Medici

Semiconductor Simulation in 2D

Medici predicts the electrical characteristics of arbitrary two-dimensional structures under user specified operating conditions. It is applicable to a broad variety of technologies, ranging from d submicron devices to large power structures. Typical device applications include diodes, BJTs, MOSFETs, JFETs, MESFETs, HBTs, HEMTs, IGBTs, CCDs and GTOs.

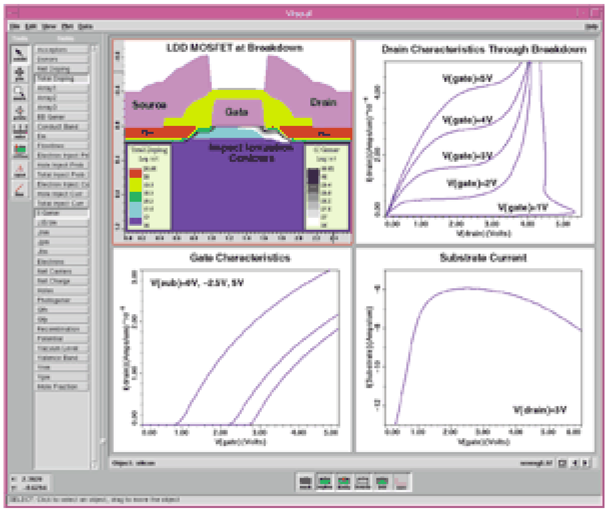
MEDICI HELPS YOU:

- 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.

LDD MOSFET

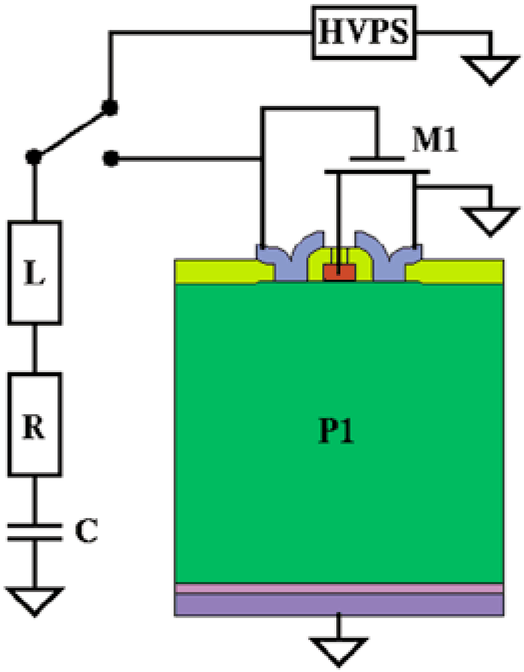
Medici's advanced simulation capabilities make it extremely useful for completely analyzing the behavior of MOSFET-based devices. In the example shown here, the electrical behavior of an l MOSFET, whose structure was created by the TSUPREM-4 program, is illustrated. The two-dimensional structure plot (below) shows the device as created by TSUPREM-4. In additio the doping contours, contours of impact ionization at breakdown, as simulated by Medici, are illustrated.

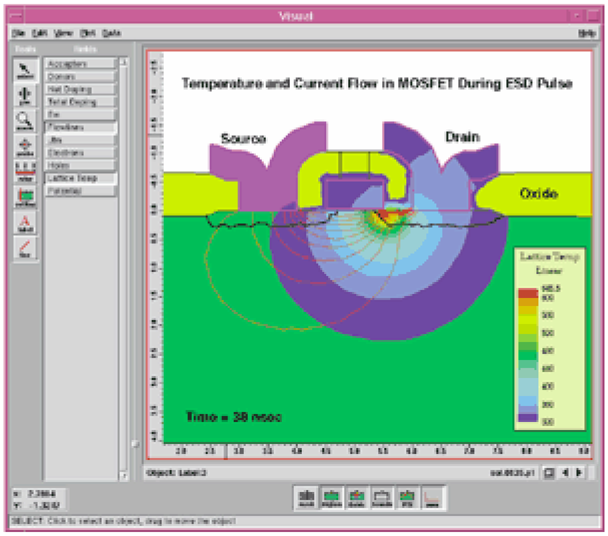
Medici's continuation method allows complex I-V curves to be simulated automatically. Breakd snapback curves appear in the top right portion of the figure. The gate characteristics for the LI structure appear in the lower left of the figure. To accurately predict substrate currents, Medici u a sophisticated energy balance calculation, the results of which are shown in the lower right po of the figure.



