SYSTEMS PRODUCTS
LOGICAL PRODUCTS
PHYSICAL IMPLEMENTATION
SIMULATION AND ANALYSIS
LIBRARIES
TCAD

- Aurora
- DFM WorkBench
- **Davinci**
- Medici
- Raphael
- Raphael-NES
- Silicon Early Access
- TSUPREM-4
- Taurus-Device
- Taurus-Lithography
- Taurus-OPC
- Taurus-Process
- Taurus-Topography
- Taurus-Visual
- Taurus-WorkBench

Davinci

Semiconductor Device Simulaion in 3D

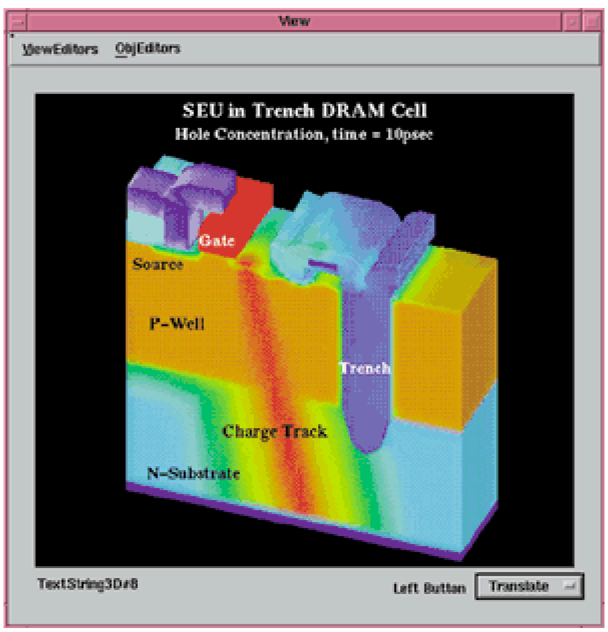
Davinci predicts the electrical characteristics of arbitrary three-dimensional structures under user-specified operating conditions. It is applicable to a broad variety of technologies, ranging fr deep submicron devices to large power structures. Typical device applications include diodes, BJTs, MOSFETs, JFETs and MESFETs.

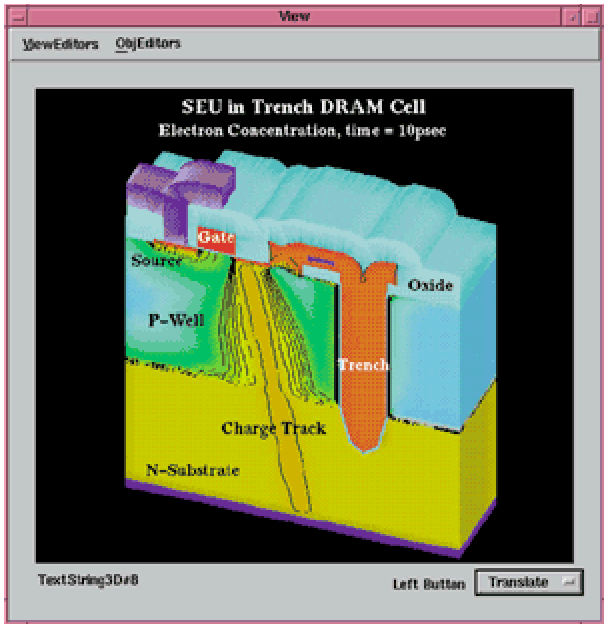
DAVINCI HELPS YOU:

