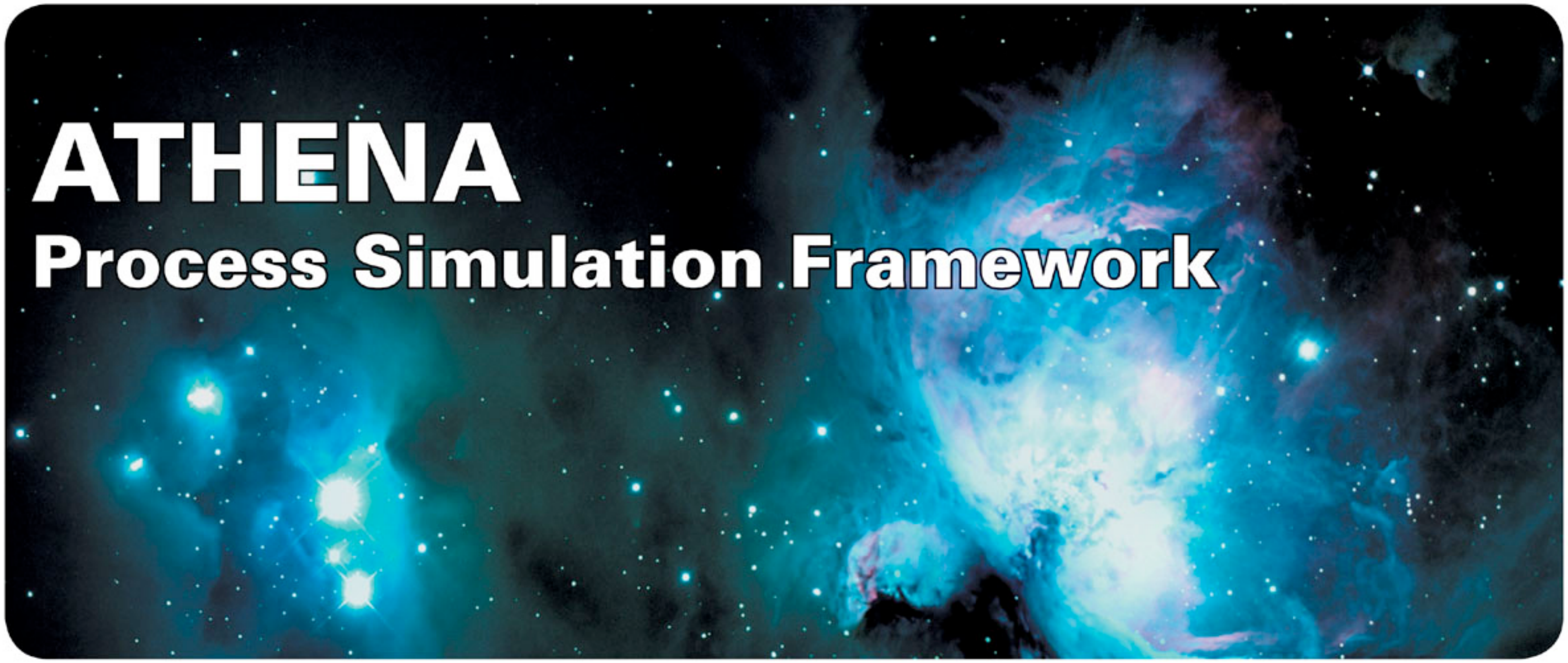
SSuprem4 Process Simulation Software



Core Process Simulation Module

SILVACO

Product Summary

- SSuprem4 is the state-of-the-art 1D and 2D semiconductor process simulator that is widely used in semiconductor industry for design, analysis and optimization of silicon fabrication technologies
- SSuprem4 accurately simulates all major process steps and physical phenomenon in modern technology, using a range of advanced physical models for deposition, diffusion, implantation, oxidation, silicidation, epitaxy and stress.
- Within the ATHENA framework, SSuprem4 is fully integrated to Optolith for photolithography simulation, Elite for physical etching and deposition simulation and MC Implant for advanced Monte Carlo ion implantation

Key Benefits

- Easy to use, self writing (menu driven) input files
- Unlimited support by phone/fax/email
- Industry leading, fully integrated visualization tool
- Fully inter-active run time environment
- History file creation at every step allows real time modifications
- Continuous, in house, customer driven development
- Fully integrated with Silvaco's device simulator, greatly reducing device design/optimization times.

