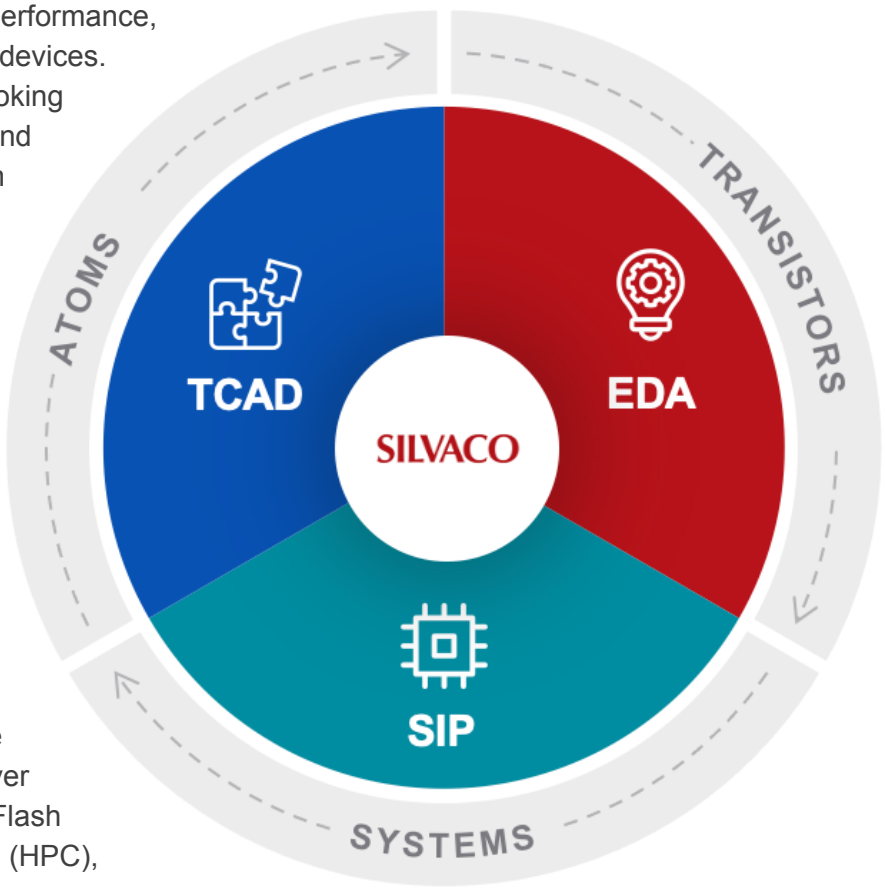
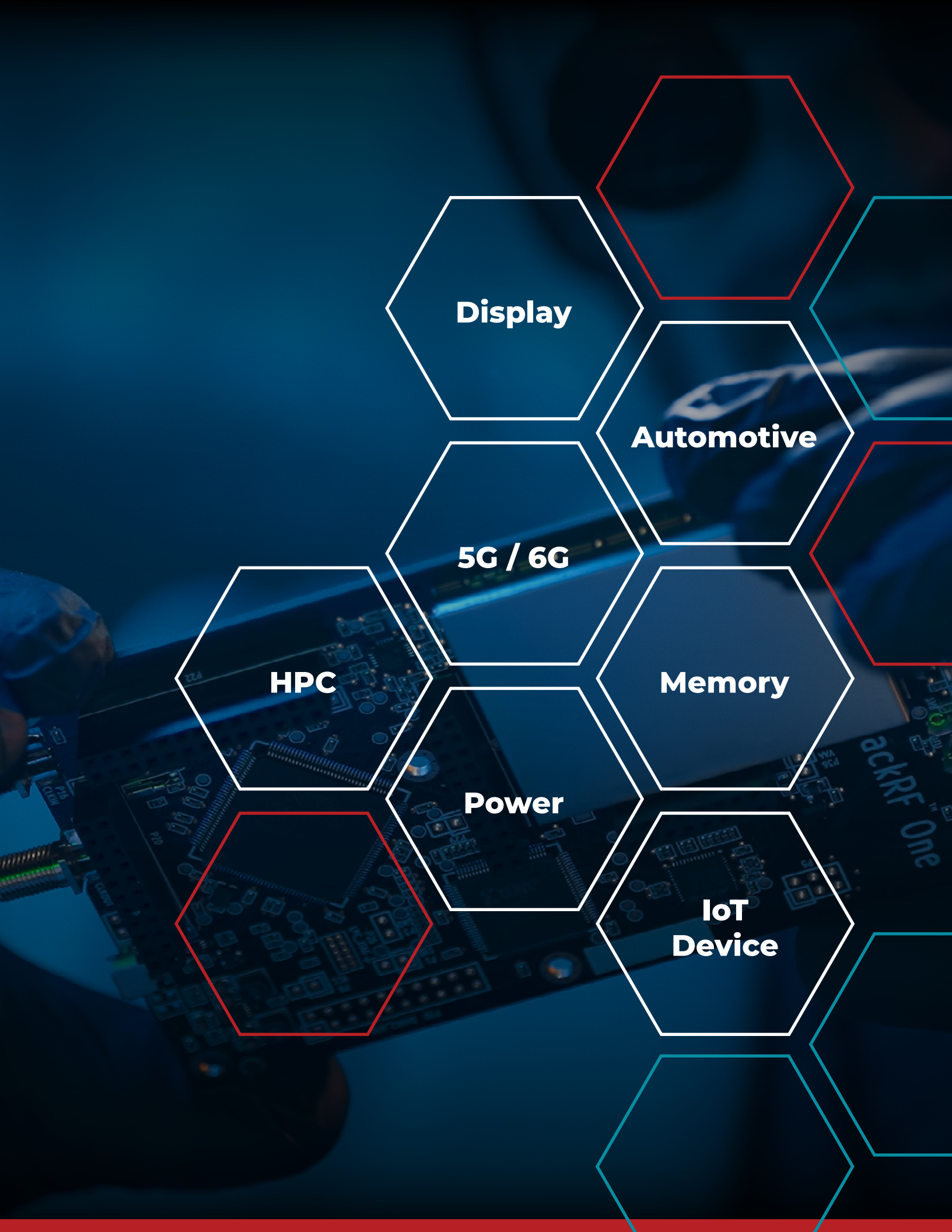

SILVACO
Enabling Semiconductor Design and AI Through Software Innovation and Automation
From Atoms to Systems

Silvaco is a provider of software solutions for semiconductor and photonics design, including TCAD, EDA software, and SIP solutions that enable semiconductor design and digital twin modeling through AI software and innovation.

