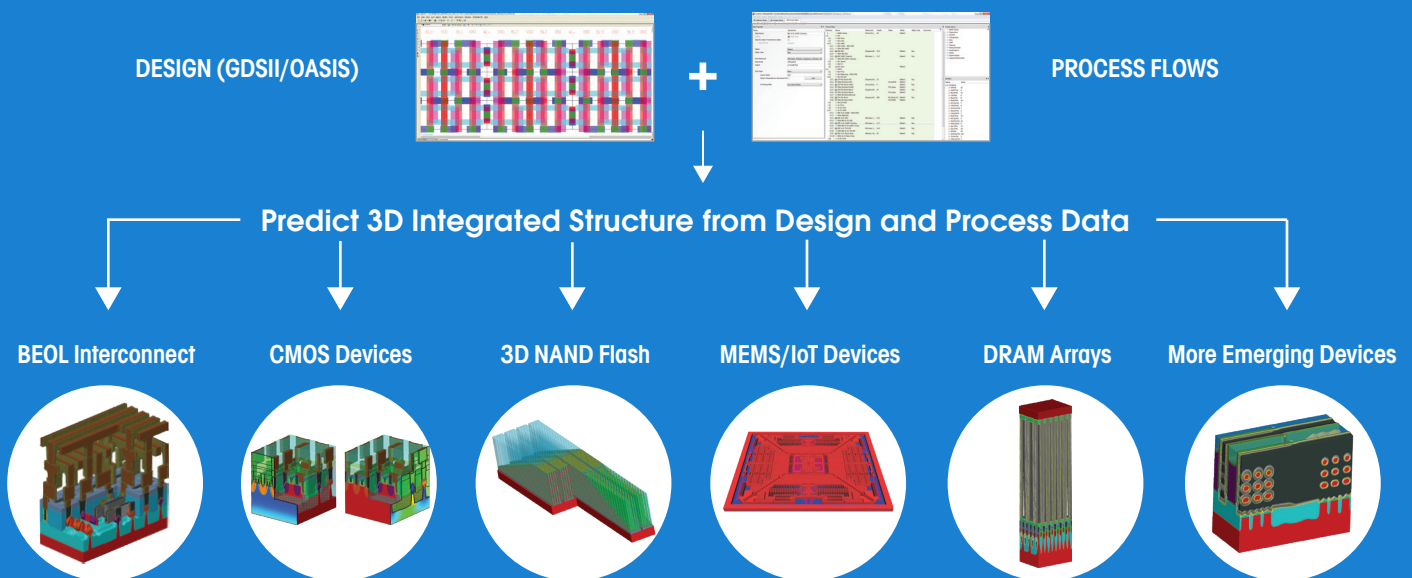


Virtual Fabrication Platform for Semiconductor Process Modeling

Addressing the Challenges of Advanced Semiconductor Fabrication

Continued semiconductor technology advancement into 3D processes, including FinFET, 3D Memory, and BEOL patterning, has significantly increased the complexity of process development. As a result, the traditional build-and-test approach to technology development has become excessively costly and time-consuming. Predictive 3D process modeling with Coventor's SEMulator3D virtual fabrication platform reduces development cycle time and costs associated with traditional silicon experimental learning. SEMulator3D enables companies to bring new technologies to volume production sooner by leveraging virtual fabricated wafers for development.



Predictive 3D Process Modeling

By offering an unprecedented combination of speed, capacity and accuracy, SEMulator3D is uniquely capable of modeling complex integrated process flows across large silicon areas. Utilizing the SEMulator3D virtual fabrication platform, engineering teams can efficiently develop process flows and perform automated virtual experiments prior to actual fabrication.

The SEMulator3D platform enables a new methodology for developing advanced semiconductor and MEMS processes. It is the fastest, most robust, and most accurate 3D semiconductor process modeling platform in the industry. SEMulator3D's process-predictive capabilities benefit all participants in the semiconductor supply chain, from technology developers to fabless IP providers to equipment and process vendors.

