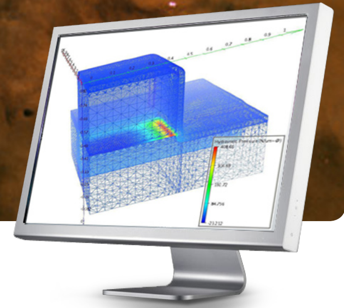
VICTORY
Process



3D PROCESS SIMULATOR

VICTORY Process is a general purpose 3D process simulator. VICTORY Process includes a complete process flow core simulator and three advanced simulation modules: Monte Carlo Implant, Advanced Diffusion and Oxidation, and Physical Etch and Deposit. Proprietary models, as well as public domain research models, can be easily integrated into VICTORY Process using the open modeling interface.

- **Sophisticated multi-particle flux models for physical deposition and etching with substrate material redeposition**
- **Extremely accurate and fast Monte Carlo implant simulation**
- **Comprehensive set of 3D diffusion models: Fermi, three-stream, and five-stream**
- **3D physical oxidation simulation with stress analysis**
- **Fast 3D structure prototyping capability enables the in-depth physical analysis of specific processing issues**
- **Accurately predicts 3D topology and 3D dopant distribution**
- **Automatic meshing and Adaptive Mesh Refinement**
- **Efficient multi-threading of time critical operations of Monte Carlo implantation, diffusion, oxidation, and physical etching and deposition**
- **Open architecture allows easy introduction and modification of customer specific physical models**
- **Seamless link to 3D device simulators including structure mirroring, adaptive doping refinement and electrode specification**
- **Silvaco's strong encryption is available to protect valuable customer and third party intellectual property**

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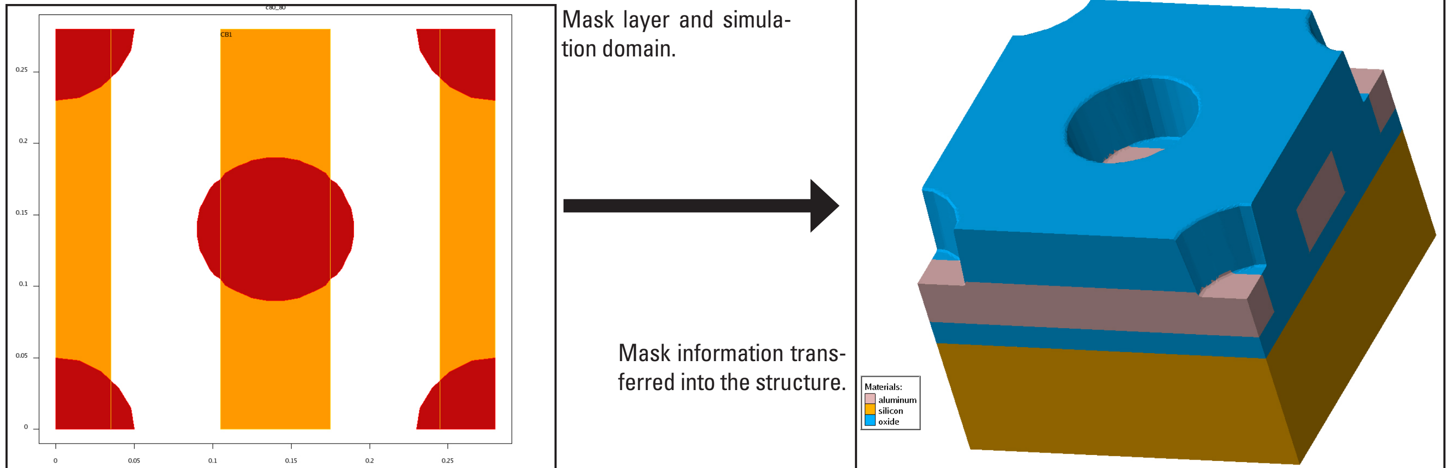
Core Process Simulator

VICTORY Process Core Simulator provides a convenient platform for fast simulation of all important process steps in 3D.

Fast Geometrical Etch and Deposition

- Idealized isotropic etching
- Idealized conformal deposition
- Selective etching or complete removal of material regions
- Idealized full structure or selective material planarization
- Mask pattern with tilted sidewalls or rounded corners
- Mask pattern transfer by vertical or dry etching
- Mask pattern transfer of aerial images
- Mask polygon definition within the input deck
- Supports mask feature variations (shrink and expand)
- Supports GDSII and MaskViews mask formats



Mask layer and simulation domain.