The company's innovative software and IP is used for the development of complex semiconductor and photonics processes, devices and systems across a variety of market segments, including display, power devices, automotive, memory, high-performance computing, foundries, photonics, IoT, and 5G/6G mobile markets. Silvaco offers a wide range of solutions as well as support for engineers and researchers worldwide. Their expertise covers a broad range of semiconductor design, from simulating devices at the atomic level to designing and analyzing transistor-level circuits and providing semiconductor IP blocks and creation tools for advanced SoC designs.

The semiconductor revolution improves the performance, cost, power and yield of processes and devices. Semiconductor companies are also looking at new materials and technologies beyond silicon, such as gallium nitride (GaN), silicon carbide (SiC) and ferroelectric materials, to achieve better performance, energy efficiency and functionality. Examples include pixels in digital displays, compound semiconductors for power conversion, advanced processes and devices for ICs (integrated circuits) and photonics applications. Silvaco provides a wide range of products that offer complete solutions for these changing markets. Our solutions are deployed in production flows across broad industry segments such as power devices, display, imaging, automotive infotainment and ADAS (Advanced Driver Assistance Systems), discrete DRAM and Flash memories, High Performance Computing (HPC), 5G/6G and IoT (Internet of Things).




Display
Automotive
5G / 6G
HPC
Memory
Power
IoT
Device

TCAD Solution Platform

TCAD software simulates semiconductor processes and devices prior to and during the semiconductor fabrication process to optimize yields, accelerate time-to-market and lower overall costs. Our TCAD solution platform, starting at the atomic and molecular levels, simulate semiconductor device behavior reducing the need to run expensive and time-consuming experiments in manufacturing. Our advanced graphical user interface with 3D animation of the device and process simulations allows easy visualization of the results. Using advanced physical models, we can simulate technologies ranging from display pixels like quantum dots, to advanced SiC and GaN power devices and latest CMOS technologies such as silicon nanowires, including their quantum effects.

To explore the entire space of possibilities requires easy-to-understand automation software that can manage large numbers of analyses to achieve optimum power and performance goals. Now in its third generation, the Silvaco TCAD platform employs sophisticated numerical methods to provide performance without compromising accuracy. With Silvaco, engineers and researchers can design novel processes and devices, explore trade-offs in performance, power, reliability and optimize their final design for manufacturing.

Silvaco's TCAD simulation of semiconductor devices combined with analog simulation of circuits reveals how device processing, structure and circuit operating environment affect the performance of a real design. Silvaco enables engineers to create optimized and reliable circuits in a single design environment. With the electronics design flow integrated into one platform, Silvaco offers the capability to produce better ICs at lower cost. Our TCAD solutions are used in production flows in leading semiconductor fabs, power devices IDMs (Integrated Device Manufacturers), Display, DRAM and Flash memory companies.

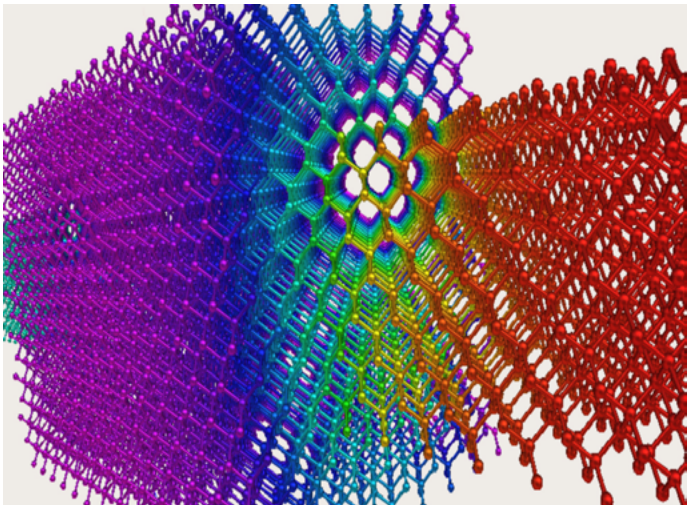
TCAD

Technology Computer-Aided Design

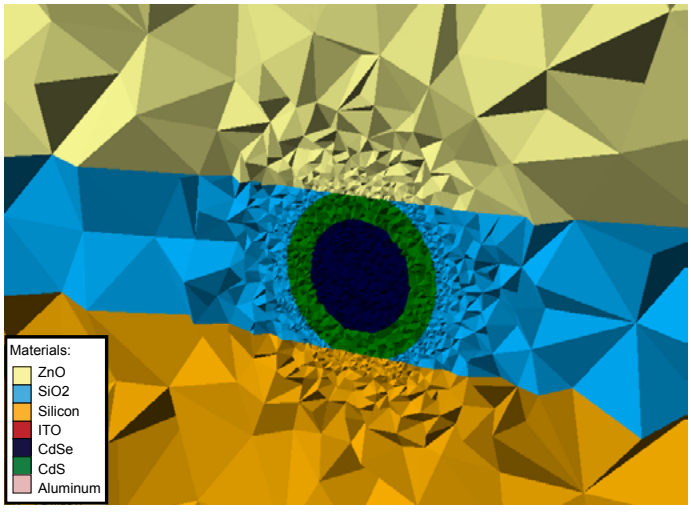
Simulate *processes & devices*

- → Builds the necessary brick and mortar blocks for the semiconductor companies
- → Used to improve manufacturability, reliability and scaling
- → Reduces development cycles and costs