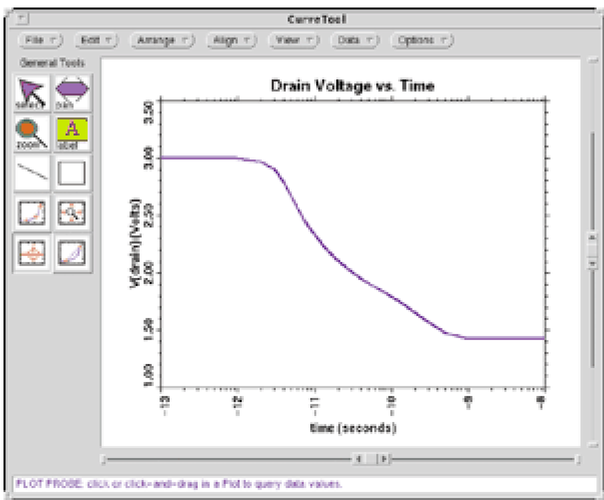
- Determine I-V characteristics, gain and speed of transistors and diodes.
- Understand internal device operation through potential, field, carrier, carrier temperature ionization rate and current density distributions.
- Analyze and understand breakdown mechanisms.
  Refine device designs to achieve optimal performance.
- Investigate failure mechanisms, such as leakage paths and hot electron effects.
- Study transient radiation effects, such as single event and dose rate upset.
- Predict the latchup susceptibility of CMOS structures.
- Design and analyze Charge Coupled Devices (CCDs).

SEU MODELING OF DRAM CELL

Davinci allows engineers to analyze and understand complex device phenomena, enabling the design and optimize innovative devices. It also accounts for 3D geometrical features.





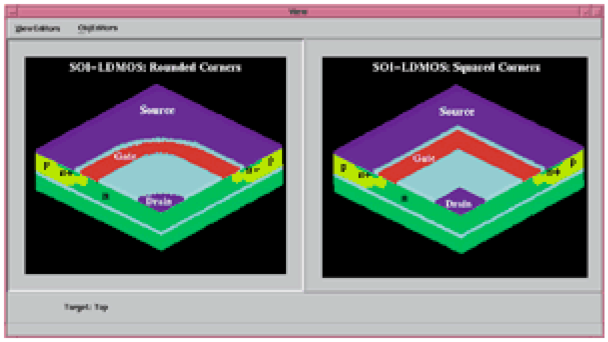


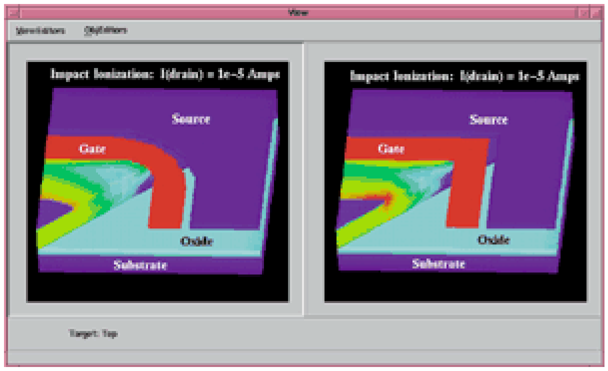
LDMOS-SOI STRUCTURE

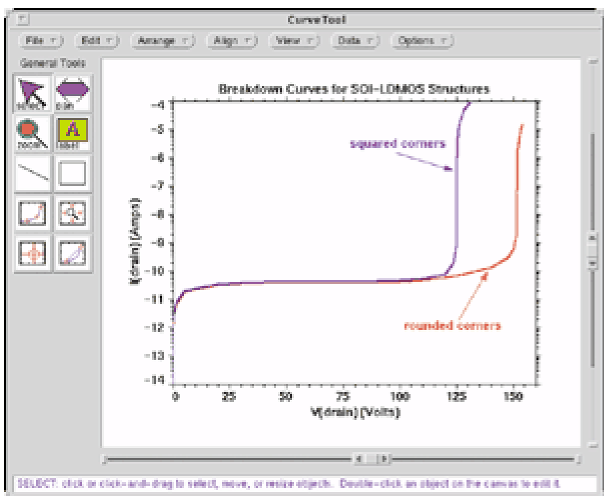
Davinci's versatility is demonstrated by analyzing the behavior of a lateral doubly diffused MOS (LDMOS) structure built on an insulating region. In this example, the breakdown characteristics structure with rounded electrodes and profiles is compared with that of a structure with squared electrode and profiles.

Davinci's continuation method was used to automatically sweep out the current vs. voltage curv through breakdown, as shown above. It can be seen that the structure with the rounded corners exhibits a higher breakdown voltage.