Applications

- Process optimization for performance enhancement
- Stress modeling
- Failure analysis
- Process robustness, manufacturability and yield analysis
- Investigation of mask (cost) reduction viability
- Novel devices
- Patent proposals and legal defense thereof

Advanced Silicon Process Simulation Solutions

- Fast and accurate simulation of all critical fabrication steps used in CMOS, bipolar and power device technologies
- Accurate prediction of geometry, dopant distributions and stresses in device structure allows the elimination or substantial reduction in the number of expensive experiments
- Analysis and optimization of standard and modern isolation processes including LOCOS, SWAMI, deep and shallow trench isolation.

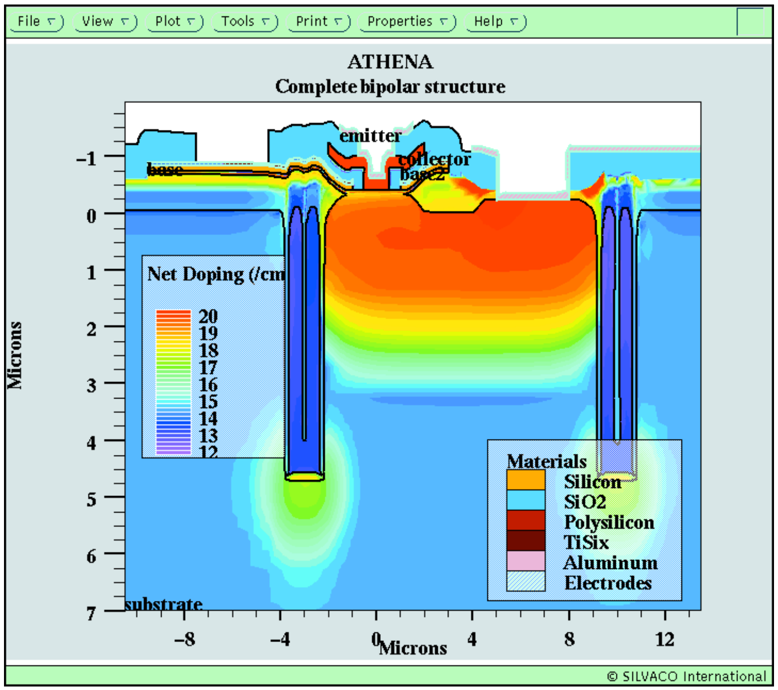
Advanced Silicon Process Simulation Solutions

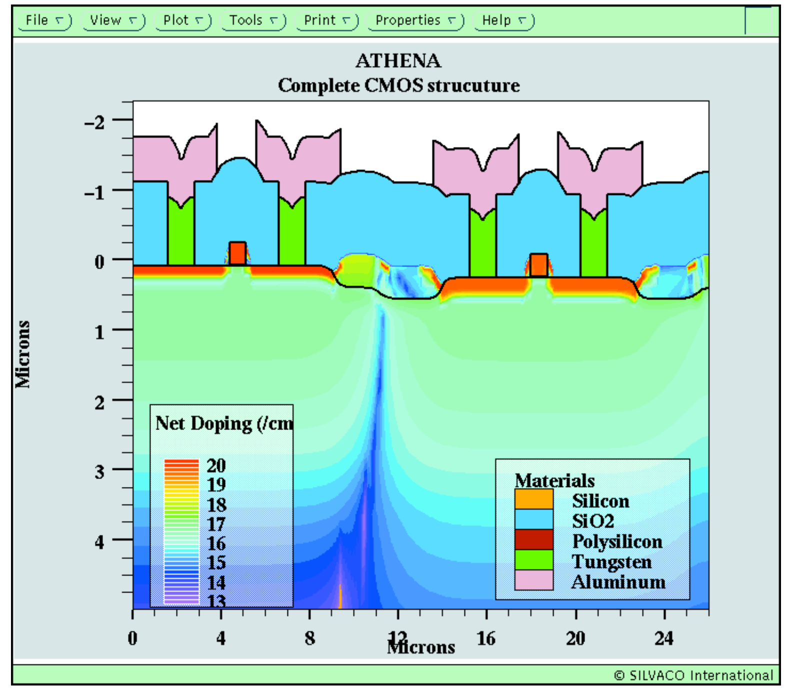
- Hierarchy of impurity diffusion models accurately predict dopant behavior in the bulk and near material surfaces.
- Various diffusion effects are taken into account, including transient enhanced diffusion, oxidation/silicidation enhanced diffusion, transient activation, point defect and cluster formation and recombination, impurity segregation and transport at material interfaces