Semiconductor wafer



Visualization of quantum effects in a nanostructure



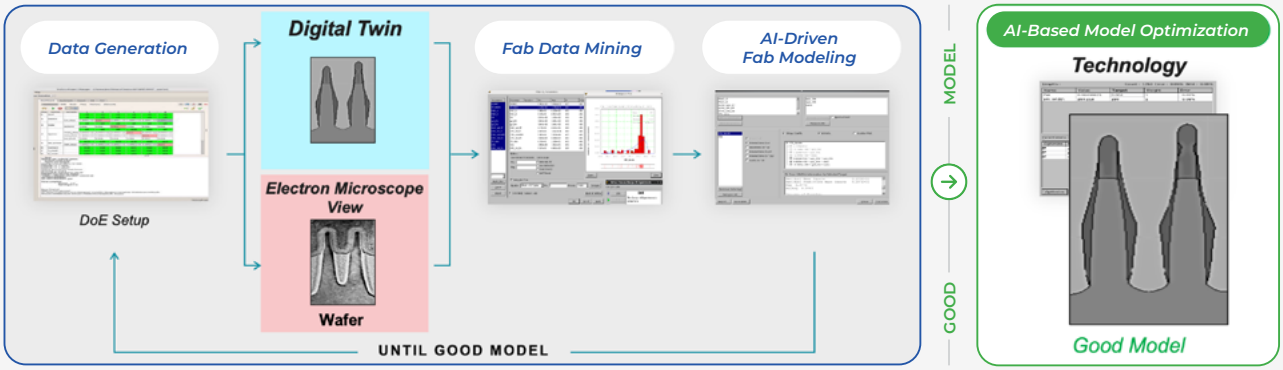
Quantum dot device showing contact layers

TCAD Solution Platform *(cont.)*

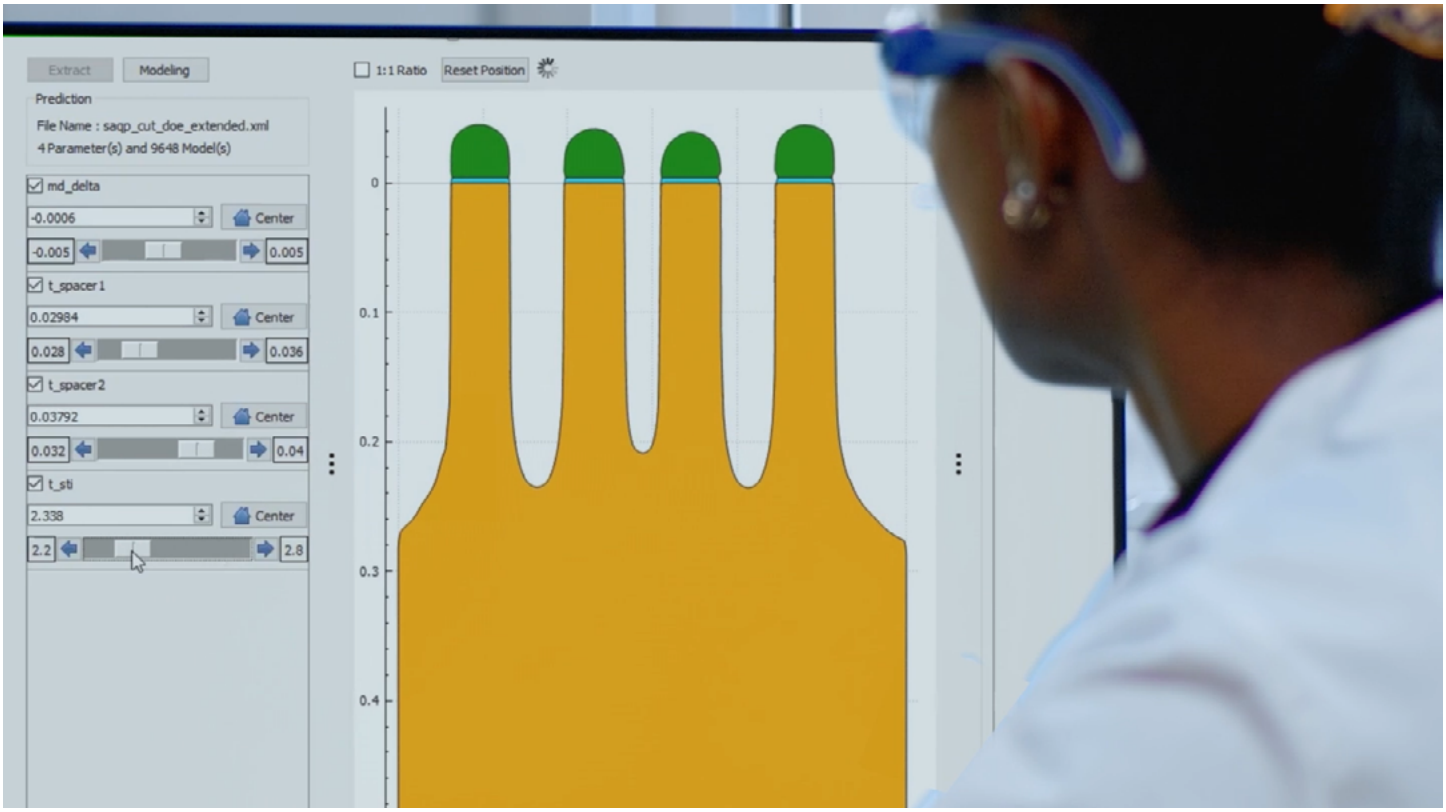
AI-Driven Fab Technology Co-Optimization (FTCO™)

We have combined our expertise in semiconductor technologies with machine learning and data analysis to develop an artificial intelligence-based solution named Fab Technology Co-Optimization, or FTCO™, for wafer-level fabrication facilities. FTCO uses manufacturing data to perform statistical and physics-based machine learning software simulations to create a computer model or "digital twin" of a wafer undergoing various fabrication process steps that can be used to simulate the fabrication process. As a virtual representation of the manufacturing process and the wafer, this "digital twin" serves as a platform through which semiconductor and IDM companies can run experiments and tests to understand the impact on the yield of a wafer due to variations in the parameters of the manufacturing process, predict the yield for further research on new products, and reduce the time-to-market for products, all without the need to run physical wafers, which can be time-consuming and expensive. We have partnered with Micron Technology, Inc. for the development of these modeling tools.

