SILVACO

Numerical design propels RF and power GaN technology.

The power of physics-based parametric design

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What is this talk about?

- What is GaN predictive design? Why the effort?
- The challenges for added insight.
- Throwing everything into one flow.
- Standards simplify design.

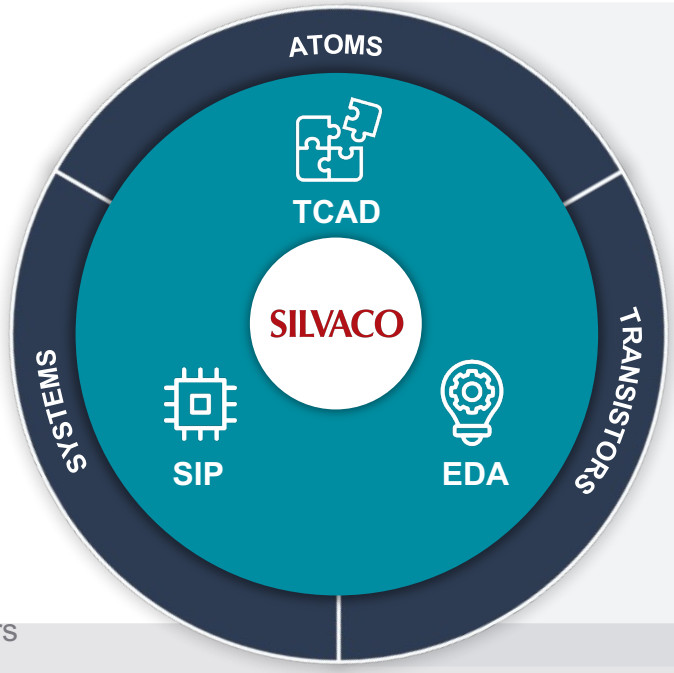
Silvaco – Who are we

Comprehensive platform for semiconductor innovation, from atoms to systems

GaN Valley member

since its origin

- Silvaco is a provider of design automation software:
  - Technology Computer Aided Design (“TCAD”) software
  - Electronic Design Automation (“EDA”) software
  - Semiconductor Intellectual Property (“SIP”)
- Advanced automation tools to design, simulate, analyze, and verify semiconductor devices from concept to product yield
- Silvaco platform adopted for next gen power semis (SiC, GaN)



7 of 10
Largest Semiconductor Companies Use Silvaco’s EDA

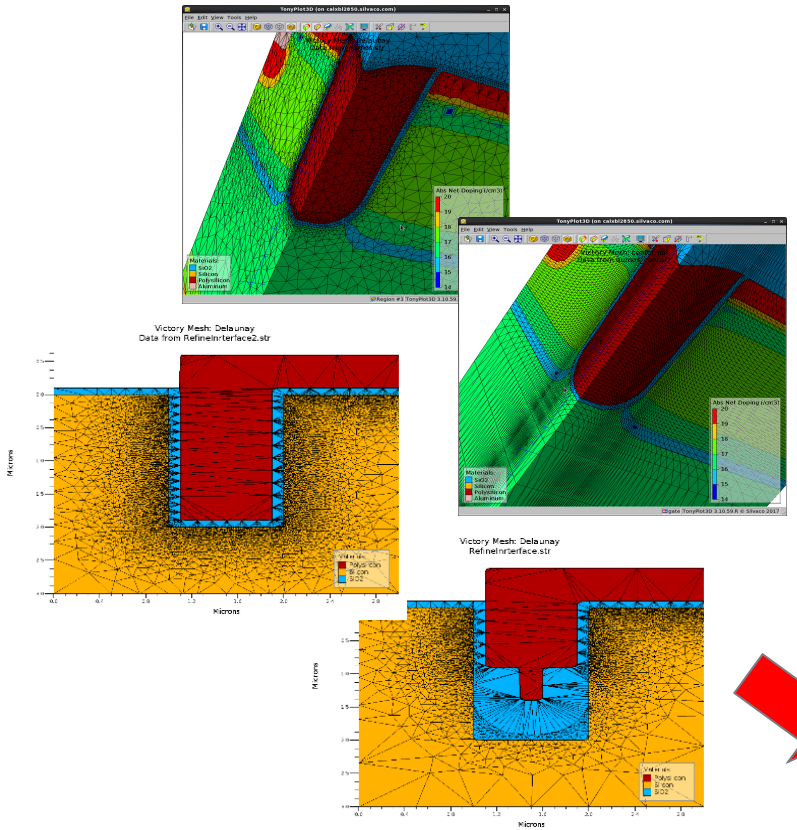
- Founded 1984
- Global presence with R&D in USA/Europe
- Key role in Compact Model Council standardisation effort