The bottom figure examines impact ionization generation at the onset of breakdown. Portions o structures have been removed to expose the internal device behavior. Breakdown is initiated ne the surface in the drain regions of the devices. The structure with the squared drain exhibits a higher impact ionization generation rate in the drain corner where the electric field is maximum, resulting in a lower breakdown voltage.



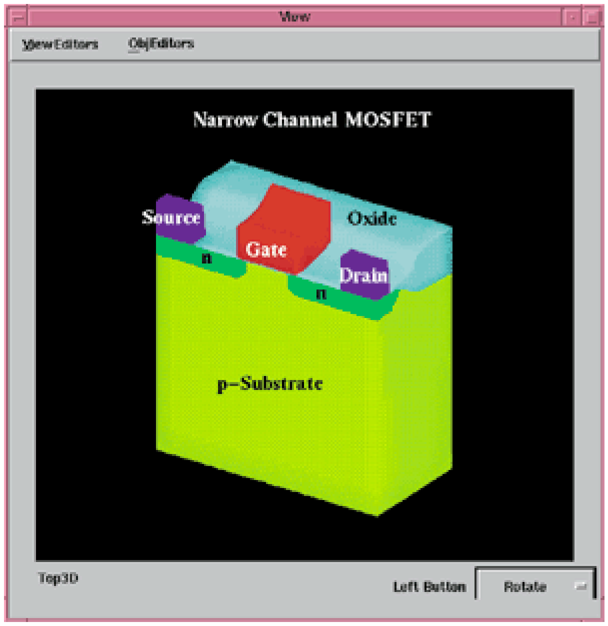


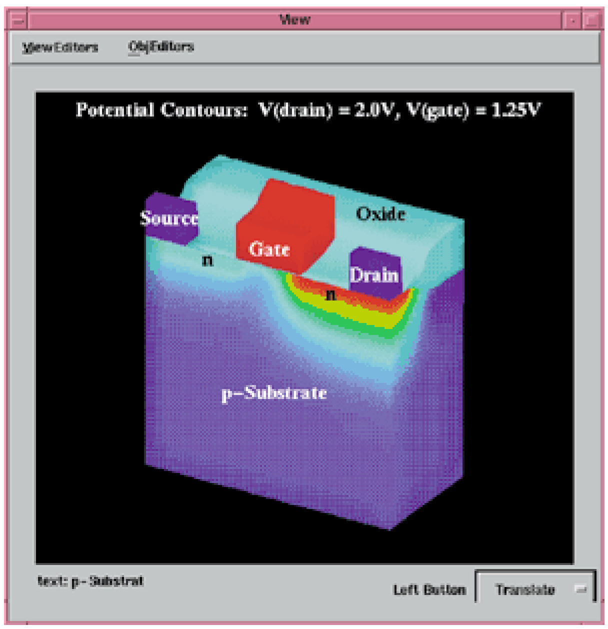


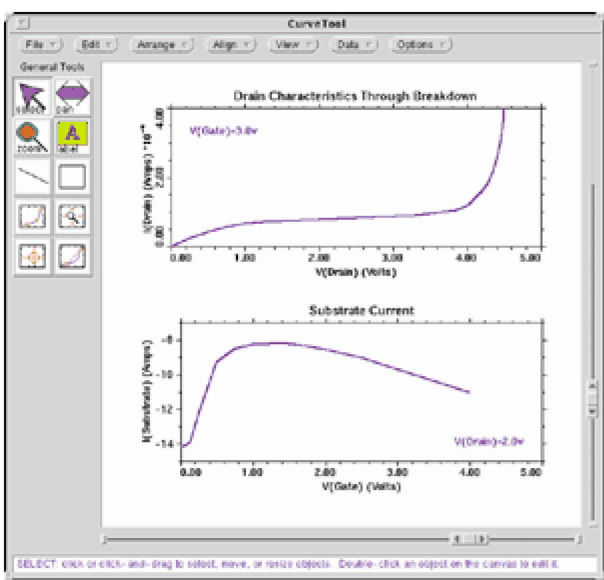
NARROW-CHANNEL MOSFET

Davinci provides accurate simulation of deep submicron devices via self-consistent solutions o carrier energy balance equations with Poisson's equation and the current-continuity equations. capability is illustrated for a narrow-channel MOSFET. TSUPREM-4 was used to simulate a cross-section that includes the channel width. The doping, regions and electrodes were then extruded to form the source and drain diffused regions, source and drain contacts, and polysilic gate. The complete structure is shown in the left figure.

