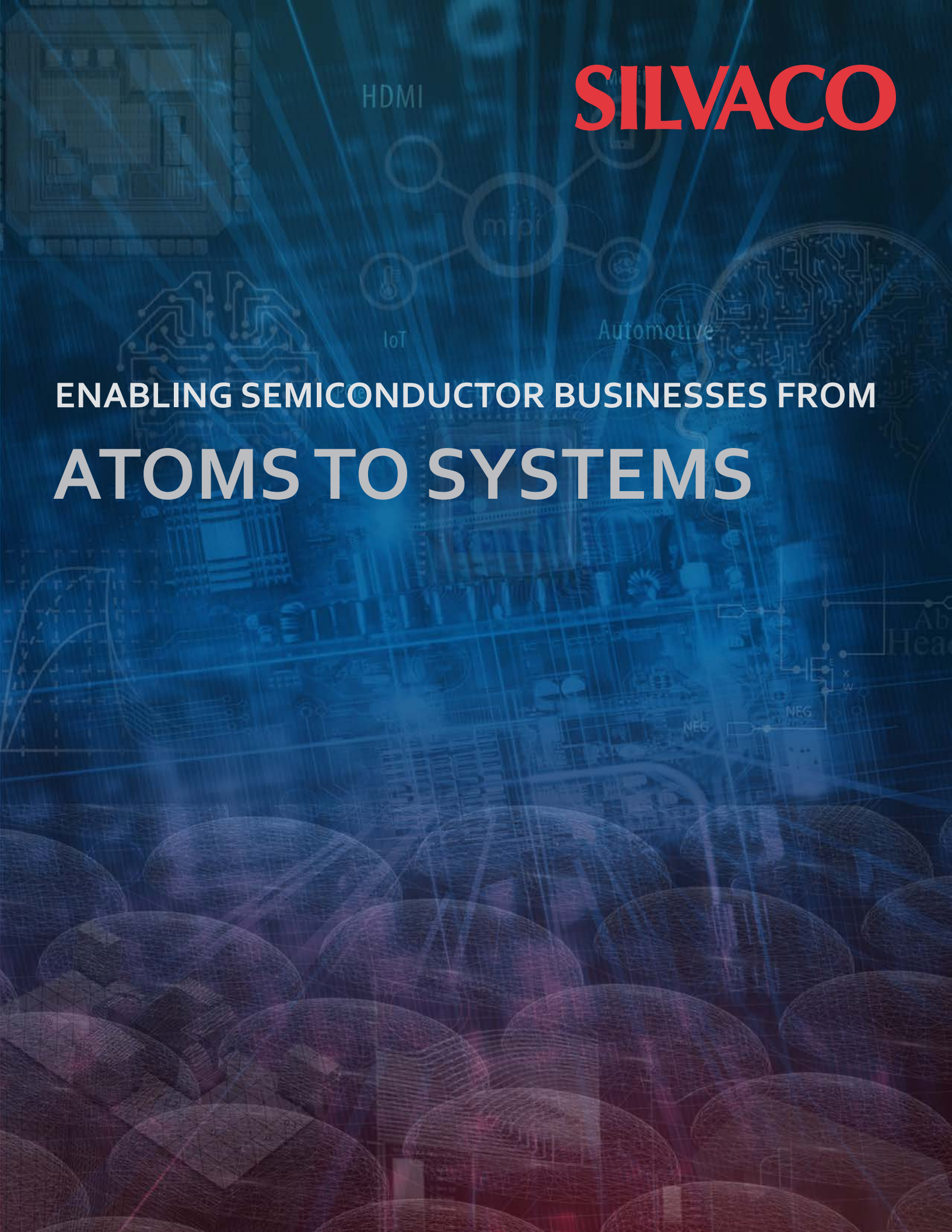
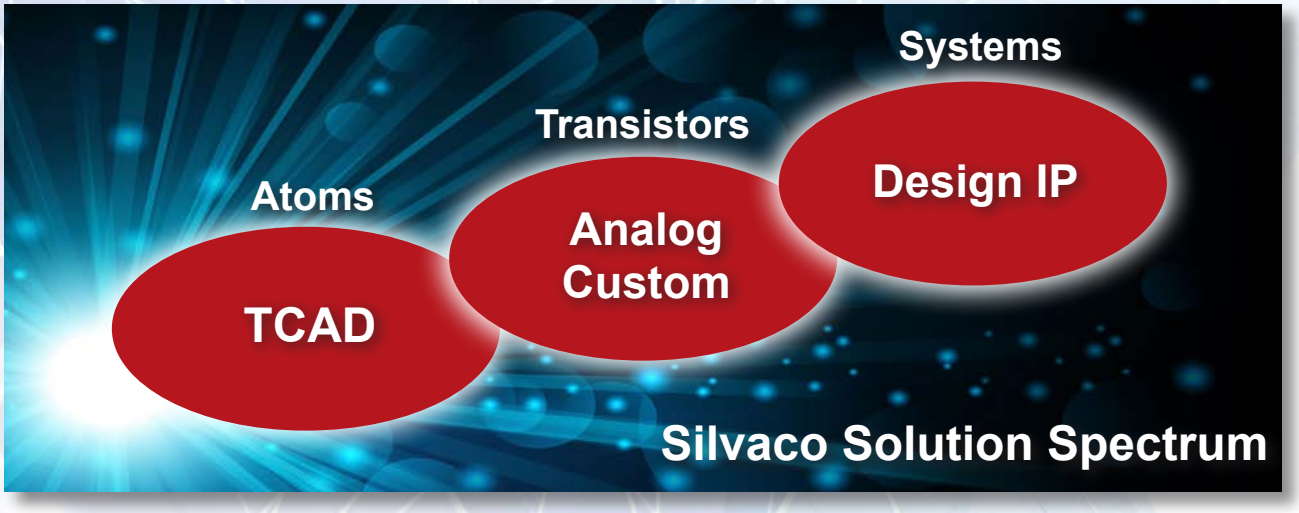