800+
Customers

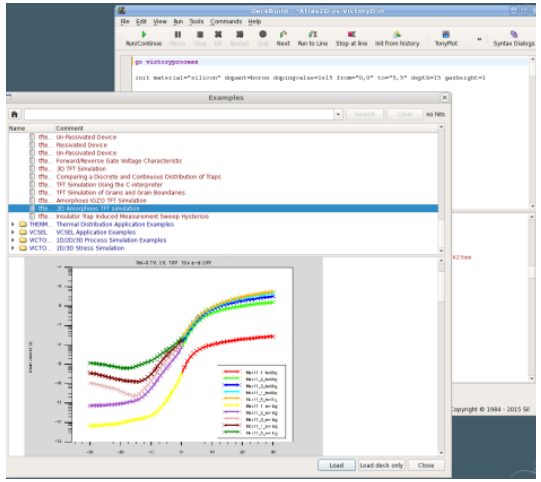
270+
Employees

Strategic presence in power electronic.
Extensive support for GaN technology.
FAB oriented tools powered by ML/AI algorithms

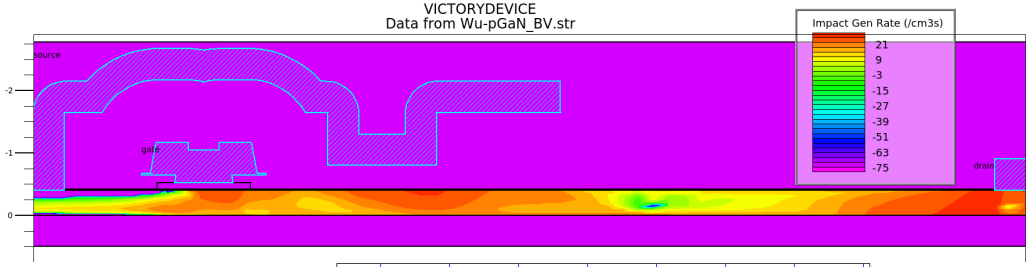
Physics based device modelling

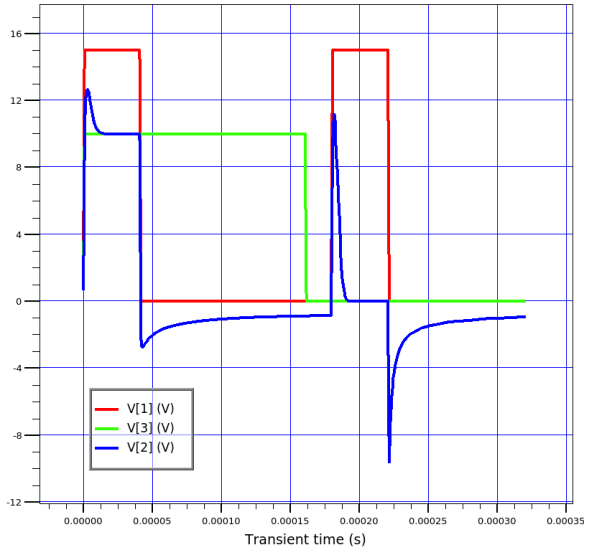


Define structure



Define models





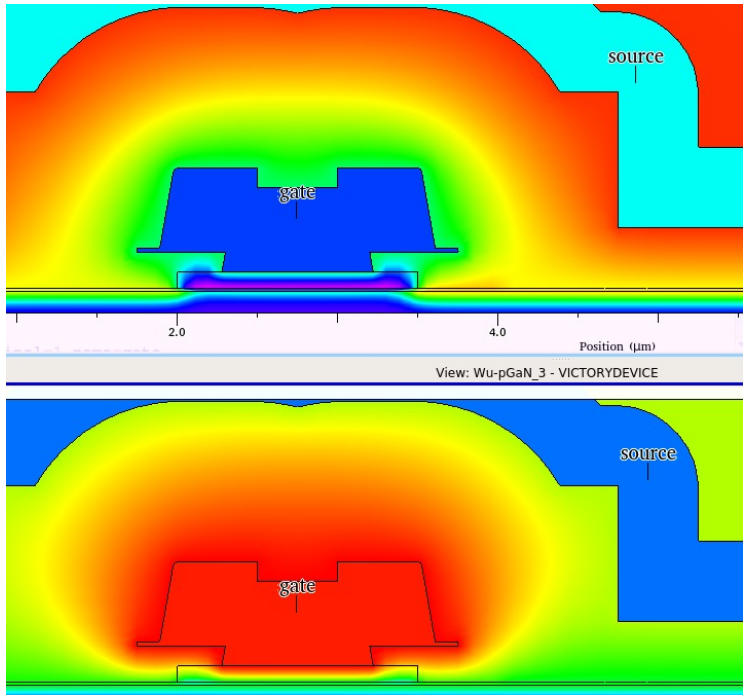
Obtain data

TCAD flow

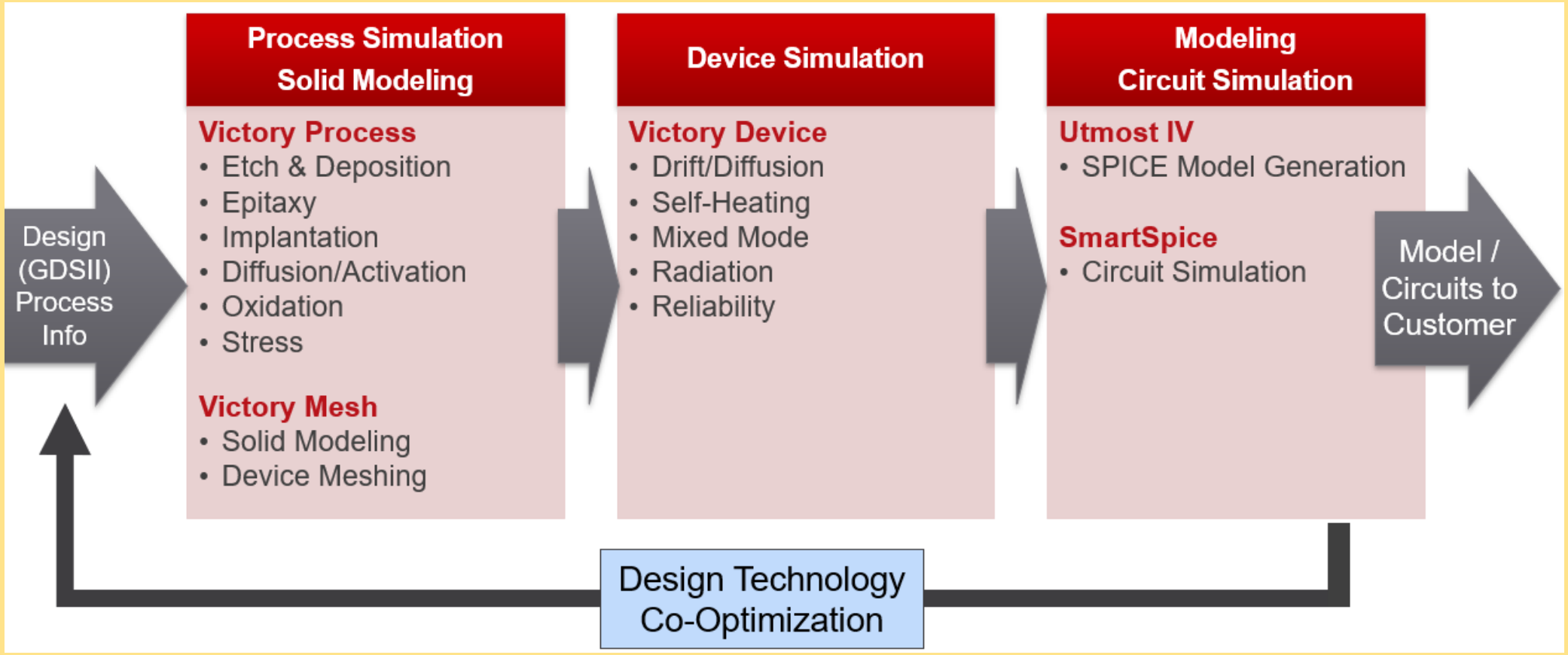