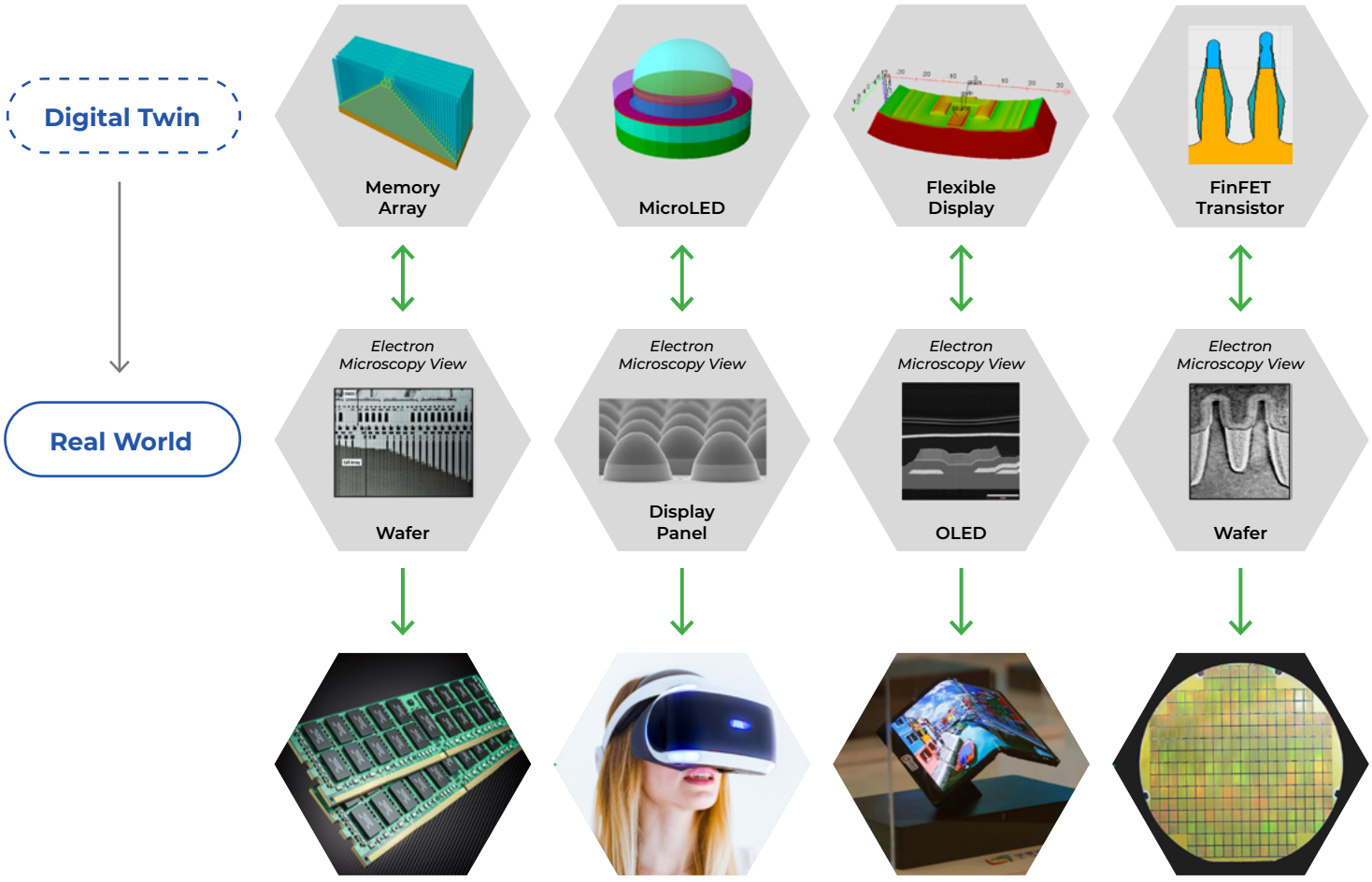
Throughout the lifecycle of the semiconductor fabrication equipment, feeding process data through digital twin models allows for continuous update and refinement of the models. FTCO, with its AI-driven statistical analyses and digital twin technology, fosters close collaboration between Fab and Process engineers, enabling faster iteration on process technology development and significant cost savings.



- Removing cost of trial-and-error using AI-driven models through digital twins
- Artificial intelligence-based solution for wafer-level fabrication facilities: Memory, CMOS, SiC, GaN, etc.
- Uses manufacturing data to perform statistical and physics-based machine learning software simulations to create a computer model or 'digital twin'



Digital twin simulation



EDA Solution Platform

Semiconductor design is impossible without EDA tools and solutions; they enable and enhance design flows to accelerate time-to-market and lower costs. The world around us is an analog one where power, temperature, voltages and currents are the key parameters for electronic circuits, requiring a broad suite of advanced tools for design and analysis. Silvaco offers comprehensive analog and custom design solutions that bring electrical and physical layout views together along with circuit simulation and physical verification to ensure correct behavior and manufacturability before committing to final silicon.

Our analog/custom IC design platform includes schematic capture, circuit simulation, layout design, physical verification, parasitic extraction and reduction, post-layout analysis including statistical variation and yield analysis.

