SYNOPSYS®

Synopsys TCAD Services

Rigorous and Predictive Modeling to Optimize Technology and Device Characteristics

Overview

Synopsys TCAD tools are used by process and device engineers at all major semiconductor companies to develop and optimize semiconductor technologies. Synopsys TCAD Services targets the optimization of processes and devices using TCAD tools and the investigation of technology development and manufacturing issues using process and device modeling methods. Synopsys TCAD Services offers calibration, simulation, model development, and consulting to customers.

Our goal is to improve time- and cost-effectiveness in the design, the development, and the manufacturing of semiconductor devices and technologies using process and device modeling techniques. We apply TCAD and process compact model (PCM) methodologies to solve technology issues and to mitigate risk by providing flexible and extensive resources, and highly trained personnel.

With today's highly complex semiconductor development and manufacturing processes, establishing new technologies and producing high-yielding products can be a daunting challenge. Access to ever more diversified technical expertise and highly skilled and specialized engineers is essential to ensure successful development of new technologies, as well as to achieve high yield and to meet time-to-market constraints.

Synopsys TCAD Services has an extensive resumé of helping customers deploy TCAD-based technology development methodologies, resulting in increased engineering productivity, reduced development costs, and increased product yield. Drawing upon a wide spectrum of experience and expertise from TCAD modeling and technology development, Synopsys TCAD Services delivers a methodology and simulation environment for consistent, accurate, and predictive process–device modeling of a wide range of technologies. Our expertise in TCAD simulation tools, process technologies, as well as broad knowledge in device applications can help you accelerate the deployment of TCAD-based technology development, advanced process control, and yield improvement to increase your company's profitability.

Turnkey Solutions

TCAD is essential for developing and optimizing semiconductor processes and devices. The latest International Technology Roadmap for Semiconductors highlights TCAD as a key technology to reduce development costs and time-to-market [1]. Synopsys TCAD Services offers a selection of services, providing turnkey solutions to customers who seek to improve their TCAD usage or who want to apply a TCAD-based methodology for process and device development and optimization. With Synopsys TCAD Services, customers can maximize their benefits of using TCAD by taking advantage of a comprehensive range of services, including:

- Performance optimization for logic, memory, optical, and analog and discrete devices
- Process (front end of line) optimization to meet device performance or manufacturability targets
- TCAD calibration for process and device modeling to establish a consistent and predictive simulation environment for technology development
- Process compact model (PCM) generation for advanced process control and parametric yield improvement in manufacturing
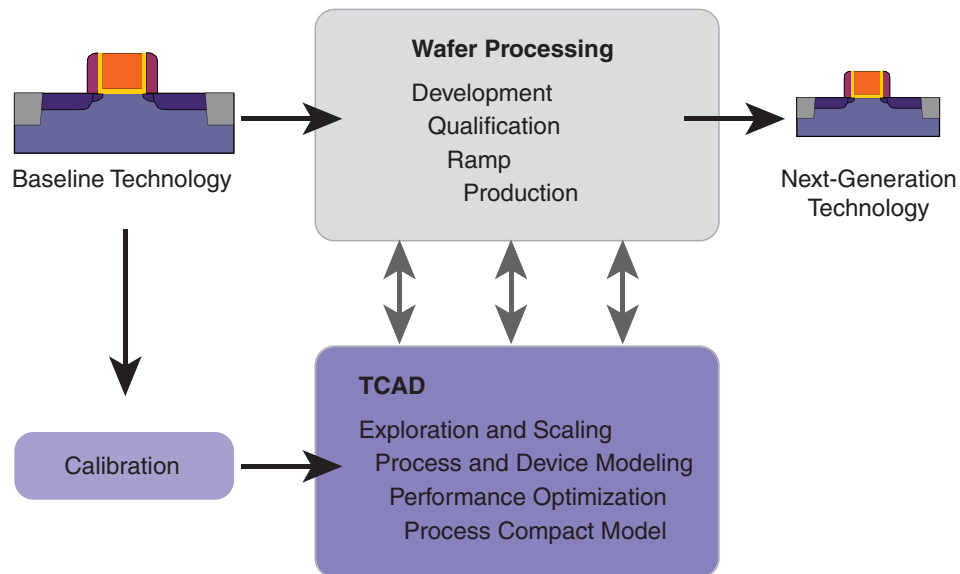
Figure 1: New semiconductor technologies are typically developed by shrinking an existing technology and incorporating new materials and structural details. TCAD plays a key role in technology development with process optimization and device design, thereby saving development time and costs.