ELECTROSTATIC DISCHARGE

Medici can be used to simulate ESD in a variety of technologies. In this example, an advanced two-MOSFET protection circuit] is simulated with the human body model (HBM) and is diagram in the left figure. The capacitor is initially charged to 2000V and discharged into the protection circuit. The middle figure shows contours of temperature and current flow within the protection MOSFET. The right figure shows the peak temperature, the capacitor voltage, the total current, the voltage at the IC input during the event.





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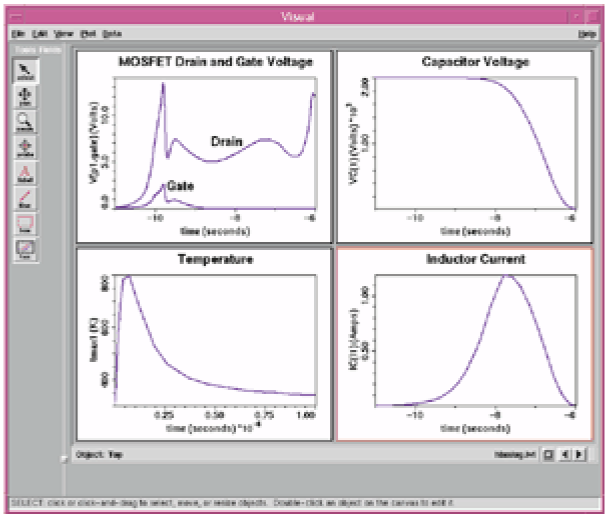
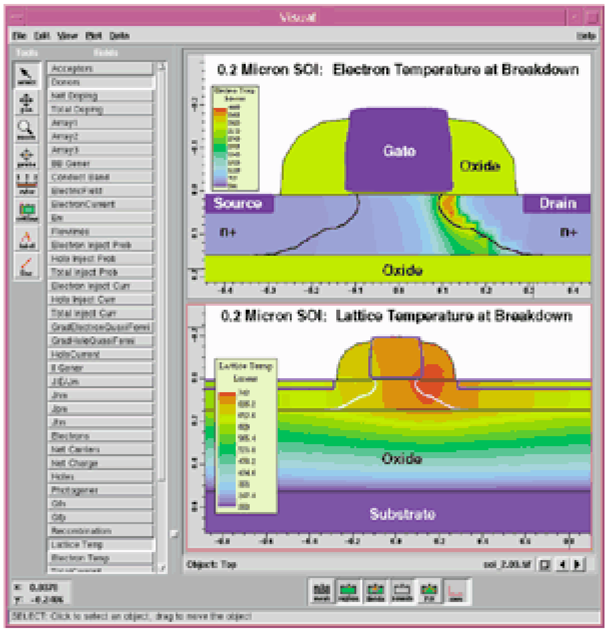
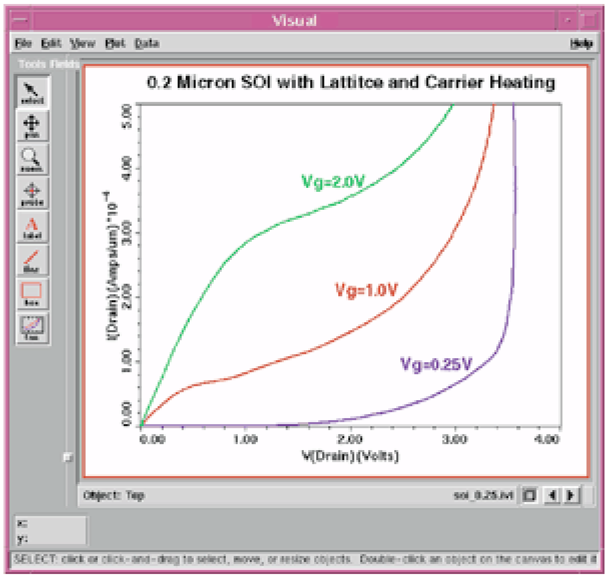


SELECT: click or click-and-drag to select, move, or resize objects. Double-click an object on the canvas to edit it.