At the foundation of analog circuit simulation are the models used to abstract the behavior of transistors and analog circuits. Circuit designers need models that can accurately predict the behavior of their designs. Our device characterization and modeling solutions and services enable design teams to generate accurate, high-quality models for use in simulation and analysis of analog, mixed-signal and radio frequency (RF) circuits in broad market segments such as Power Devices, Display, 5G/6G, IoT and Memory.

In advanced nanometer design nodes, post-layout parasitic effects substantially impact the behavior of circuits. We offer a comprehensive suite of analysis tools to speed up post-layout verification flow for analog, digital, RF, mixed-signal and memory designs. Leading IDMs and fabless companies have adopted Silvaco's suite of solutions to address the challenges of parasitic analysis and reduction for technology nodes from 65nm (nanometer) down to 4nm.

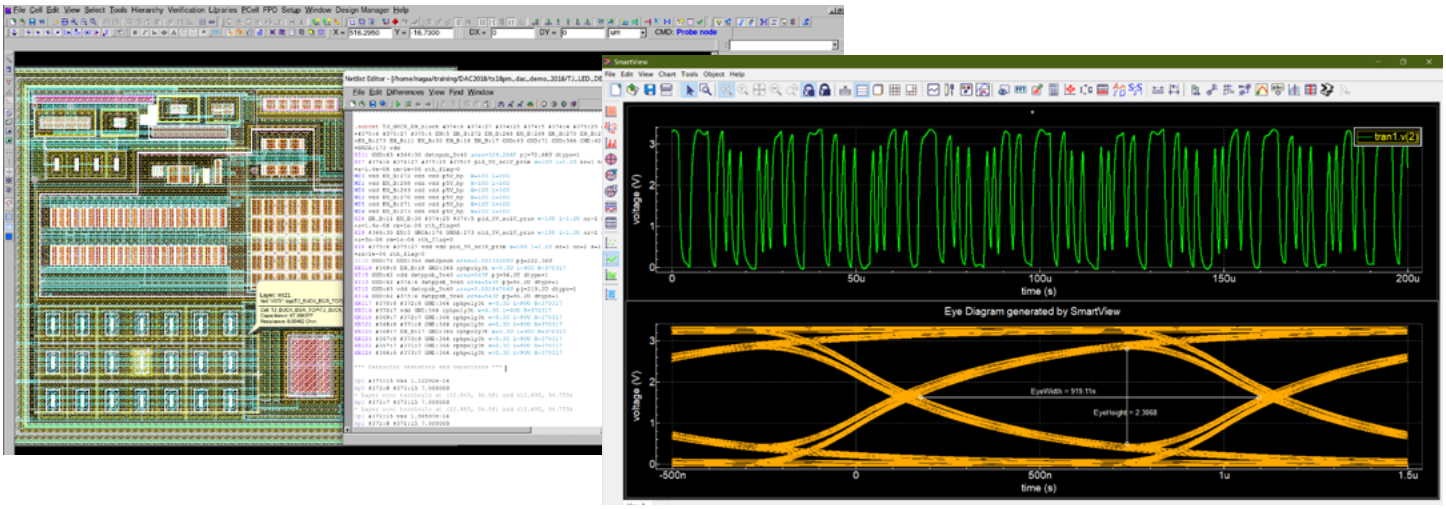
Designing SoCs in advanced process technologies requires analyses of statistical variation in IC manufacturing processes and operating conditions. Analysis of circuit structures across process, voltage and temperature variations has traditionally consumed astronomical computing resources. Silvaco's patented machine learning technology reduces this problem so that statistical simulation is practical and accurate. With our variation analysis tools, designers can make the right implementation decisions to develop efficient and reliable analog, standard cells, IO and memory designs.

Silvaco's EDA solutions have helped create thousands of analog and custom circuit designs in partnership with semiconductor foundries. Whether the electronic application is in homes, factories, or automobiles, Silvaco design solutions have touched lives throughout the world.

EDA
Electronic Design Automation

Design *electronic systems*

- → Design, analysis and verification tools for implementing chip designs
- → Addresses vertical market segment needs
- → Helps achieve lower cost, better performance, and shorter time to market



Silvaco analog custom IC design solution — design, simulation, and verification

High performance computing

Semiconductor IP (SIP) for SoC Designs

Moving from analog and custom design to complex SoCs, design teams need pre-verified, production-proven IPs as building blocks to accelerate time-to-market (TTM). Silvaco provides semiconductor design IP (SIP) blocks as well as tools for the creation and verification of IP building blocks Additionally, we provide an enterprise-level SIP management platform for managing, tracking, and controlling usage of IP blocks in SoCs.

Silvaco SIP products include wired interfaces, bus fabrics, peripheral controllers and cores for automotive, consumer and IoT/sensor applications. Our catalog of IP meets the requirements for consumer, mobile and HPC applications including wired and high-speed interfaces, analog and mixed-signal blocks.

Silvaco Foundation IP offerings include Standard Cell Libraries, Embedded Memory Compilers for SRAMs (Static Random Access Memory), ROMs (Read Only Memory) and Register Files. Our Foundation IP enables customers to reduce power consumption in their designs while providing optimal performance, density and yield, for foundry process technologies from 250nm to 3nm. We work closely with semiconductor foundries to optimize our physical IP, enabling our customers to fast-track their IC design while reducing risks.

Our Standard Cell IP creation platform enables creation, optimization, characterization and verification of Standard Cell libraries. It enables semiconductor foundries and digital CMOS IC design teams to custom-tailor digital cell libraries and explore the impact of alternate device models, design rules and cell architectures. Silvaco is committed to offering best-in-class Foundation IP and associated services and is a one-stop shop for chip developers, fabless companies and foundries.