SILVACO

ENABLING SEMICONDUCTOR BUSINESSES FROM

ATOMS TO SYSTEMS

For over three decades, Silvaco has solved semiconductor design challenges by offering affordable and competitive TCAD (Technology Computer Aided Design) software, EDA (Electronics Design Automation) software, proven design IP (intellectual property), and world class support to engineers and researchers across the globe. Silvaco solutions span from atoms to systems: starting with simulation of material behavior impacting semiconductor devices, to design and analysis of transistor circuits, and lastly providing IP blocks for systems-on-chip (SoC) designs.

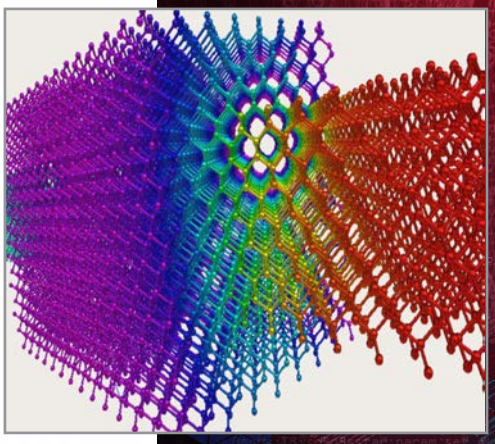


Our solutions are deployed in production flows across broad industry segments such as leading display companies, automotive OEM suppliers, and top Memory , 5G, and IoT (internet of things) providers.

DESIGN SOLUTIONS

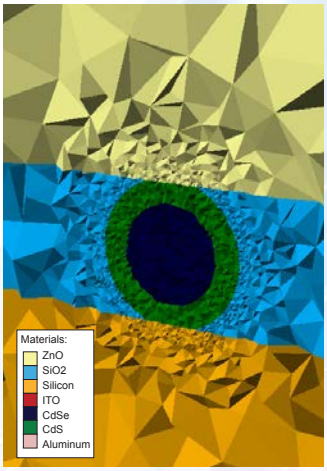
The semiconductor revolution is driven by the need to deliver processes and devices with better operating performance, lower cost, reduced power, and higher manufacturing yield. Examples range from pixels in digital displays, novel transistors for power conversion, advanced devices for ICs (integrated circuits), and optoelectronic applications.