SILICON ON INSULATOR

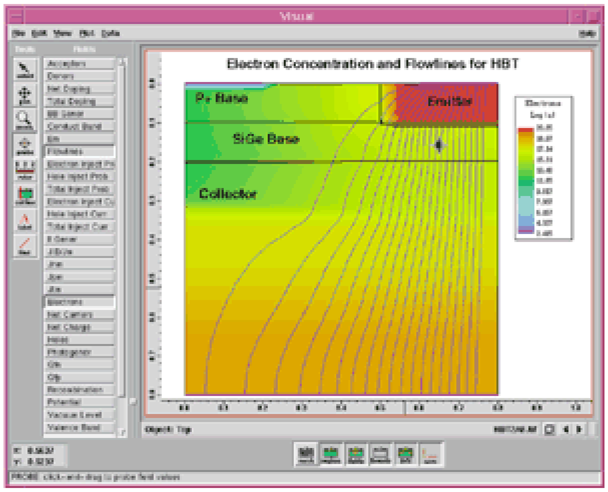
Short-channel SOI devices such as the 0.2 micron SOI MOSFET shown in the figure on the lef require carrier heating and lattice heating effects to be accounted for. Medici can model the ene exchange between the field and the carriers and also between the carriers and the lattice. The plot in the left figure shows the electron temperature near breakdown. The bottom figure displa the lattice heating distribution. The heat conductivity in the oxide is much lower than in silicon, a therefore the heat propagates differently in the two materials. The IV curves in the right figure feature the kink effect at low gate biases and incipient breakdown around Vd=3.5V.

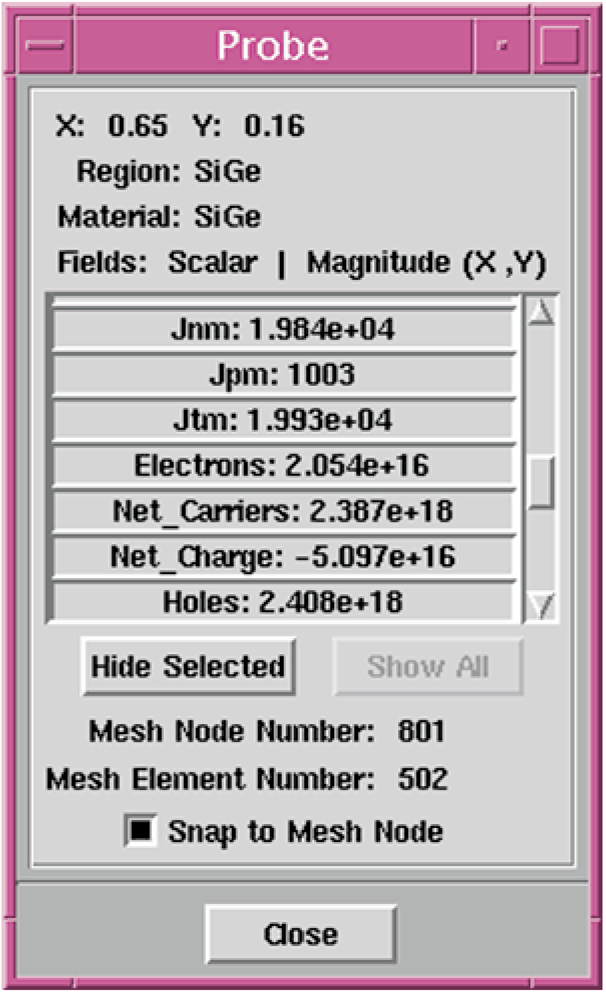




HETEROJUNCTION BIPOLAR TRANSISTOR

For analog and mixed-signal applications, different tradeoffs are involved in the design of SiGe HBTs. Medici simulations have been performed on two SiGe HBTs with similar total Ge conten of different shapes: triangular and rectangular. The top figure shows electron concentration and line contours at Vbe=0.8V and Vce=2.0V for a triangular shape. Comparison of the device characteristics (bottom figure) shows the device with triangular Ge distribution has higher beta early voltage.





X: 0.65 Y: 0.16

Region: SiGe

Material: SiGe

Fields: Scalar | Magnitude (X ,Y)