Potential contours at the bias corresponding to maximum substrate current are shown in the mi figure. Drain and substrate characteristics, including the effects of electron temperature variatic are shown in the gure on the right.


View
ViewEditors
ObjEditors
Narrow Channel MOSFET
Source
Gate
Oxide
Drain
n
n
p−Substrate
Top3D
Left Button
Rotate


View
ViewEditors
ObjEditors
Potential Contours: V(drain) = 2.0V, V(gate) = 1.25V
Source
Gate
Oxide
Drain
n
n
p−Substrate
text: p-Substrat
Left Button
Translate


CurveTool
File
Edit
Arrange
Align
View
Data
Options
General Tools
Drain Characteristics Through Breakdown
V(Drain) (Volts)
Substrate Current
V(Gate) (Volts)

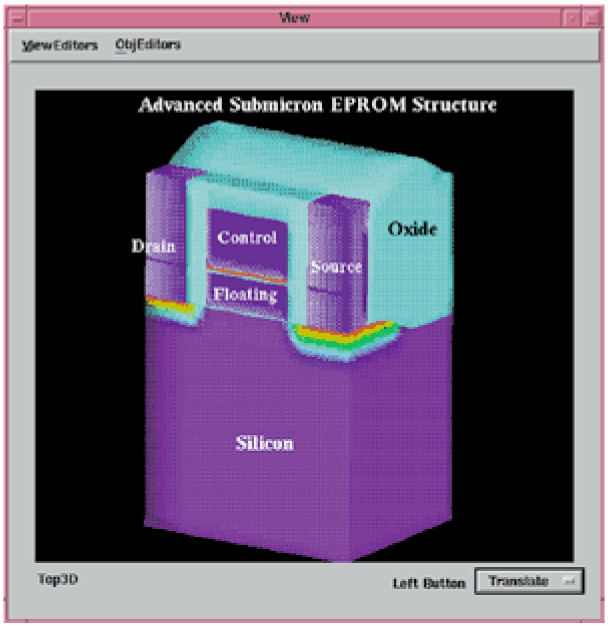
EEPROM SIMULATION
In this example, Davinci is used to simulate the programming characteristics of an EEPROM structure.

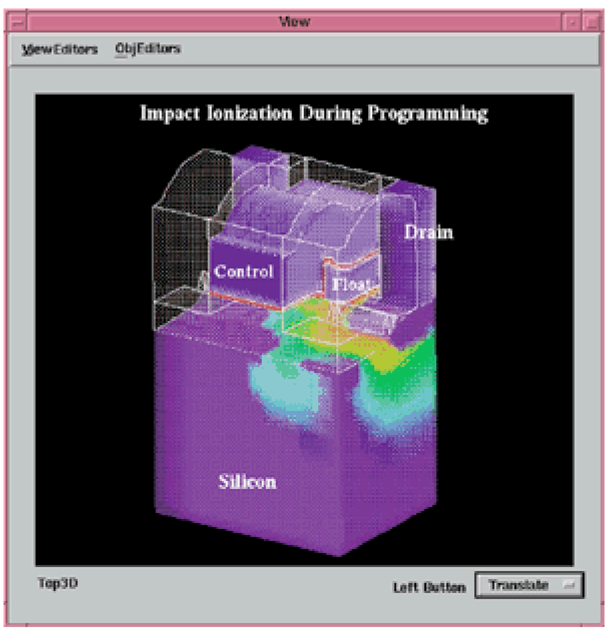
3D simulation is required for this example because the floating gate overlap of the field oxide makes an important contribution to the cell capacitance.