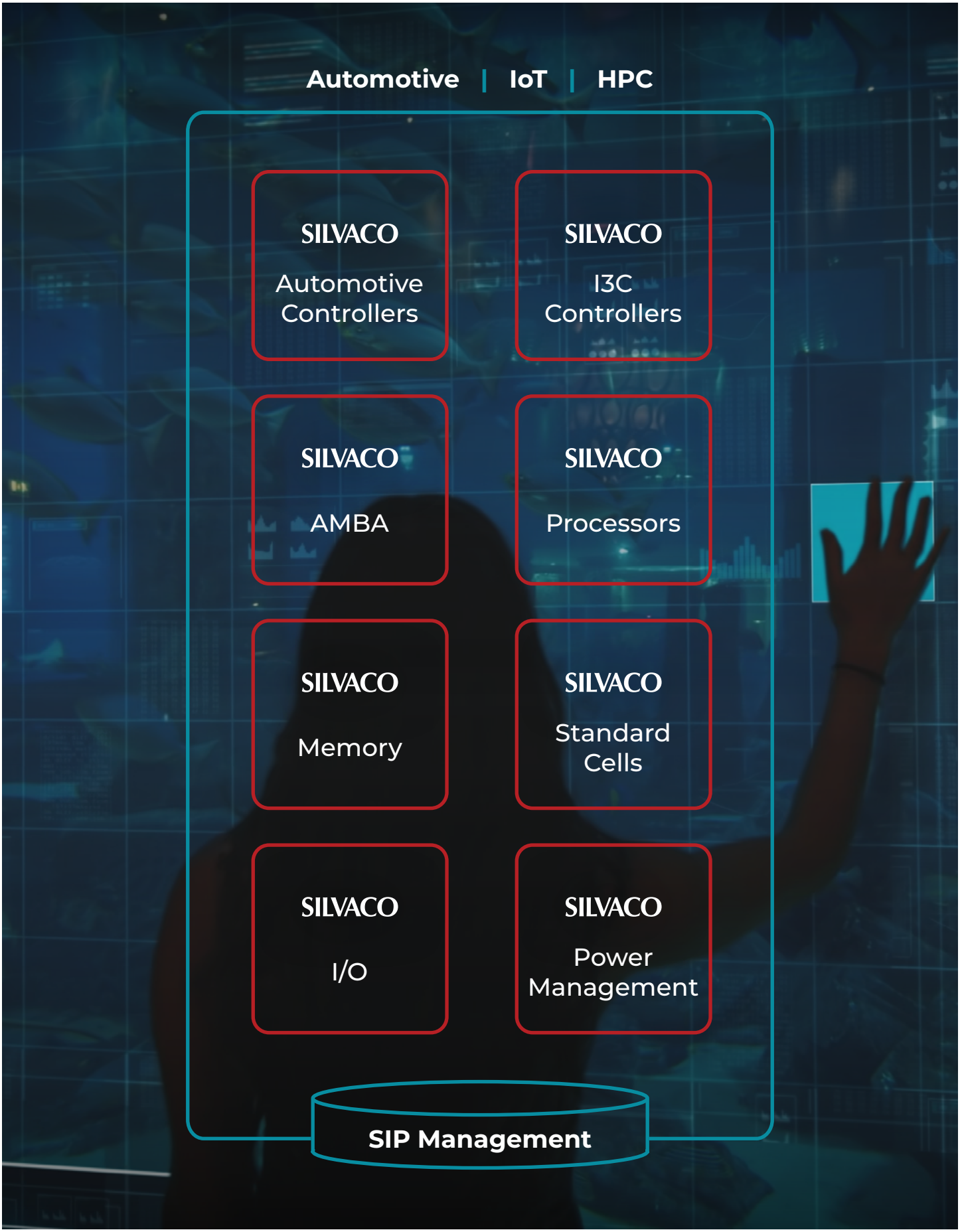
With the increasing usage of SIPs in large and multinational semiconductor companies, tracking and managing usage of SIPs across various design groups and geographies has become a critical and time-consuming effort. Our unique enterprise-level IP management platform enables semiconductor companies to manage, track and version-control both internal IP and the IP purchased from various suppliers, saving effort and preventing unauthorized or erroneous usage of SIPs in SoC projects.

SIP

Semiconductor Intellectual Property

Reuse *proven design modules*

- → Silicon-proven, functional SIP blocks used within larger designs
- → Engineers leverage an extensive library of reliable, high-yielding design
- → Helps achieve lower cost, and shorter time to market


Automotive | IoT | HPC
SILVACO
Automotive Controllers
SILVACO
I3C Controllers
SILVACO
AMBA
SILVACO
Processors
SILVACO
Memory
SILVACO
Standard Cells
SILVACO
I/O
SILVACO
Power Management
SIP Management

END MARKET EXPERTISE

Power Semiconductor Devices Leader

The power electronics market is growing rapidly, driven by the accelerating demand for electric vehicles, high-performance computing power systems, renewable energy, communications, aerospace and consumer electronics. The new requirements of these markets are driving the increased adoption of different types of semiconductors such as silicon carbide (SiC), gallium nitride (GaN) and other wide bandgap materials to replace traditional silicon in high-voltage applications.

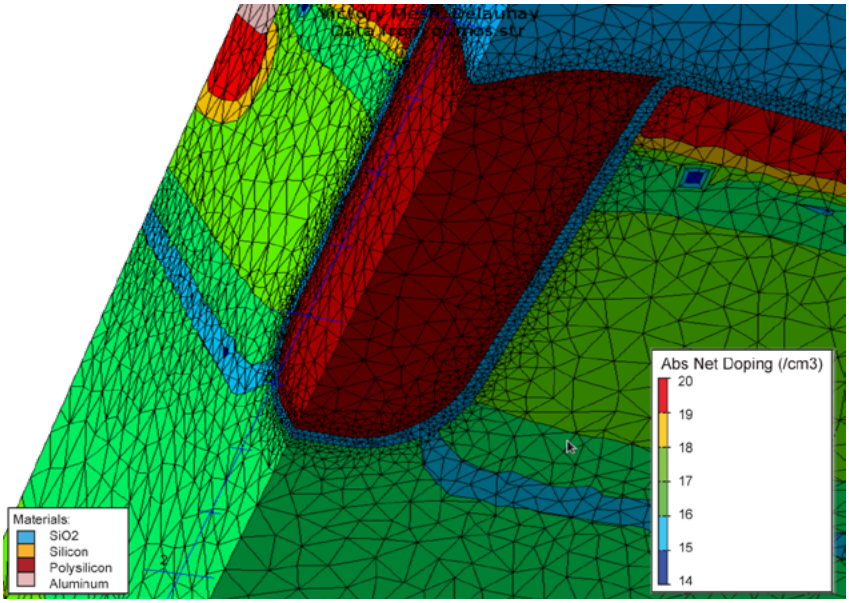
Companies designing or manufacturing power devices using silicon, SiC, or GaN technologies need to use TCAD simulations as part of their R&D efforts to understand their devices in greater detail and improve their device performance.