Jnm: 1.984e+04

Jpm: 1003

Jtm: 1.993e+04

Electrons: 2.054e+16

Net_Carriers: 2.387e+18

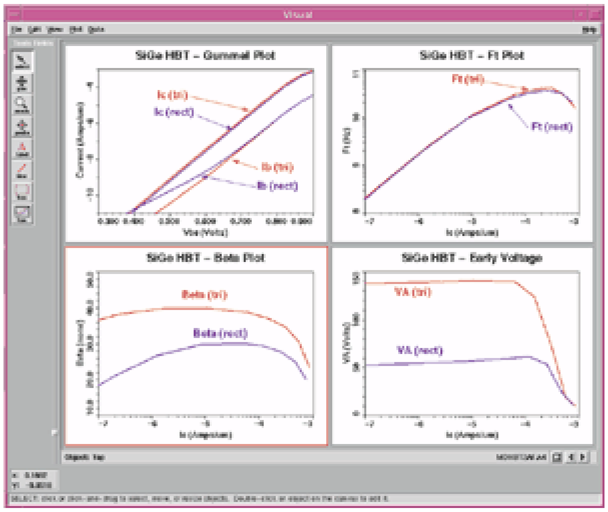
Net_Charge: -5.097e+16

Holes: 2.408e+18

Mesh Node Number: 801

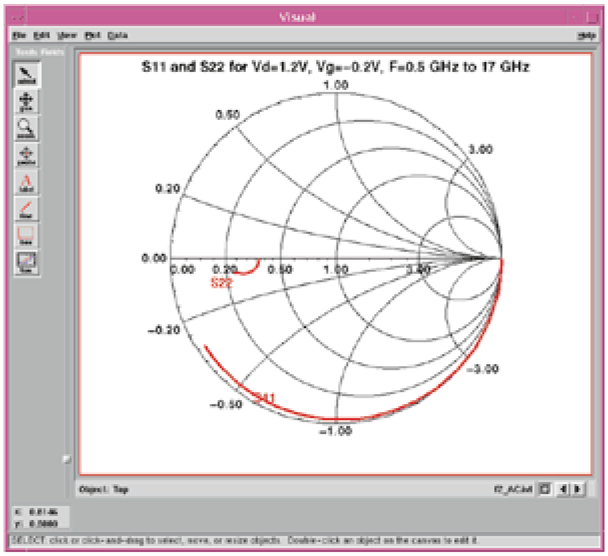
Mesh Element Number: 502

☒ Snap to Mesh Node



GALLIUM ARSENIDE

Medici features capabilities for the simulation of compound semiconductor devices, including a
advanced energy balance model, energy-dependent mobility models which account for the velo
overshoot effect, and energy-dependent relaxation time constants. The middle figure shows the
characteristic increase in electron concentration and channel width at the drain side of a recess
gate MESFET. A comparison between results from drift-diffusion and energy balance is shown
the right figure to point out the importance of non-local effects in this type of device. Small signa
analysis provides reflection and transmission S-parameters plotted in the left figure.



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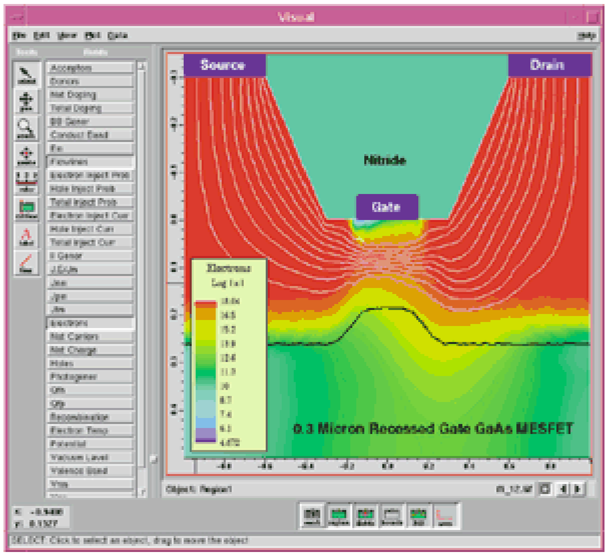
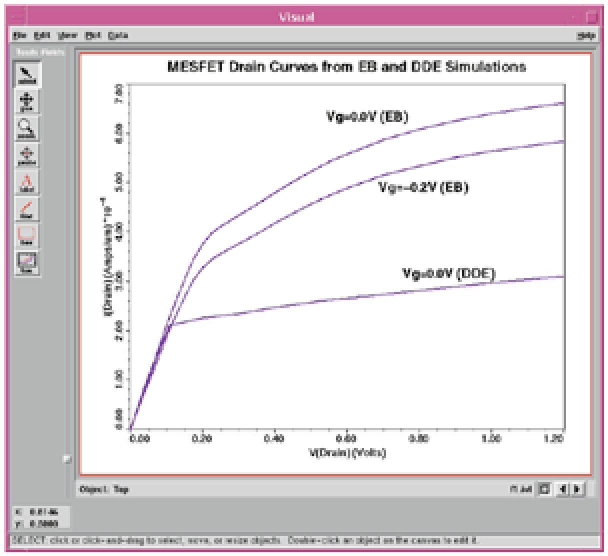
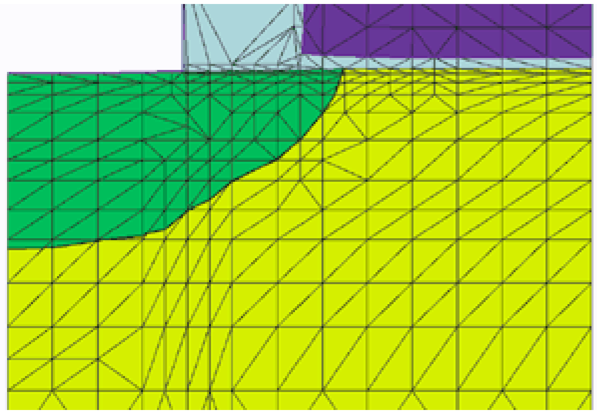
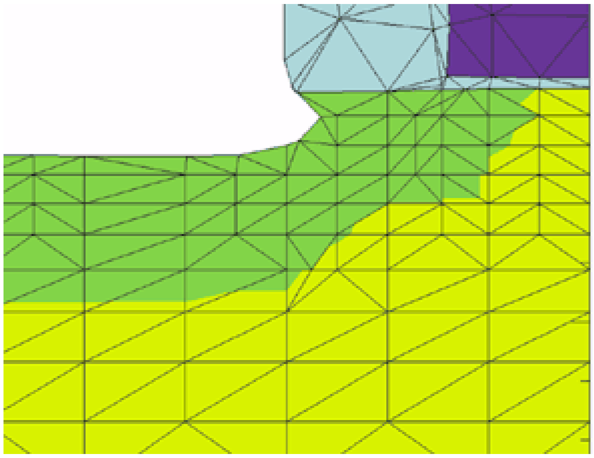