Advanced Silicon Process Simulation Solutions

- Geometrical etch and comformal deposition as well as several structure and grid manipulating techniques allow simulation and analysis of many device geometries
- Mask formation specification through the MaskViews layout editor allows the user to efficiently analyze mask layout variation effects on individual process steps and final device structure
- Seamless interface with lithography simulator Optolith and etching and deposition simulator Elite allows analysis of real topology in physical processes
- Interfaces automatically with ATLAS for subsequent device simulation

Advanced Silicon Process Simulation Solutions

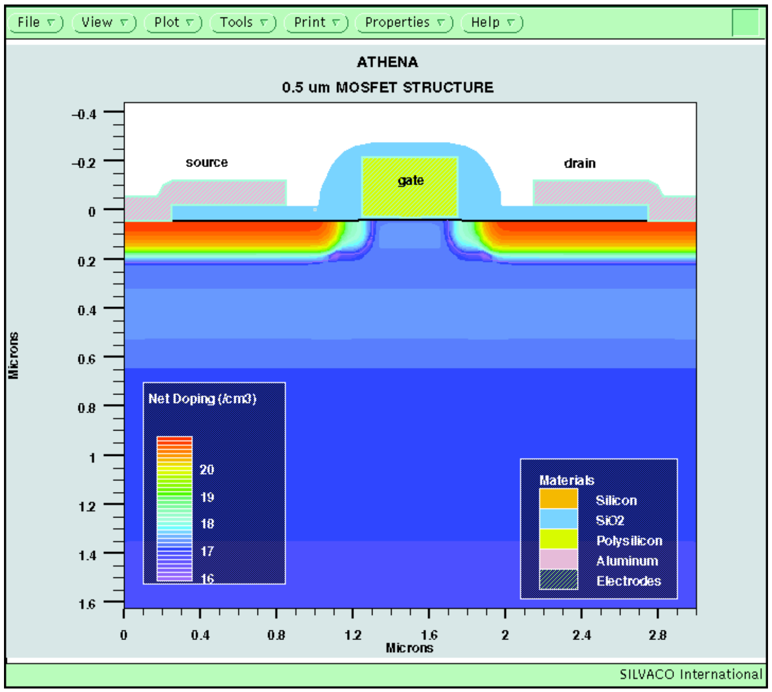




Complete Device Fabrication

- SSuprem4 is applicable to all silicon device technologies. The comprehensive capabilities of SSuprem4 including robust oxidation models, comprehensive implantation models, a hierarchy of diffusion models and general purpose deposition and etch models enable the simulation of complex geometries
- Standard MOS and bipolar transistors, devices such as FLASH EEPROM cells, advanced geometry CCDs and all types of power devices can be modeled
- Any structure created in SSuprem4 can be passed to device simulators for electrical analysis