TCAD modeling of power technologies allows engineers to make virtual changes in device operating conditions such as process, voltage and temperature, device structure (for example, planar versus trench-based), or in device level process technology (such as doping and layer thicknesses). This exploration builds qualitative and then quantitative understanding of devices. Iterative simulation then allows engineers to optimize device performance and operating area.

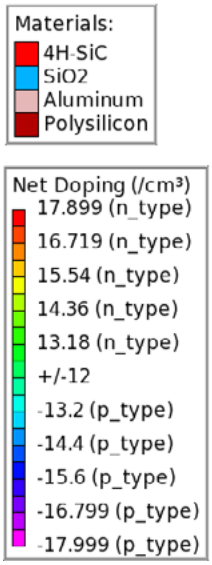
With optimized devices, engineers can produce better semiconductor products and reduce the time needed to reach volume production by decreasing the number of prototype wafers that need to be manufactured and characterized. Another benefit for product engineers in fabless companies is the ability to suggest improvements in the manufacturing process to their chosen foundry to improve yield and performance. Silvaco is a leading provider of TCAD to power devices market and its AI-driven FTCO solution uniquely optimizes power electronics fabrication process.

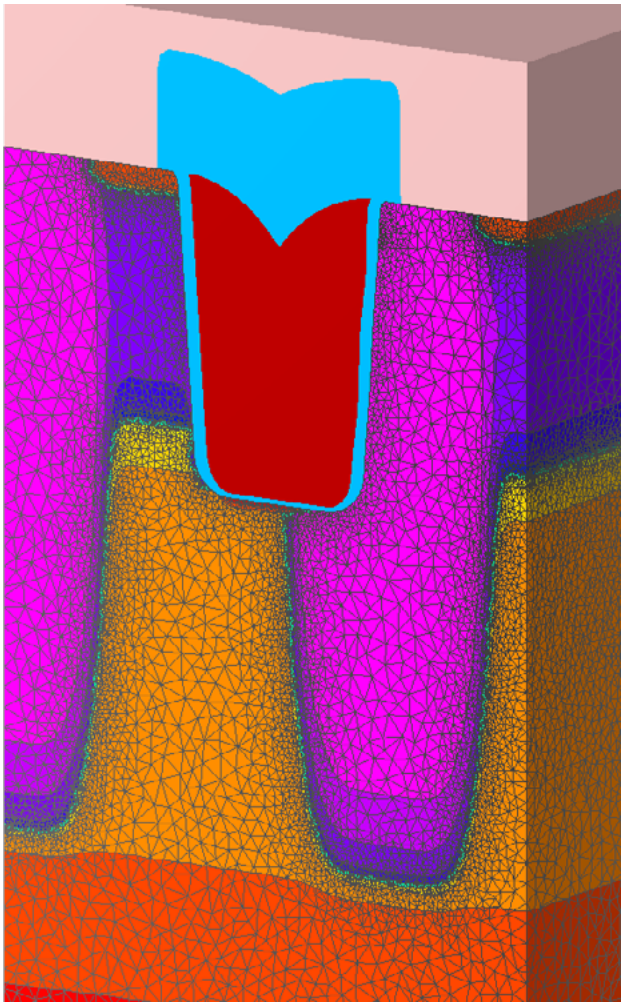
Power devices deployed in manufactured circuits require analog design software such as Silvaco's analog and custom design suite. Schematic capture of the circuit components and their connectivity is combined with device modeling and circuit analysis to simulate real world operation across a wide variety of temperature and electrical conditions to ensure correct performance. Because Silvaco's TCAD and analog/custom design solutions are integrated, they are ideal for power device engineering teams.

Used by foundries and fabless semiconductor companies worldwide, Silvaco is a market leader in software solutions for the development and analysis of power devices.



Delaunay mesh to resolve complex 3D geometry features and doping profiles





Doping profile of a silicon-carbide power device

END MARKET EXPERTISE

Display Design Leader

A wide range of consumer and commercial products are moving to more advanced display technologies. In the mobile phone, wearables, virtual reality, tablet, laptop and TV markets, manufacturers are making huge investments in new technologies such as OLED, AMOLED, quantum-dot LED, MicroLED and flexible displays. At the same time, well-established display technologies, such as LCD, continue to evolve and improve. These trends are driving large changes in materials and fabrication methods for displays worldwide.