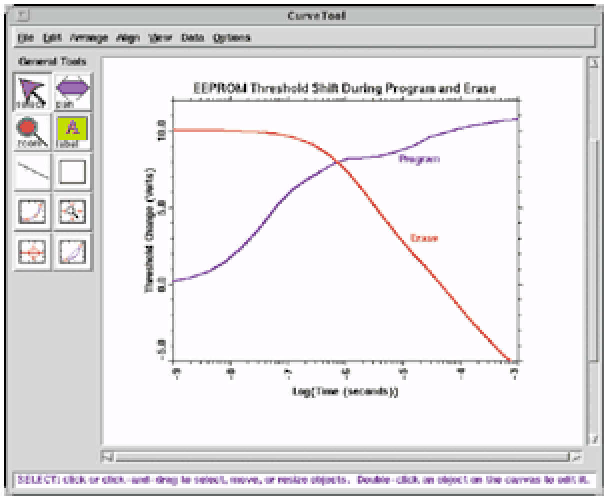
To create the simulation structure, a 2D cross-section simulated with TSUPREM-4 is passed in Davinci and is extruded in the third dimension, as shown in the left figure. The center figure shc impact ionization which occurs during programming. The internal electrode structure can also b seen.

Programming and erase are then simulated to calculate the threshold voltage as a function of ti (right figure). The programming mechanism is hot electron injection at the drain. Erase is via Fowler-Nordheim tunneling.

This example demonstrates use of Davinci with the Programmable Device AAM.







DAVINCI SPECIFICATIONS

SIMULATION FEATURES

- Self consistently solves Poisson's equation, the electron and hole current-continuity equations, the electron and hole energy balance equations and the lattice heat equation.
- Steady state, transient and AC-small signal analysis.
- Current-continuity solutions in insulators.
- Arbitrary doping from analytic functions, tables and process simulation.
- Voltage, current or charge boundary conditions for electrodes.
- Lumped elements (R, L, C), contact resistance, Schottky contacts.
- Supports multiple materials such as Si, Ge, GaAs, SiGe, AlGaAs and SiC, as well as arbitrary user-defined materials.
- Automatic I-V curve tracing and time-step algorithms.
- Robust solution methods and algorithms.
- Extraction of device parameters such as threshold voltage (Vt), subthreshold slope, saturation current (Idsat), bipolar current gain (§), cutoff frequency (fT) and sheet resista as well as arbitrary user-defined quantities.
- Optimization for tuning device performance and model calibration.

PHYSICAL MODELS

- Shockley-Read-Hall and Auger recombination.
- Recombination including tunneling.
- Mobility dependencies on impurity concentration, lattice temperature, carrier concentratio carrier energy, parallel and perpendicular electric fields.
- Band gap narrowing.
- Band-to-band tunneling.
- Band-to-band recombination.
- Fixed oxide charge and fast interface states.
- Gate current based on temperature.
- Field-, carrier energy- and lattice temperature-dependent impact ionization.
- Energy balance models for both elemental and compound materials.
- Photogeneration of carriers and single event upset (SEU).
- Fermi-Dirac and Boltzmann statistics.
- Gate current models: ÒLucky electron-model and angle-dependent model.
- Non-Maxwellian generation function, appropriate for modeling gate current.

INPUT/OUTPUT

- Accepts input structures directly from TSUPREM-4 process simulation.
- Supported within Taurus-WorkBench.
  3D visualization via Davinci standard graphics and Taurus-Visual.
- Menu-driven interface with context-sensitive help.

ADVANCED APPLICATION MODULES
Advanced Application Modules (AAMs) have been developed for Davinci to address specialized technology needs. AAMs optionally available for Davinci include:

- Circuit Analysis AAM.
- Lattice Temperature AAM.
- Programmable Device AAM.
- Heterojunction Device AAM.
- Anisotropic Materials AAM.
- Trapped Charge AAM.
- Optical Device AAM.

SYSTEM REQUIREMENTS

- Platforms: UNIX workstations from DEC.
- Hewlett-Packard, IBM and Sun Microsystems.
- Memory: 185 Mbytes (30,000-node version of Davinci).
- Disk space: 19 Mbytes.