Our TCAD (Technology Computer Aided Design) software, starting at the atomic and molecular level, simulates semiconductor device behavior without the need to run expensive and time-consuming experiments in manufacturing. Our advanced graphical user interface with animated 3D device capability and process simulations make visualization of results simple. Using the newest physical models, we can simulate from quantum dots to nanowires, with their quantum effects, to individual devices, functioning circuits, and systems' dynamic performance. 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.



Visualization of Quantum Effects in a Nanostructure

Our TCAD solution is now in its third generation and employs the latest numerical and analytical methods to provide the highest 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. In addition, semiconductor foundries can rely on powerful statistical tools including design of experiments (DoE) combined with machine learning to reduce the number of samples to process in a semiconductor fab and reduce turn around time (TAT) for optimizing process parameters.



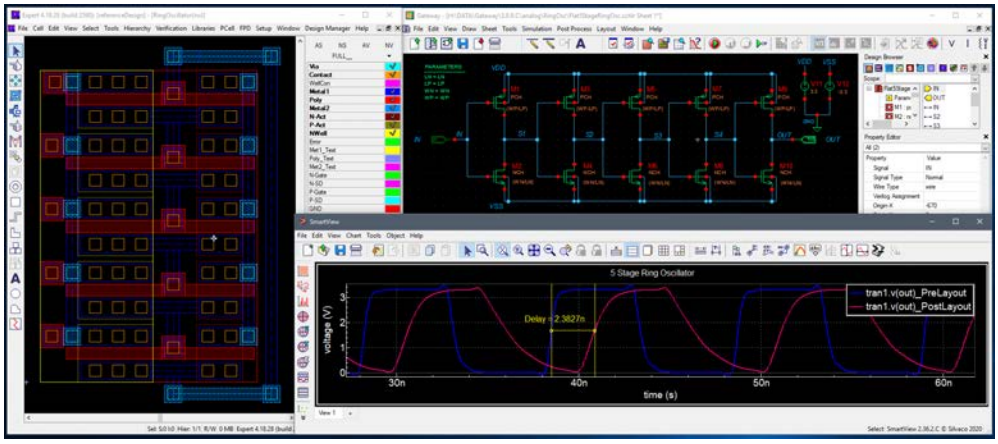
Quantum Dot Device Showing Contact Layers

TCAD

ANALOG CUSTOM IC DESIGN

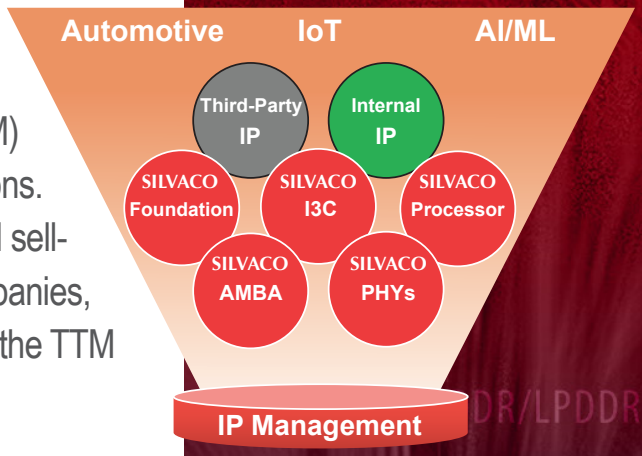
The world around us is an analog one where power, temperature, voltages, and currents are the key parameters for electronic circuits, requiring a broad suite of advanced tools for design and analysis. Silvaco offers comprehensive analog and custom design solutions that bring electrical and physical layout views together along with circuit simulation and physical verification to ensure correct behavior and manufacturability before committing to final silicon.