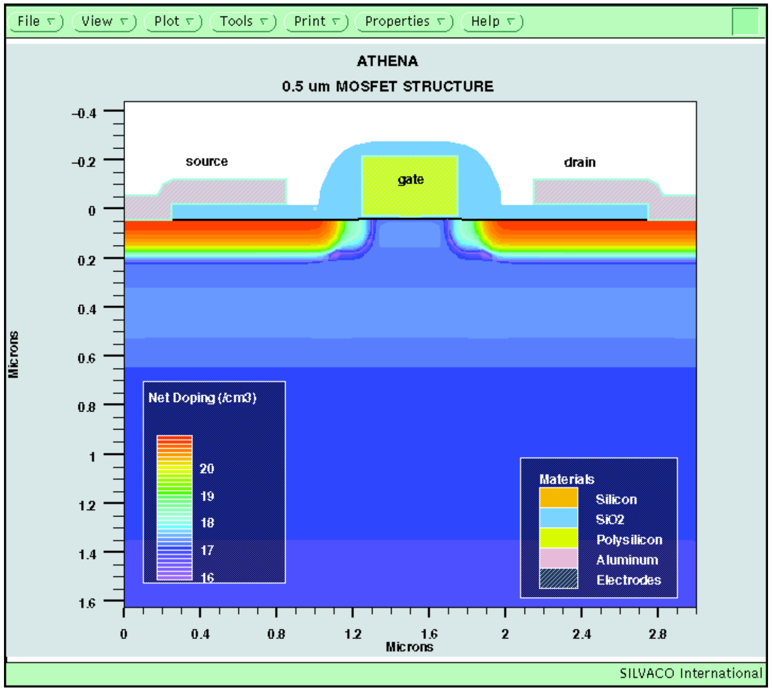
Complete Device Fabrication



- Use of SSuprem4 to simulate a 0.5mm MOSFET
- SSuprem4 includes a STRETCH capability to enable rapid simulation of multiple channel lengths
- This allows simulation of the shortest device and stretching of the gate to various lengths in a fast post-processing calculation