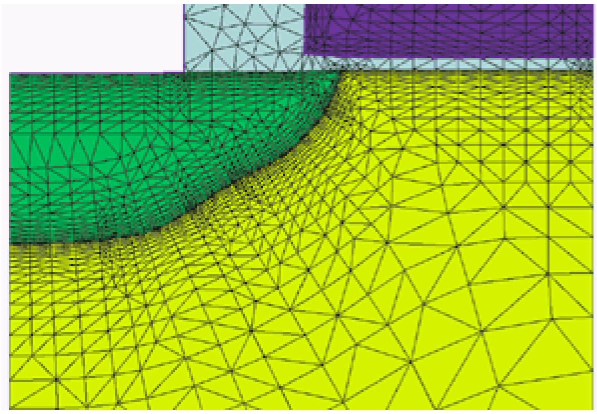


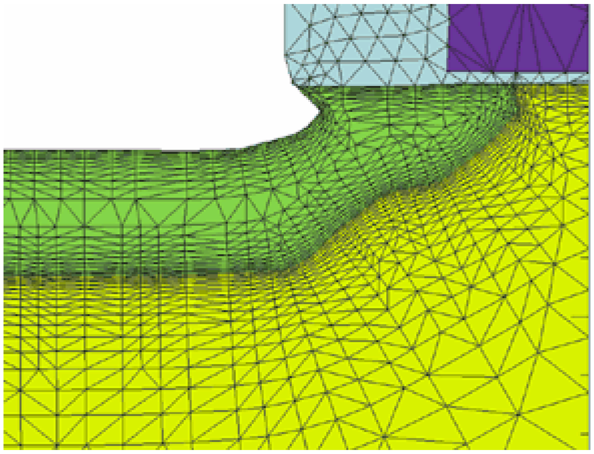
ADVANCED MESH GENERATION

Medici features an advanced automatic boundary conforming (ABC) meshing capability that generates meshes ideal for device simulation. This capability will utilize the topography obtaine from process simulation results and will create a mesh that conforms to interfaces between reg and to metallurgical junctions. This allows complex device structures to be meshed easily and efficiently for accurate and fast device simulation results.









MEDICI 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, process simulation.
- Rectangular or cylindrical coordinates.
- 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.
- Periodic boundary conditions.

- 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.
- Photogeneration of carriers and single event upset (SEU).
- field-, carrier energy- and lattice temperature-dependent impact ionization.
- Energy balance models for both elemental and compound materials.
- Fermi-Dirac and Boltzmann statistics.
- Gate current models: Lucky electron model and angle dependent model.
- Non-Maxwellian generation function. More appropriate for modeling gate current.
- Gate current based on carrier temperature.

INPUT/OUTPUT

- Supported with Taurus-WorkBench, Avant!'s environment for physical simulation.
- Visualization via Taurus-Visual or Medici standard graphics.
- TIF standard interface for interprogram communication.
- Menu-driven interface with context-sensitive help.

ADVANCED APPLICATION MODULES

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

SYSTEM CONfiGURATION REQUIREMENTS

- Platform: Medici operates on UNIX workstations from Hewlett-Packard, IBM and Sun Microsystems.
- Memory: 104 Mbytes for a 10,000-node version of Medici.
- Disk Space: 17 Mbytes for executable.