Semiconductor Engineering and Optimization Services Based on TCAD Modeling

Synopsys TCAD Services has developed rigorous and reliable methods to apply TCAD process and device simulations to device development, process integration, and optimization for performance or yield. Our methodologies are deterministic, through the application of TCAD, and cover the most relevant issues in modern technology applications.

Logic

- Ultrashallow junction (USJ) process engineering including 'cocktail' implants and advanced annealing technologies
- Strain engineering and modeling of process-induced strain on device performance
- Front end of line (FEOL) device optimization through extension, and halo and source/drain junction engineering
- Process compact modeling for threshold voltages, on-current and off-current, capacitances, and delay time based on dominant process parameters

Analog and Discrete

- Heterojunction bipolar transistor (HBT) process and device optimization
- Bipolar CMOS DMOS (BCD) technology and consistent multidevice process optimization
- High-voltage MOS or IGBT optimization for Vt, Ron, BV, and delay times covering 2D and 3D effects
- Process or layout optimization for robustness and performance increase of discrete devices, and extraction of compact models for ruggedness optimization

Electrostatic Discharge

Electrostatic discharge (ESD) is a fundamental threat to all types of semiconductor device. Synopsys TCAD Services provides a combined solution for ESD characterization and modeling, with the goal to establish an ESD model that allows process or layout optimization. Based on transmission line pulsing (TLP) measurements, Synopsys TCAD Services can build a calibrated TCAD ESD model and extract a compact model description of the ESD structures for use in circuit simulation.

Memory

- SRAM and DRAM cell optimization, and junction engineering especially for extension/buried strap implants
- Single event upset (SEU) simulation for process radiation-hardening (doping and layout dependency) and soft error rate (SER) estimation of DRAM
- Injection current and field optimization for nonvolatile memory (flash and SONOS)

Optical and Solar

- CMOS image sensor and CCD sensor process and device optimization for dark current, transfer characteristics, optical crosstalk, and efficiency analysis
- Solar cell optimization of light trapping (3D textured surfaces) and external quantum efficiency
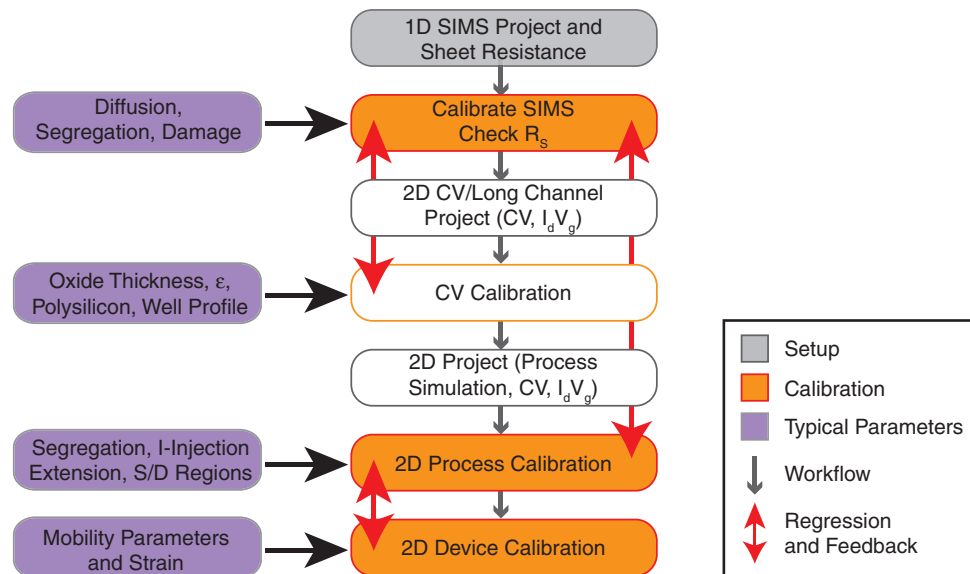
Figure 2: Information flow diagram for calibrating a CMOS technology. The calibration methodology combines 1D doping profiles and sheet resistance measurements with 2D process and device simulations in a systematic way to generate a set of physically consistent calibrated model parameters.