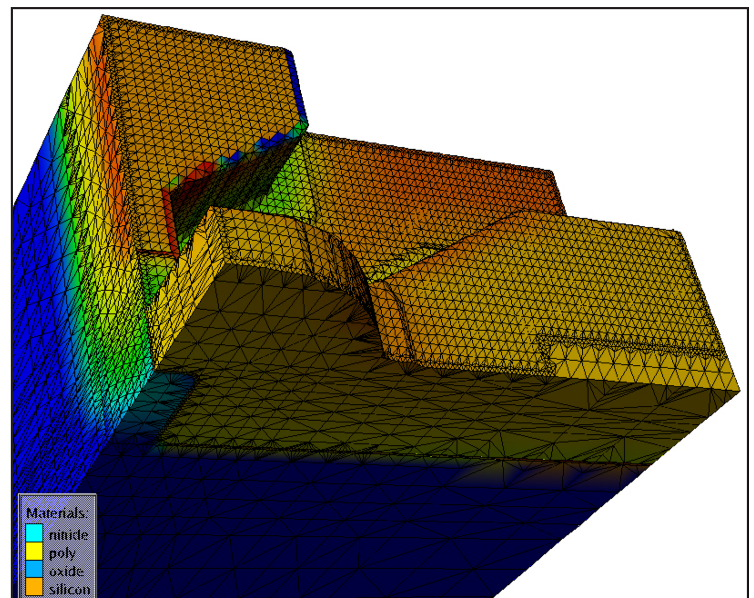
Mask information transferred into the structure.

Analytical Ion Implantation

- Experimentally verified Pearson and dual Pearson implant models
- Extended implant moments tables with energy, dose, tilt, and rotation variations
- Accounts for multi-layer implant moments scaling
- Fully compatible with ATHENA/SSUPREM4

Basic Diffusion and Oxidation

- Fermi diffusion model compatible with ATHENA/SSuprem4
- Fick diffusion model for non-semiconductor materials
- Simulation of multiple dopant diffusion
- Accounts for solid solubility, dopant activation, and segregation at material interfaces
- Analytical oxidation with explicitly specified oxide thickness
- Fully multi-threaded equation assembler and linear solver provide substantial speed improvement on multi-core computers



Boron distribution in a complex structure after analytical implant and Fermi diffusion.

Physical Etch and Deposit

Physical Etch and Deposit Module is a comprehensive set of models covering a wide variety of topology evolution processes used in semiconductor fabrication and in hard coating for media and tribological applications. Run times are very fast on Linux configured multi-core systems due to efficient multi-threading.

Physical Etch

- Selective etching
- Isotropic, anisotropic, and directional etching
- Crystal orientation dependent anisotropic etching (e.g. silicon in KOH)
- Plasma etching with material redeposition

Physical Deposit

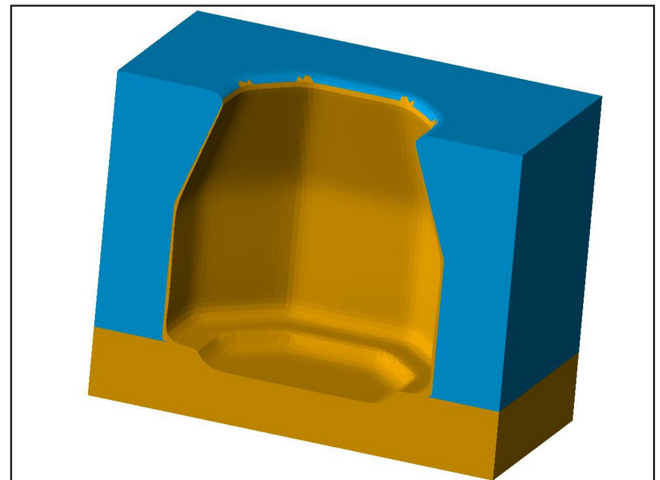
- Conformal, non-conformal, and directional deposition
- Sputter deposition
- Ion assisted sputter deposition

Open Model Interface Capabilities

- User definable models for etch rates, conformity, anisotropy, and sticking coefficients
- User specified technological models (e.g. etch rate versus gas flow)
- User definable surface reaction models
- User definable particle transport characteristics through flux models
- All models account for ballistic transport
- Manual and Automatic selection of transport mode
- Transport and reaction of multiple particles

Ion Milling (IM) and Ion Beam Deposition (IBD)

- Static and rotating beams
- Selective switching of rotating beams on and off
- Highly collimated and divergent beams for IM and particle fluxes for IBD
- Capability to simulate re-depositon effects
- Configurable material specific yield functions and re-emission efficiencies
- Account for shading effects



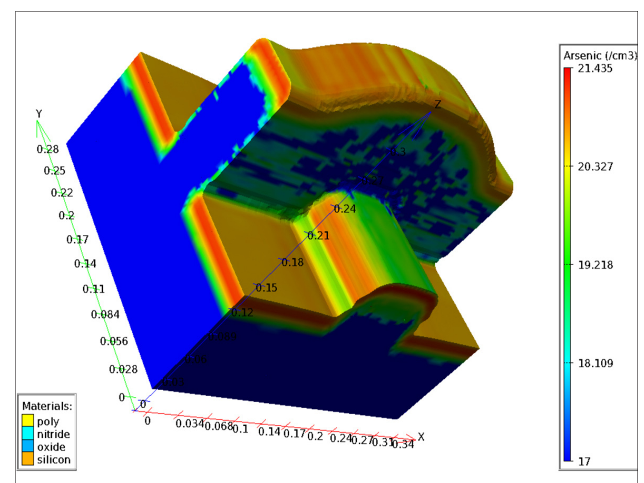
Result of ion milling simulation with redeposition.