Aiming for predictive modelling

To predict technology performance, we need good understanding of:

- Investigate the intimate effects of device geometry
- Establish dopant profile from process thermal budget
- Calculate crystallographic stress and its influence on polarization
- Electrically active impurity traps. How they influence transient switching.
- Channel length and shield plates impact Bv and RDSon.
- Leakage currents and 2DEG carrier concentration and scattering.



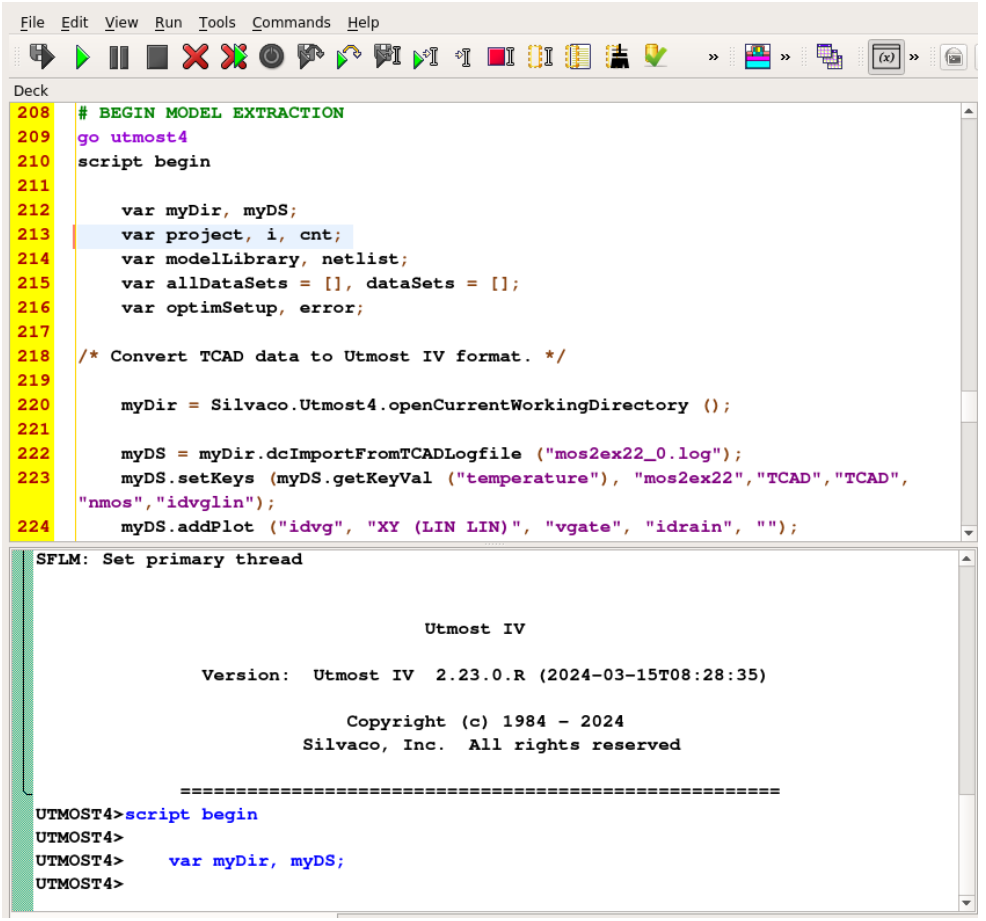
FAB driven design optimisation



FAB oriented design flow ➡ complex DOE matrix + ML driven data analysis

Script Mode: TCAD Flow Integration

- Single script linking all modules.
- Everything runs inside one UI (Deckbuild).
- Integrates
  - measurements,
  - data conversion,
  - simulations,
  - extractions and
  - optimizations.
- Embed inside complex DOE and ML driven parametric model creator.