Benefits

- Construct highly predictive and accurate 3D process models that reflect the complex interactions between designs and integrated process flows
- Decrease costly & time-consuming silicon learning cycles
- Identify and correct process failures prior to fabrication
- Perform virtual variation experiments not feasible in the actual fab
- Reduce time to yield optimization by performing process window analysis
- Improve productivity and accelerate time to solution
- Applicable to any process and any layout, regardless of complexity or technology

Valuable at Every Stage of Technology Development

Process Exploration

Test processes not yet ready in the fab for integration impacts

Design Rule Validation

Check untested designs for yield-limiting process sensitivities

Process Margin Analysis

Identify process windows, and determine inline specifications

Device Design

Export 3D models to FEA/BEA solvers for additional analysis

Wafer Characterization

Reduce metrology costs and accelerate silicon-based learning

Yield Optimization

Separate multi-process cross-wafer uniformity effects & optimize yield

Defect Analysis

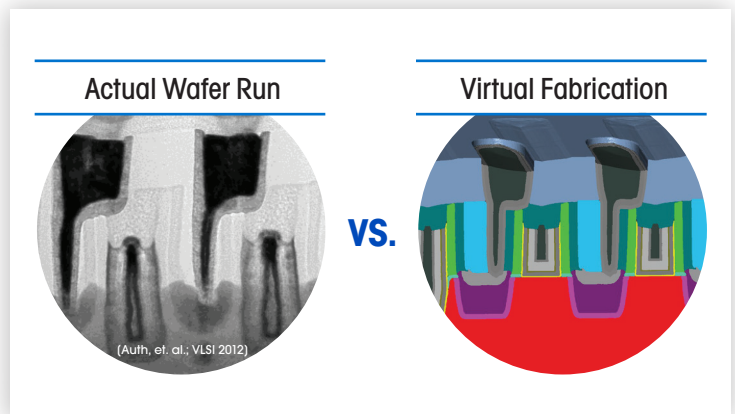
Study & prioritize defect evolution modes through each process step

Documentation & Visualization

Create predictive 3D documentation for complex flows

SEMulator3D Replicates the Actual Fab, and is Faster & Lower Cost

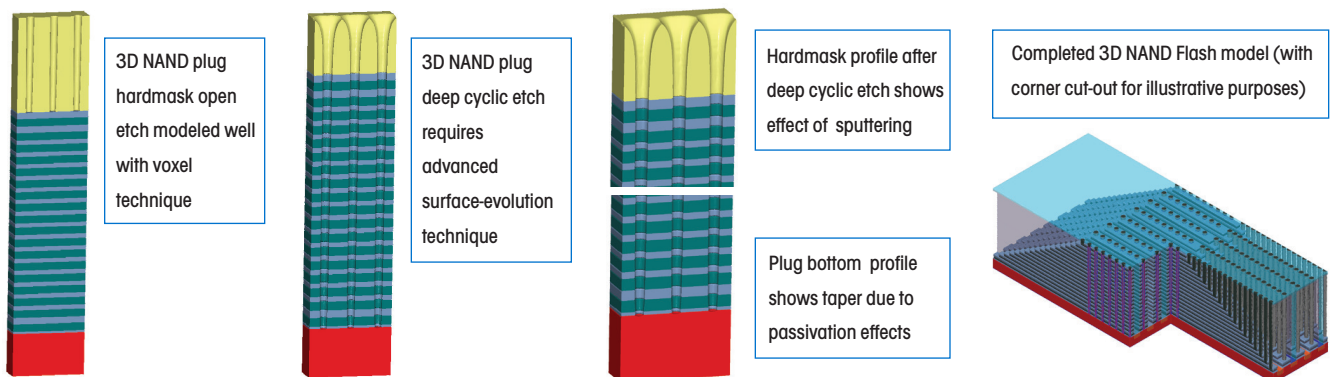
Unlike actual wafer runs which take weeks to months, virtual fabrication takes minutes or hours to produce results. Starting from a virtual silicon wafer, it performs a series of unit processes (some requiring masks) to produce complex 3D structures. Just as in an actual fab, upstream unit process parameters (such as deposition conformality, etch anisotropy, selectivity, etc.) interact with other processes and design data in a complex way to impact the completed structure. The implications of process integration in terms of critical dimensions and other structural measurements can be easily visualized and quantified without the time and expense of actual wafer runs.