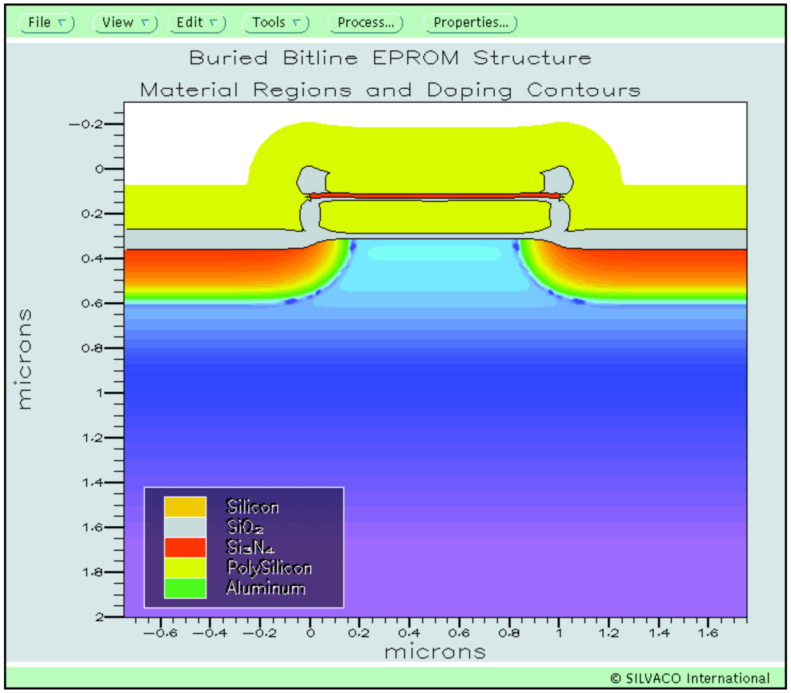
SILVACO

Complete Device Fabrication



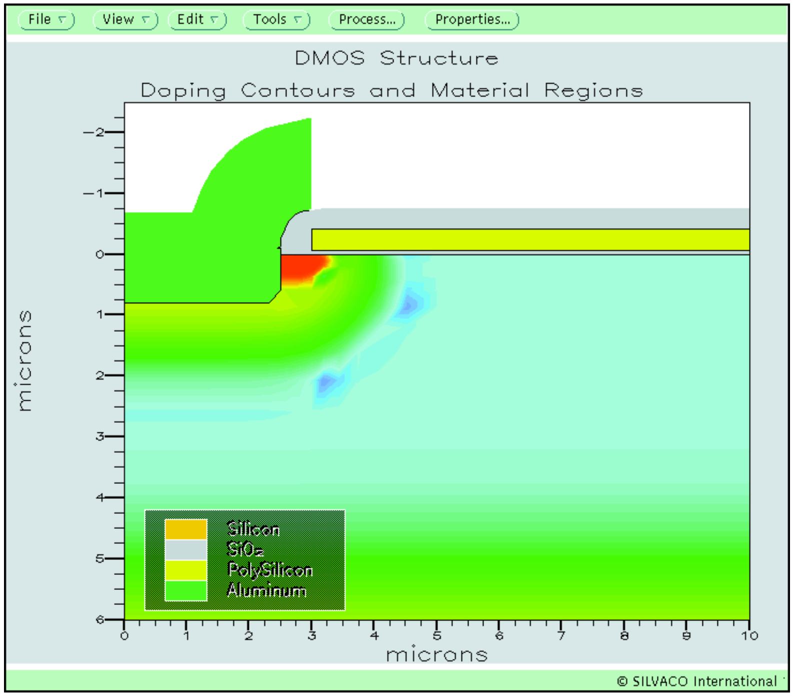
- Use of SSuprem4 to simulate a 0.5mm MOSFET
- SSuprem4 includes a STRETCH capability to enable rapid simulation of multiple channel lengths
- This allows simulation of the shortest device and stretching of the gate to various lengths in a fast post-processing calculation

Complete Device Fabrication



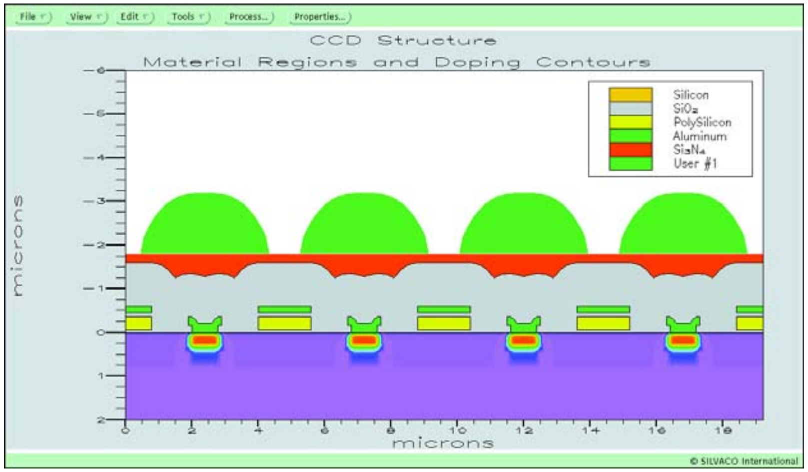
- Buried bit-line EPROM cell
- The polysilicon oxidation model allows accurate simulation of important EPROM effects such as the lifting of the polysilicon floating gate and the stress in the inter-poly ONO structure

Complete Device Fabrication



- Device geometries are larger in power device processing, but the final transistor structures are often two-dimensional in nature
- The example shown above is a power DMOS transistor with a self-aligned source contact process