Standardization – why is it important?

CEA-Leti and Silvaco Look to Develop Innovative SPICE Models

Santa Clara, California

Si2 Approves Two IC Design Simulation Standards for Fast-Growing Gallium Nitride Market

Compact Model Coalition Models Expected to Reduce Costs, Speed Time-to-Market

For Immediate Release

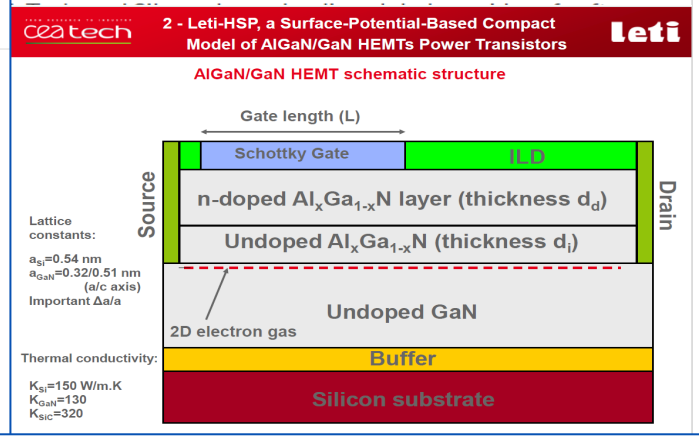
AUSTIN–The Silicon Integration Initiative's (Si2) Compact Model Coalition (CMC) has approved tw
market for gallium nitride semiconductors.

The approved standards are the 12th and 13th models currently funded and supported by the C
(Simulation Program with Integrated Circuit Emphasis) models for IC design.

John Ellis, president and CEO, said gallium nitride devices are used in many high-power and high
broadband wireless systems, and automotive. "Although it's currently a small market, gallium ni

To reduce research and developments costs and increase simulation accuracy, the semiconduct
models. Si2 is a research and development joint venture focused on IC design and tool operabili
incorporated into design tools widely used by the semiconductor industry. The equations at wor
leading universities and national laboratories. The CMC directs and funds the universities to sta

Dr. Ana Villamor, technology and market analyst at Yole Développement (Yole), Lyon, France, sa
We project an explosion of this market with 79% CAGR between 2017 and 2022. Market value w



Left to Right Iliya Pesic, Silvaco Chairman, Emmanuel Sabonnadière, CEA-Leti CEO sign collaboration agreement to develop innovative SPICE models

Silicon Integration Initiative Targets New Silicon Carbide Standard SPICE Model

April 27, 2021 / in Compact Model, Frontpage / by Terry Berke

The Si2 Compact Model Coalition has voted to fund and standardize a SPICE model for silicon carbide-based metal-on-silicon field-effect transistors. Featuring high efficiency and fast operation with low switching losses, silicon carbide-based metal-on-silicon-field effect transistors are popular in high-growth semiconductor applications such as photovoltaic inverters and converters, industrial motor drives, electric vehicle powertrain and EV charging, and power supply and distribution.

Peter Lee

A CMC working group will oversee the model development as part of advancing Si2's mission to reduce interoperability costs, said Peter Lee, CMC chair. Participating companies include Analog Devices, Cadence Design Systems, Infineon, Qualcomm, Siemens EDA, Silvaco and Synopsys. The decision to launch the working group came after the CMC evaluated the model's ROI for members and interest by the industry at large. "I'd encourage companies with a stake in SiC devices to join this effort and help guide selection of the model which best represents their intended use," advised Lee. "They can benefit from both cost reduction that comes from shared model support and a standardized and qualified model that has ongoing bug fixes and requested feature enhancements from many like-minded companies."