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 solution leads the industry in enabling 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 display, 5G and memory. Silvaco's solutions have helped create thousands of analog and custom circuit designs in partnership with over 20 of the world's leading semiconductor foundries and used by 15 of the world's leading display companies. Whether the electronic application is in homes, factories, or automobiles, Silvaco design solutions have touched lives throughout the world.



Silvaco Analog Custom IC Design Solution

Moving from analog and custom design to complex SoCs (system-on-chips), design teams need pre-verified, design-proven IPs as building blocks to reduce time to market (TTM) of products for automotive, consumer, and industrial applications. Silvaco is unique in the industry by packaging, supporting, and selling silicon-proven design IP from major semiconductor companies, including Samsung Foundry, NXP, and Infineon, that enhance the TTM for our customers.



Silvaco also provides its own soft IP for digital design that have been used in hundreds of IoT products. Complementing our IP offerings, we provide enterprise-level IP management software for secure tracking of third-party or in-house IP components. With our patented fingerprint technology, design teams can authenticate IPs before they are used in a design, avoiding costly design iterations and silicon re-spins. Silvaco also offers a comprehensive tool suite for creation, optimization and characterization of digital cell libraries, enabling IC design teams to explore the impact of alternative device models, design rules, and cell architectures to improve the performance of their SoCs..

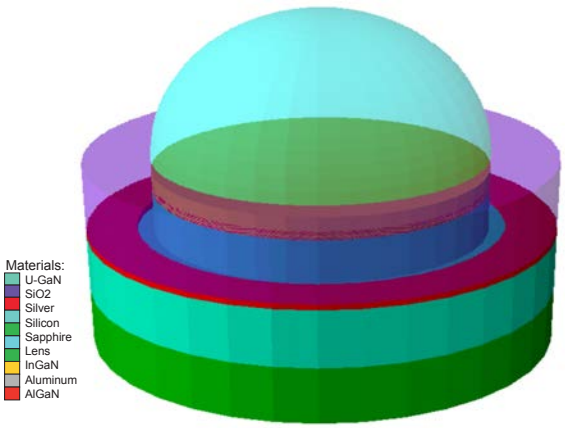
Finally, designing SoCs in advanced process technologies requires analyses of statistical variation in IC manufacturing processes and operating conditions. Analysis of circuit structures across process, voltage, and temperature variations has traditionally consumed astronomical computing resources. Silvaco's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

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. Through a single design environment, engineers can realize optimal and reliable circuits. Our design optimization flow extends Moore's' law by improving circuit performance, reducing power and improving yield. By having the electronics design flow under one umbrella, Silvaco gives the industry the ability to make better ICs at lower cost.

DESIGN IP & LIBRARY OPTIMIZATION

DISPLAY DESIGN LEADER

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



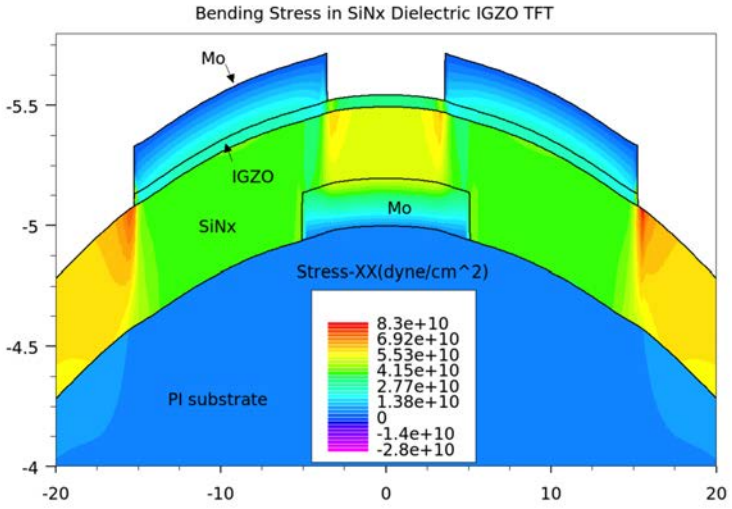
Final MicroLED Structure for Device Simulation

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 and custom design tools are enablers of innovation in the display market. With the significant growth in display sizes beyond 100" and at same time 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 and 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 digital 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 and customs design suites provides display development teams with 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 15 display manufacturers.