Complete Device Fabrication

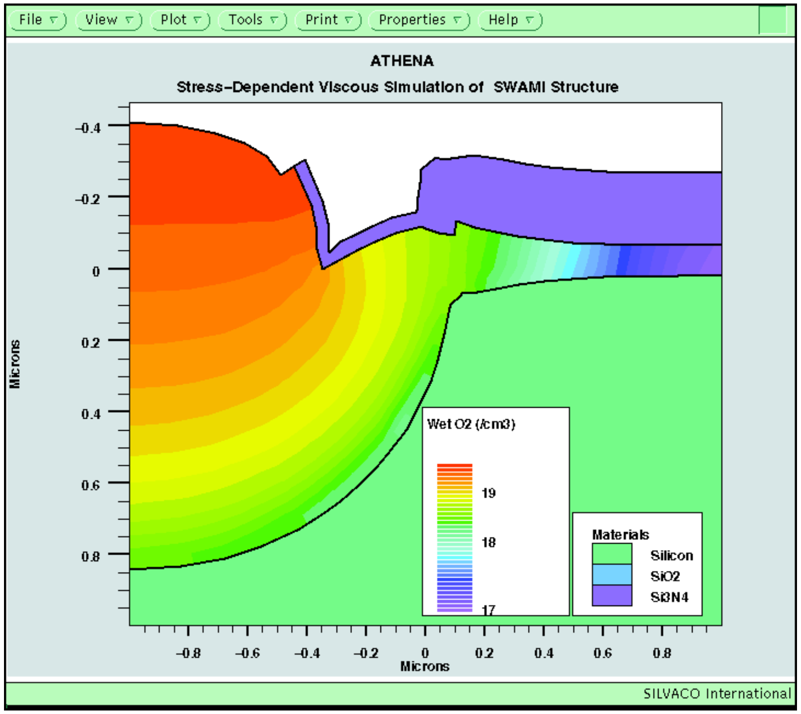


- For advanced CCD structures, lens shaped structures are used to provide increased optical resolution
- Symmetry is used to speed the simulation time
- Only one section of the structure is simulated which is is then reflected several times to produce the repeating gate structure used in the electrical analysis

Isolation Technology

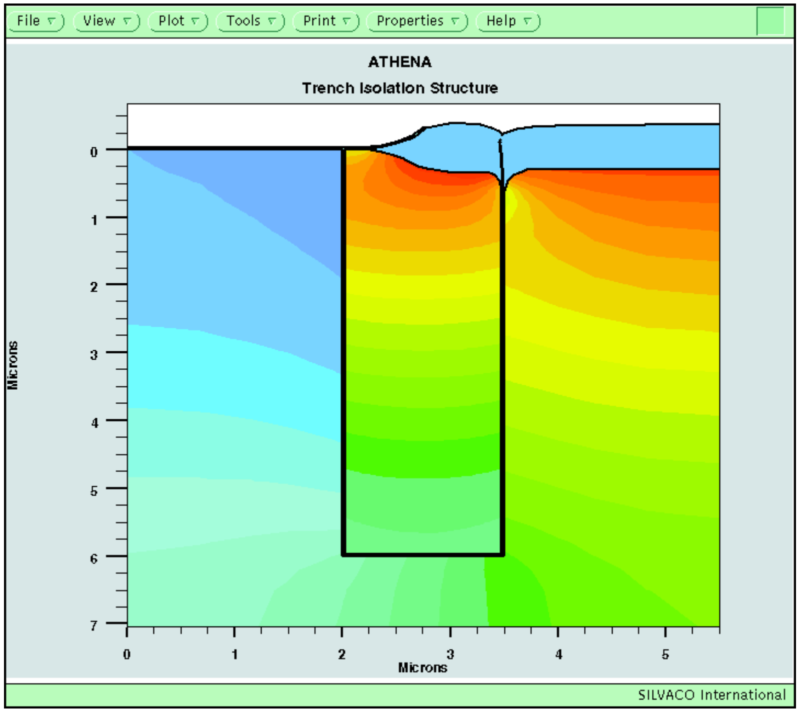
- Isolation technology is used to separate the active devices in a circuit
- With the drive to reduce layout design rules, the optimization of such technology has become increasingly important
- Complex local oxidation schemes are used to provide advanced isolation structures
- The oxidation models and flexible griding algorithms in SSuprem4 permit simulation of the oxide encroachment and stress effects in multiple layers

Isolation Technology



- This example illustrates a sidewall-masked isolation (SWAMI) structure with oxidation in a shallow recess using a nitride mask
- The effect of stress produced by lifting the upper layers, is included in the calculation of oxidation rates