Colin Shaw

"Next Generation SiC MOSFETS has many features that make them suitable, and even superior to legacy silicon solutions, for several high voltage applications. While the devices can handle high-temperature and voltage, its minimal ON-resistance allows smaller packages and better energy savings than comparable silicon devices," stated Colin Shaw from Silvaco, the working group chair.

GaN FET: 2 CMC Standard Models

- GaN FET models in SmartSpice:
  - ASM (CMC Standard, SmartSpice Level 90)
  - MVSG (CMC Standard, SmartSpice Level 91)
  - LETI-HSP (SmartSpice Level 278)
- Model extraction initially based on Verilog-A, currently using SmartSpice built-in models
- Utmost IV GaN FET Examples:
  - MVSG: https://silvaco.com/examples/utmost4/section1/example18/index.html
  - ASM: https://silvaco.com/examples/utmost4/section1/example23/index.html
- Utmost IV GaN FET Model Extraction Webinars:
  - https://silvaco.com/webinar/tcad-based-model-extraction-flow-for-gan-hemt-devices-part-1-2/
  - https://silvaco.com/webinar/tcad-based-model-extraction-flow-for-gan-hemt-devices-part-2-2/

Template Categories	Quick-Start Templates
MOSFET	BSIM3v3, BSIM4, BSIM-BULK, HiSIM2, HiSIM_HV2, PSP
GaN HEMT	ASM, MVSG
TFT	RPI poly-Si TFT, RPI amorphous Si TFT
BJT	Gummel-Poon, VBIC, Mextram
IGBT	HiSIM_IGBT
Diode	Diode Level 1