Advanced Monte Carlo Ion Implantation

Advanced Monte Carlo Ion implantation is a generic 3D ion implantation simulator.

- Very accurate ion distributions in both crystalline and amorphous materials, arbitrary geometries, multi-layer structures, implant doses, energies, and angles
- Accurately calibrated for wide range of energies starting as low as 200 eV and spanning to the high MeV rang
- Accounts for all complex implantation effects such as reflections and re-implantations, shadowing, deep trenches and voids, arbitrary implant directions and wafer orientation
- Applies 3D binary collision approximation which predicts channeling not only into primary channel but in all possible secondary channels and crystallographic planes
- Provides time efficient and cost effective solutions for important technology issues such as shallow junction formation, multiple implants and preamorphization, HALO implants, retrograde well formation, and well proximity effect
- Fully multi-threaded with run time reduction almost linearly proportional with number of CPUs

Arsenic LDD Implant in a FinFet Structure



10 million ion trajectories were simulation in 5 minutes on 8 CPU computer.

Diffusion and Oxidation

Diffusion and Annealing

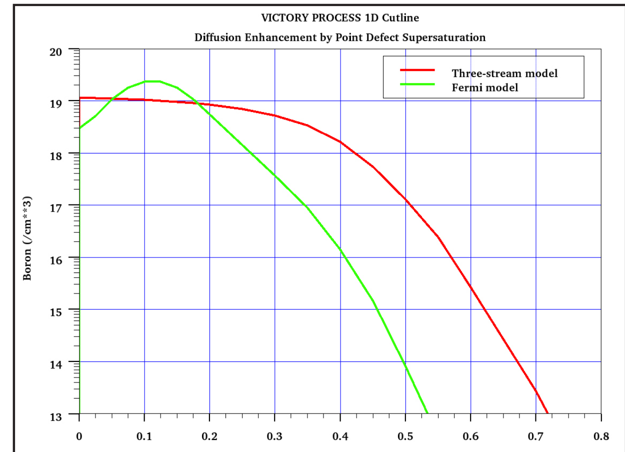
- Simulation of transient enhanced diffusion effects
- Three-stream and five-stream diffusion models
- Point defect trapping and clustering models
- Impurity segregation at all material interfaces
- Impurity activation and solid solubility

Open Modeling Interface Capabilities

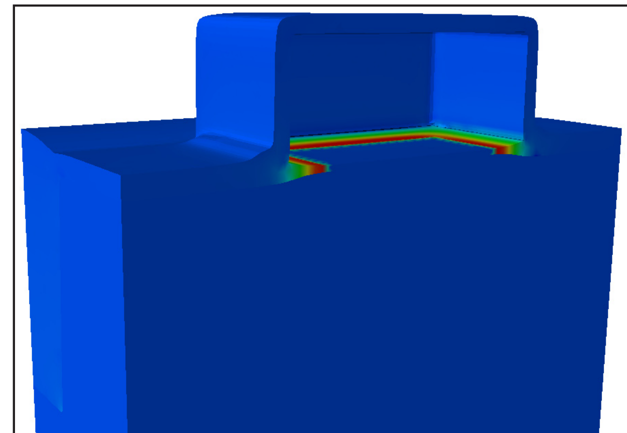
- Definition of model species
- Definition of model parameters
- Definition of reaction functions
- Configuration of the PDE system

Oxidation Models

- Oxidation can be simulated in empirical, full physical, or hybrid mode
- Empirical mode is applied for very thin oxidation layers
- Deal-Grove and Massoud models are used in empirical mode
- Full physical mode simulates oxidant transport, reaction on Si/SiO2 interface, viscous flow, material deformation, and stress formation
- Automatic switching between empirical and full physical mode depending on oxide thickness
- Empirical mode is used in planar regions with coarse mesh allowing layer thicknesses smaller than mesh size to be resolved
- Full physical mode is used in regions with fine mesh
- Hybrid mode is automatically applied when local refinement is used



Comparison of Fermi and 3-stream diffusion model in the presence of interstitial super-saturation.


Stress-profile induced by poly-silicon re-oxidation.

VICTORY Process Inputs/Outputs

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Rev. 071411_14