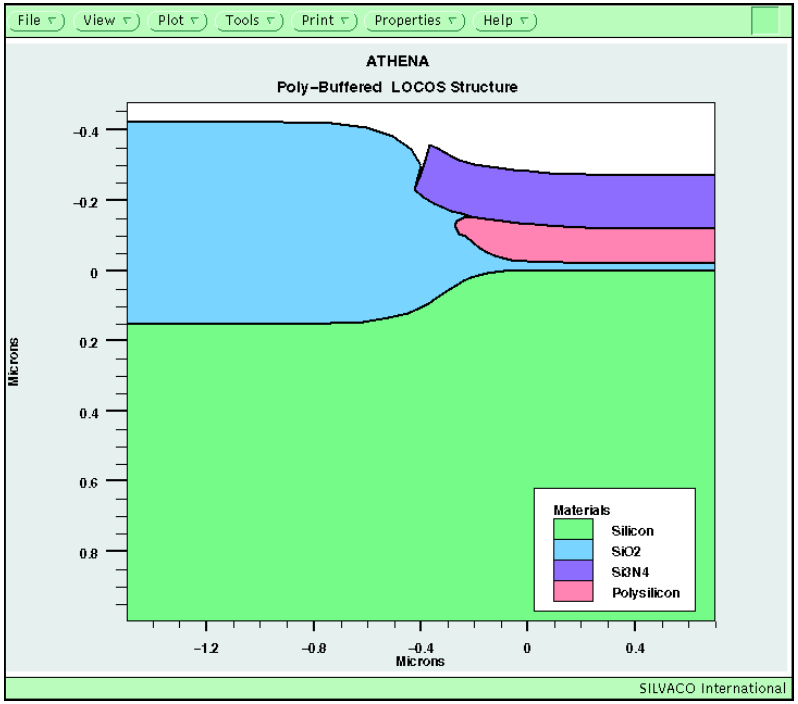
Isolation Technology



- Trench oxidation with the interstitials injected by oxidation
- Interstitials injected at the oxidizing interface are “trapped” in the trench while those in the silicon diffuse around the bottom of the trench and affect diffusion in the areas to the left of the trench