Available Quick-Start Templates

- Models with currently available Utmost IV Quick-Start templates

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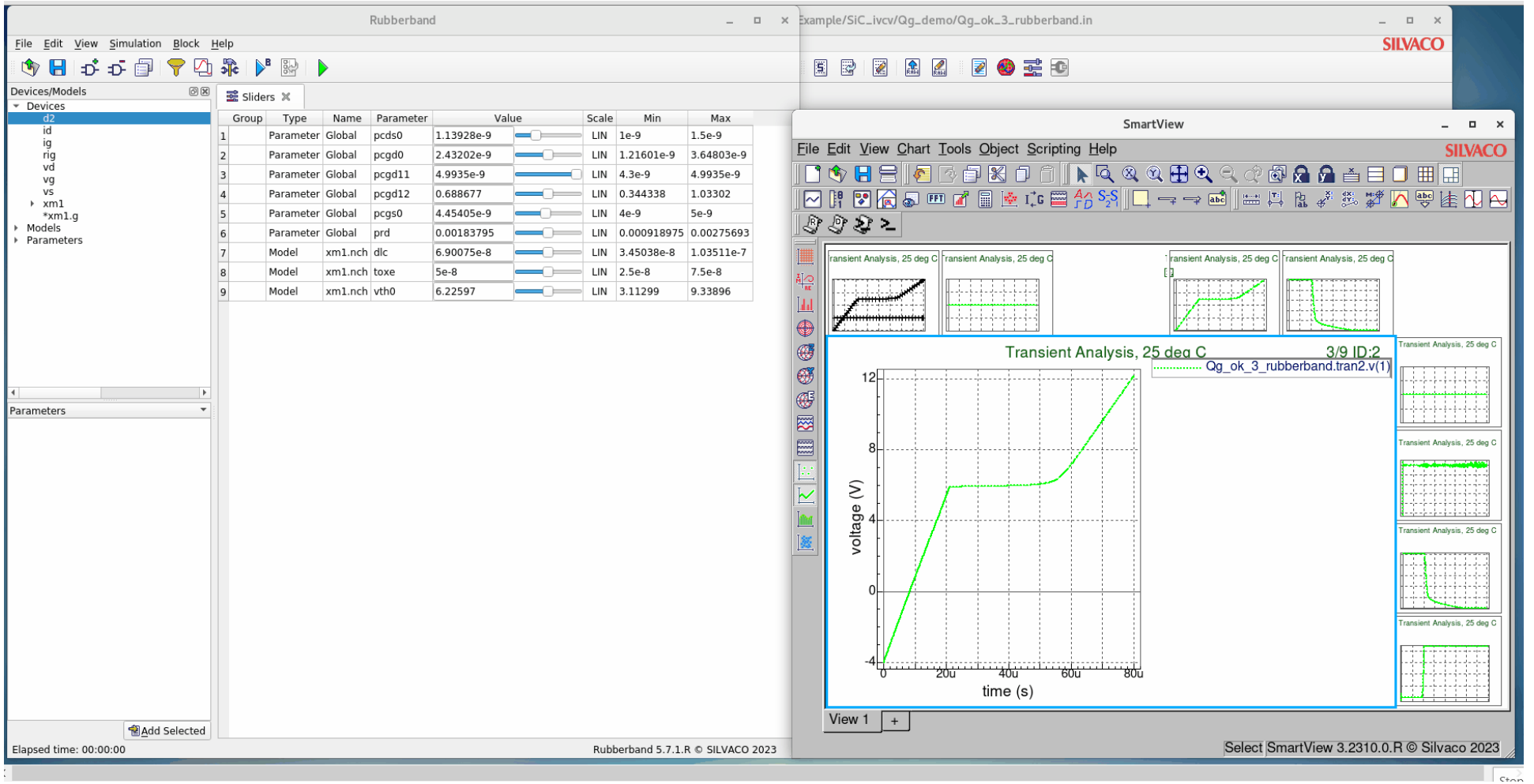
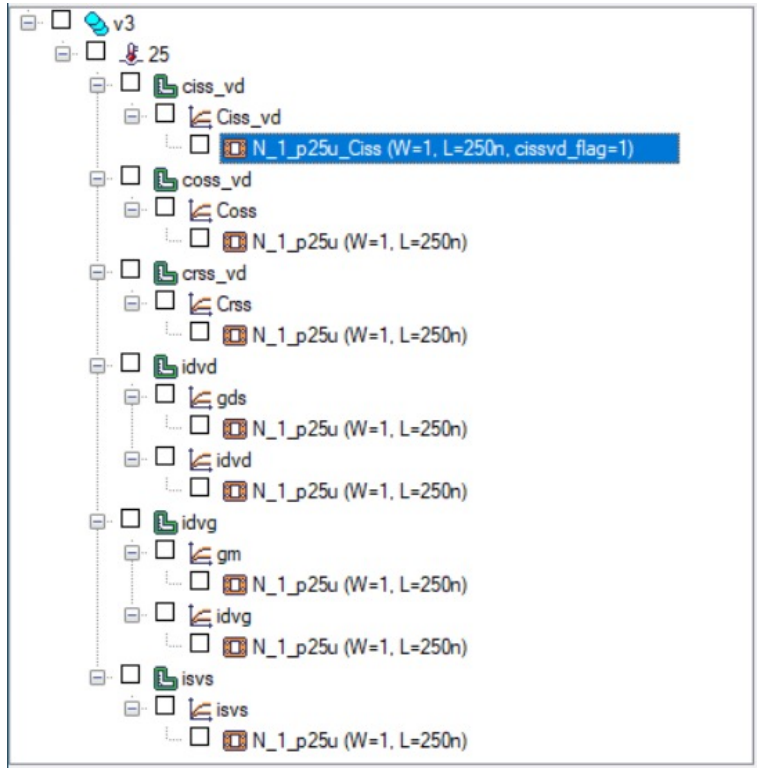
Dynamic Characterization