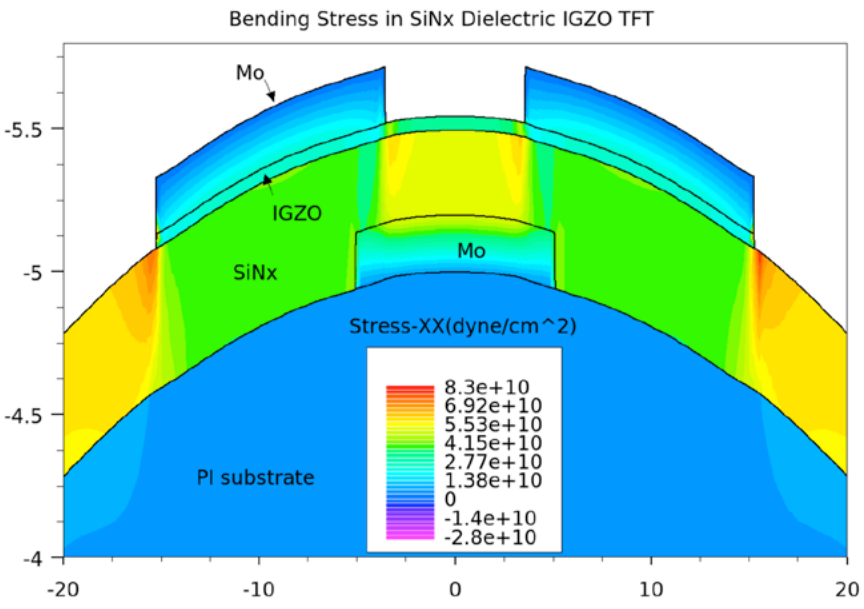
Significant innovation for display technology starts with simulation of complex atomic and quantum-level behaviors. This creates the need for tools that can work in almost every physical domain – electronic, electromagnetic, optical, thermal and chemical. These tools need advanced physics modeling that span from the quantum mechanical level to the system level.

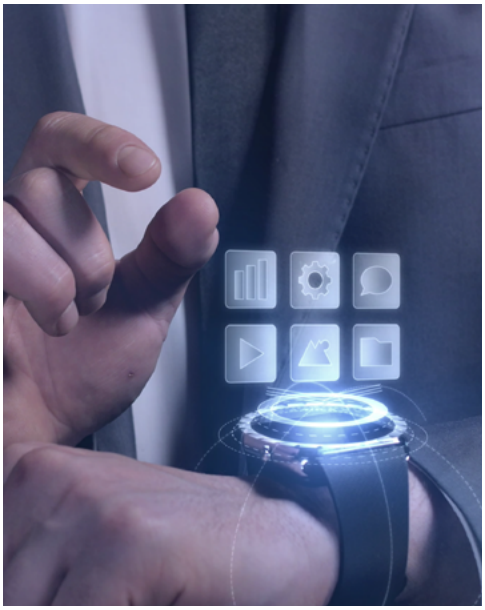
Silvaco's TCAD solution models the complex and diverse structures found in the newest displays and simulates them to provide insight into their performance and behavior.

Silvaco's analog/custom design tools enable innovation in the display market. With the significant growth in display sizes beyond 100" along with increasing pixel density from 4K to 8K UHD standards, the scale of display designs is growing dramatically, requiring even more detailed analysis of pixel elements. Our device modeling tools help display designers generate accurate models of pixels to enable them to simulate the correct behavior of displays.

Our analog/custom design solution, with its pixel array placement and routing capabilities, is tuned to quickly produce circuit layouts that match the required manufacturing constraints and ensure design quality. To analyze the electrical behavior of displays, our circuit simulation tool uses advanced modeling of devices to capture their static and dynamic behavior, with capacity to handle millions of thin-film transistors (TFTs).

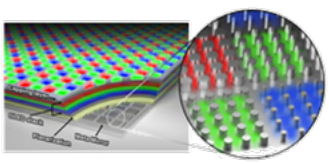
The integration of Silvaco's TCAD with analog/custom design suites provide display development teams with the comprehensive analysis they need to better understand and optimize pixel performance. Silvaco's complete display solution is the reason it is deployed at the world's top display manufacturers.



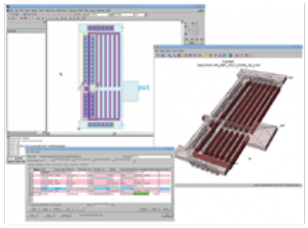


Bending stress of oxide TFT device on flexible substrate

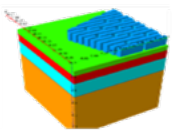
Final MicroLED structure for device simulation



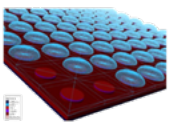
Micro LED



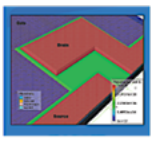
OLED Simulation



OLED Simulation



OLED Modeling



OLED Modeling

A Brilliant Future

From the electrification of automobiles to the potential of 5G/6G wireless networks, utilization of AI and IoT, our connected world is being shaped by the growth of these transformative technologies. Powerful on their own, these technologies are fundamentally changing the ways we interact with the world, the ways in which we do business and even how we communicate with each other. As this convergence continues, new opportunities and challenges are emerging.

At the edge of IoT, new devices with ultra-low energy demands will be needed to harvest sensor data across a wide variety of environments. IoT communication to the cloud requires newer kinds of wireless connectivity, such as 5G/6G, that operate at extreme frequencies. Materials such as gallium nitride and composite materials such as silicon carbide are needed for the next generation of electronics to make proliferation a success. At the data center, AI technologies require new types of memory solutions. In consumer electronics and computing, the move to advanced nodes is driving the need for deeper process analysis for yield improvement and closer collaboration across multiple disciplines of design and semiconductor fabrication. For ultra-fast computing in data centers, cryogenic cooling of hardware will be needed to achieve the target of what we now consider to be extreme performance. All of these technologies rely on semiconductors and the necessary TCAD and EDA software to simulate, analyze and optimize their performance, reliability and efficiency. At the same time design teams rely increasingly on pre-verified IPs as building blocks to accelerate time to market. With its comprehensive portfolio of products and its strong customer base, Silvaco is well positioned to benefit from these trends. Silvaco's customers are building the future and driving our product-development roadmaps.

To realize this future, we need more than just technology. Silvaco is investing in and fostering the next generation of designers. We have deployed our design suites at hundreds of universities and academic institutions worldwide to support new innovations and to educate the next generation of engineers and researchers.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AI

Semiconductor design challenges span the levels of atoms, devices and systems. Silvaco is committed to solving these challenges with competitive software, design IP and world-class support services for engineers and researchers across the globe. We see a brilliant future for this fast-changing industry. Silvaco is matching this growing pace and will continue to be the technology behind our customers' success helping them move at a faster pace.

SILVACO

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