Solving Today's Most Advanced Process Integration Challenges

Challenges in current semiconductor processing extend beyond the single-device areas typically analyzed in the past. Traditional process modeling methods are limited to individual devices due to modeling performance limitations. SEMulator3D seamlessly switches between two sophisticated modeling methods: Voxel Modeling, a fast, robust, digital approach, and Surface Evolution, an analog approach capable of modeling a wide range of physical process behavior with great accuracy. This unique technology enables SEMulator3D to quickly solve process problems and provide insights into the impact of process variability.

Advanced 3D NAND Process Modeling in SEMulator3D



Product Features

Coventor offers several different software configurations to meet the diverse needs of the Semiconductor and MEMS industries. The SEMulator3D Basic Module is the basis of the software platform. The full Virtual Fabrication Software Bundle is comprised of three modules: **Basic**, **Advanced Modeling** and **Automation**. Additional software modules including **Electrical Analysis**, **Analytics**, **Advanced Design**, **3D Export**, and **3D Reader** are also available to meet the needs of the most advanced applications.

	Element	Contents	Overview
Virtual Fabrication Bundle	Basic	Core Modeling Capabilities: <ul style="list-style-type: none"> ✓ Process Editor <ul style="list-style-type: none"> ✓ Default Step Library ✓ Custom Python Library ✓ Direct Voxel-Data Export ✓ Default Material Database ✓ Layout Editor (GDS compatible) ✓ 3D Voxel Modeling Engine ✓ 3D Model Viewer 	Package contains everything necessary to simulate and view complex CMOS process flows using the voxel modeling engine. Voxel modeling is extremely efficient and ideal for modeling unit process steps that can be characterized geometrically; for example, lithography, spin-on deposition, and wet etches.
	Advanced Modeling	3D Surface Evolution Modeling Engine: <ul style="list-style-type: none"> ✓ MultiEtch Process ✓ Selective Epitaxy Process ✓ Crystal Plane-Dependent Etch ✓ Pattern-Dependent Etch ✓ Visibility-Limited Deposition/Etch ✓ Directed Self Assembly Dopant Concentration Handling: <ul style="list-style-type: none"> ✓ Ion Implant ✓ Thermal Diffusion ✓ Doped Epitaxy ✓ Doped Deposition ✓ Gradient Visualization 	Provides accurate physics-driven process models for advanced technologies. A powerful, predictive modeling tool to build process understanding, mitigate technology risk and eliminate cycles of learning in technology development. With minimal input parameters that are easy to calibrate, process engineers can gain significant understanding of the behavior and variability of etch and epitaxy steps and their ramifications in the context of the full technology flow.
	Automation	<ul style="list-style-type: none"> ✓ Expeditor Batch Execution Engine ✓ Analysis Editor ✓ Virtual Metrology ✓ Structure Search ✓ Design - Technology Checking ✓ Profile Export (Dopant/Surface) 	Automate large number of experiments and use metrology to measure critical geometry. Structure search inspects entire build area for design/process violations.
Additional Modules	Electrical Analysis	<ul style="list-style-type: none"> ✓ Port/Net Assignment ✓ Resistance Solver ✓ Capacitance Solver ✓ Device Analysis 	Calculate resistance of conductor nets and capacitance between nets directly within SEMulator3D. Generate IV curves to measure transistor performance across process changes.
	Analytics	<ul style="list-style-type: none"> ✓ Automated Experiment Wizard ✓ DOE plus Monte Carlo Analysis ✓ Multivariate Regression ✓ Automated Calibration 	Used to identify important parameters and help understand their impact on process variation. Automatically optimize SEMulator3D process parameters to make the virtual 3D model match a physical semiconductor.
	Advanced Design	<ul style="list-style-type: none"> ✓ Layout Expert Tool 	Viewing, cropping and merging of large GDS/OASIS files in a graphical layout.
	3D Export	<ul style="list-style-type: none"> ✓ Surface/Volume Mesh Generator 	Export SEMulator3D models to other modeling platforms.
	3D Reader	<ul style="list-style-type: none"> ✓ 3D Model Reader 	Disseminate 3D model results across teams.