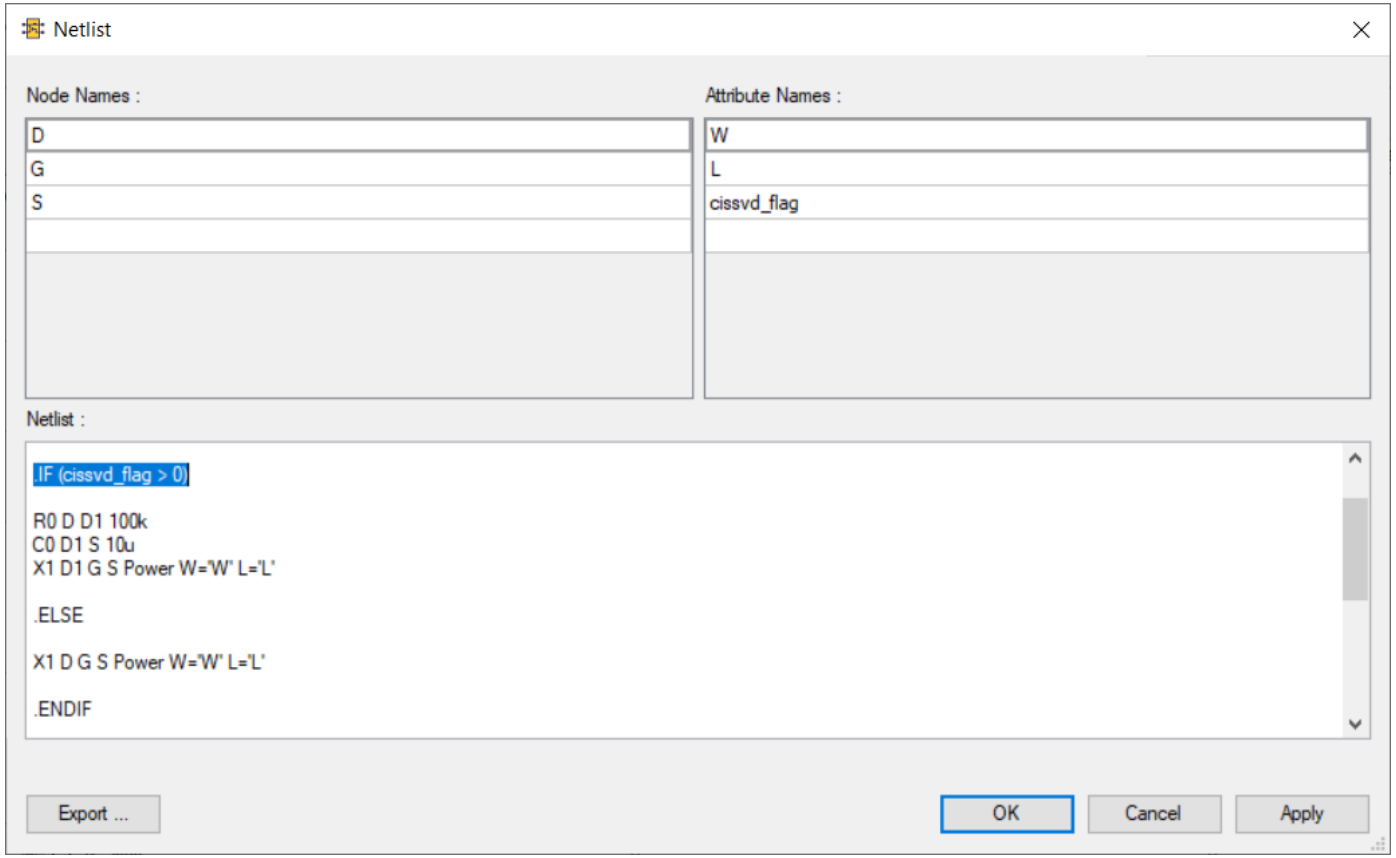
- Using SmartSpice Rubberband to tune Qg



Single Utmost IV Netlist Supporting All Data

- Use attributes to help distinguish the netlist
  - Example: Ciss data set includes a “cissvd_flag” attribute set to 1
- In the Utmost IV netlist use .IF/.ELSE/.ENDIF based on the attribute value





Conclusions

- Constant technology development to respond to market rising expectations.
- Need comprehensive understanding of device physics.
- TCAD produces hard to measure data.
- Physics based compact models contain meaningful technology related parameters.
- Can never have enough automation in design.
- FAB need advanced Design of Experiment and ML driven data analysis tools.


Thank you
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