TCAD Calibration

A predictive TCAD simulation environment allows 'virtual wafer runs' for the optimization of processes and devices, thereby reducing the need to use expensive experimental wafers during technology development. The number of iterations in real silicon can be dramatically reduced with a TCAD-based technology development environment. As a side benefit, device and process engineers gain insight into the device behavior that helps isolate and solve problems at the root cause.

Through the vast experience in process technologies over the last two decades, Synopsys TCAD Services delivers a consistent and efficient calibration methodology to increase simulation predictiveness based on your specific fab or process conditions. The Synopsys TCAD Services team uses systematic calibration strategies that preserve the physical meaning of the models, so the calibrated parameters maintain predictive behavior across process splits. The result is a calibration to the individual technology node and manufacturing environment that forms the basis of a TCAD modeling environment to help you:

▪ Perform mission-critical device and process optimization with your TCAD team.
▪ Unlock the full potential of new tools and platforms with Synopsys experts and consistently apply the most advanced models and the appropriate TCAD methodologies.
▪ Accelerate your team's learning curve and design productivity through know-how and method transfer during calibration and customer-specific training.

Advanced Model Development

As technology is pushed to its limits, so are modeling and simulation approaches. To go beyond the limitations of existing approaches and to keep up with the latest modeling and simulation strategies, Synopsys TCAD Services can help you implement highly specialized modeling strategies, allowing you to profit from the competitive advantages afforded to early adopters of the latest and most accurate modeling technologies.

TCAD Flow Setup and Integration

To help TCAD teams optimize their workflow and environment, Synopsys TCAD Services offers dedicated services including improvement of TCAD environments and consistent TCAD platform deployment for multiuser or multisite environments.

To achieve the highest possible degree of consistency between in-line processing and TCAD modeling, we can deploy a TCAD database that integrates your recipe management or manufacturing execution systems.

Manufacturing Integration

When the process moves from development to production, linking TCAD to manufacturing helps improve process control and raise the process capability index (Cpk) by variability and robustness modeling. With software enhancements and full fab integration, we provide services that link production and manufacturing data directly into your TCAD environment. The full advantage of process and yield control support by TCAD is guaranteed by this integration. Reverse engineering and virtual process control help to maintain and improve the technology over the entire life cycle.

Process Compact Modeling

The Synopsys process compact modeling approach incorporates statistical design-of-experiment methods within the calibrated TCAD environment to generate response surface models (RSMs) from which PCMs are extracted. These computationally efficient models, which relate process input parameters to key device electrical responses, are making their way into manufacturing environments. They help, for example, to simulate the impact of process parameter variability on device performance. Such models provide mathematically efficient tools for performing process optimizations and sensitivity analyses.

Synopsys TCAD Services offers a service to perform statistical modeling and to extrapolate the physical process–device model into a more general PCM that encapsulates the correlation between process variation and electrical parameters for parametric yield analysis. In-line statistical measurement data can also be linked and correlated directly to modeling data to provide a more comprehensive capability for advanced process control and parametric yield analysis. For more advanced modeling approaches, Synopsys TCAD Services can also provide customized models to address the individual needs of customers.

[1] *International Technology Roadmap for Semiconductors* (ITRS), Modeling and Simulation, 2007 edition, available at <http://www.itrs.net/Links/2007ITRS/Home2007.htm>, February 2009.

For more information about Synopsys TCAD products and services, go to http://www.synopsys.com/Tools/Pages/default.aspx, or contact your local Synopsys representative, or email tcad_team@synopsys.com.

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