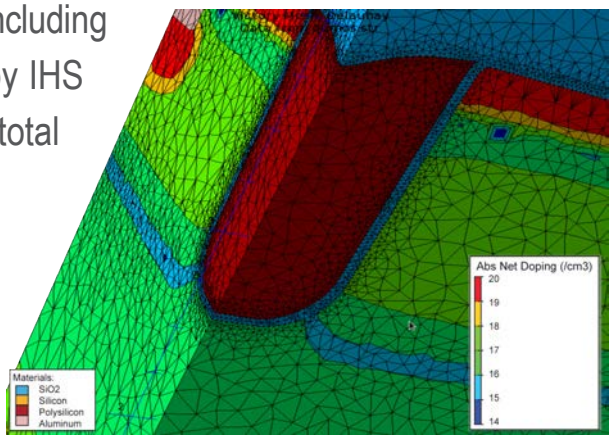
Bending Stress of Oxide TFT Device on Flexible Substrate

POWER SEMICONDUCTOR DEVICES LEADER

The power electronics market is growing rapidly, driven by the accelerating demand of electric vehicles. Power devices are at the heart of modern electric vehicle revolution from charging stations to a vehicle's drive train electronics.

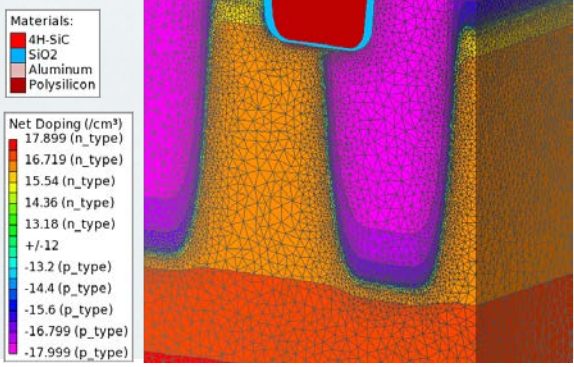
The new requirements of these markets are driving the increased adoption of different kinds of semiconductors such as silicon-carbide (SiC), gallium-nitride (GaN), and other wide bandgap materials to replace traditional silicon in high-voltage power devices. Including both SiC and GaN power devices, a market projection by IHS Markit Inc. shows a CAGR of 33% through 2025 for a total value of $3.7B.

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



Delaunay Mesh to Resolve Complex 3D Geometry Features and Doping Profiles

Doping Profile of a
Silicon-Carbide Power Device



TCAD modeling of power technologies allows engineers to make virtual changes in device operating conditions, device structure (for example, planar versus trench-based), or in device 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.

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 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 and custom design solutions are integrated, they are ideal for power device engineering teams.

Used by foundries and fabless semiconductor companies worldwide for over 25 years, Silvaco is a market leader in software solutions for the development and analysis of power devices.

A BRILLIANT FUTURE

From the electrification of automobiles to the potential of 5G wireless networks, utilization of AI and the 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 we do business, and even the ways 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, that operate at extreme frequencies. Materials such as gallium nitride (GaN) and composite materials such as SiC are needed for the next generation of electronics to make proliferation a success. At the data center, AI technologies require new types of memory technologies such as magneto-resistive random-access memory (MRAM) that perform weighting calculations in the memory chip itself. 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 EDA software to simulate, analyze, and optimize their performance, reliability, and efficiency. Silvaco is well positioned to benefit from these trends with its comprehensive portfolio of products and its strong customer base that are building this future and driving our product development roadmaps.

In order 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.

Semiconductor design challenges span the levels of atoms, devices, and systems. Silvaco is committed to solving these challenges with competitive and affordable 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 moving at a faster pace.

SILVACO

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