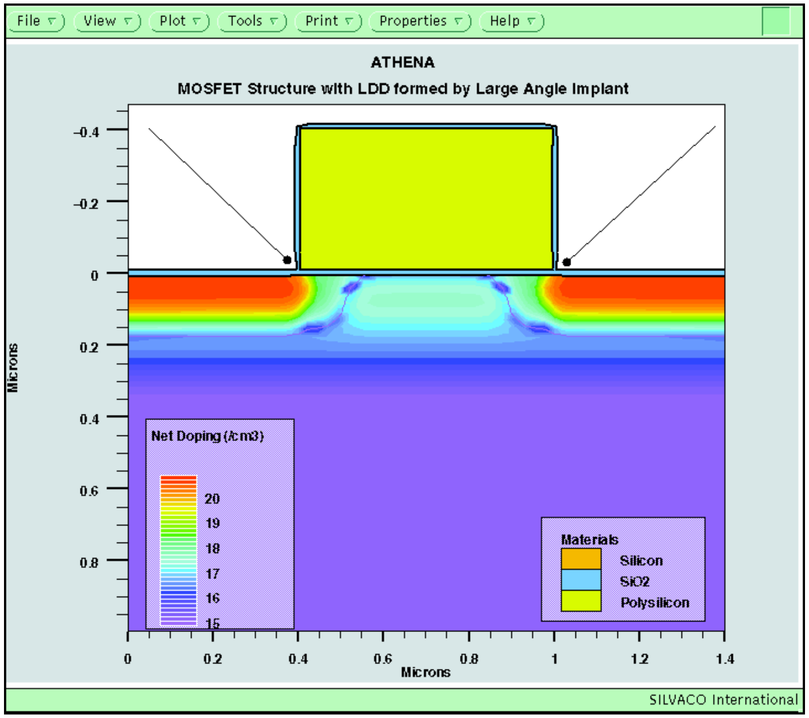
SILVACO

Isolation Technology



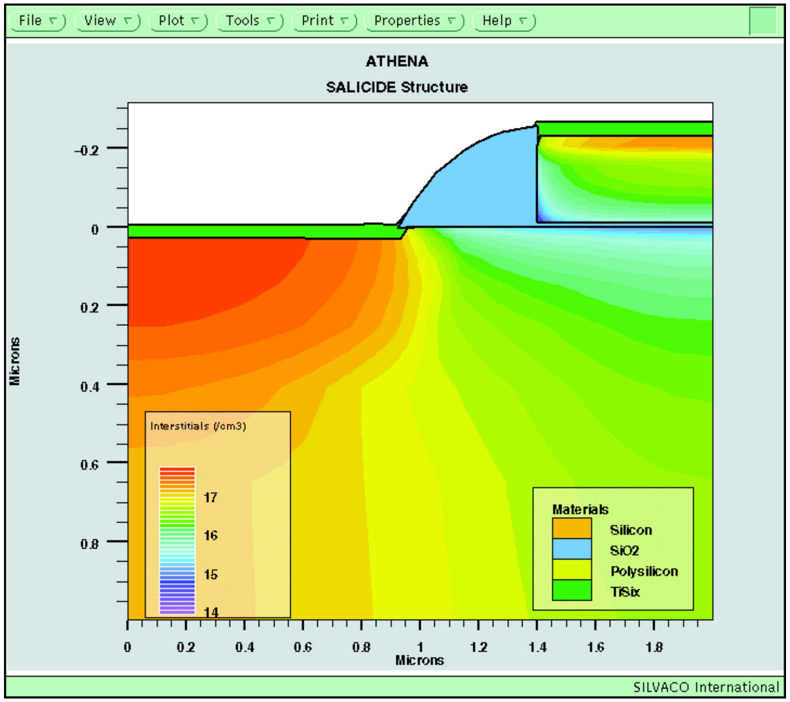
- Shown is an example of poly-buffered LOCOS isolation
- The lifting of the polysilicon layer, due to stress, is clearly illustrated

Ion Implantation



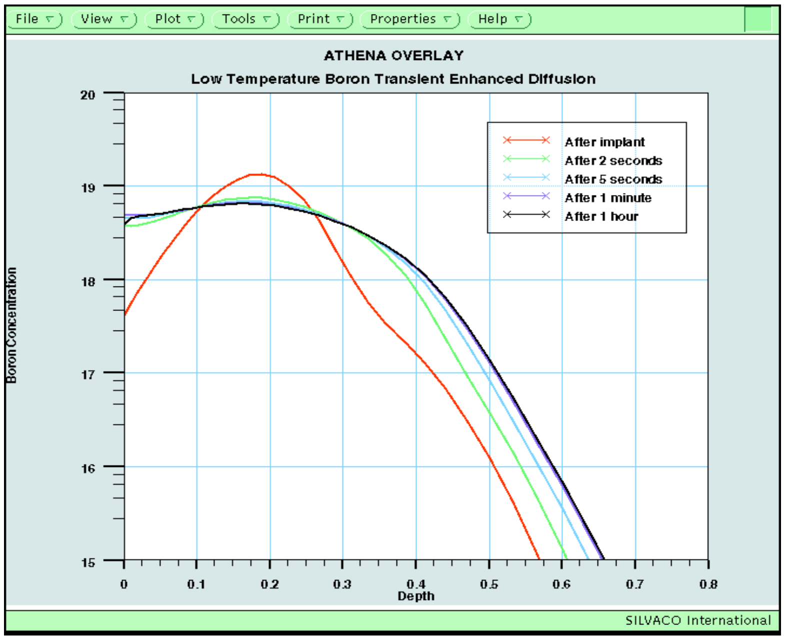
- The lightly doped drain (LDD) regions of a half micron MOSFET can be formed without spacers using a large angle tilt implant in a LATID process
- This implant is rotated through 360 degrees to give a symmetrical device structure. SSuprem4 uses an extremely fast analytical method to simulate the effects of tilt and rotation
- Device with a phosphorus LDD implanted at 45o as indicated by the arrows

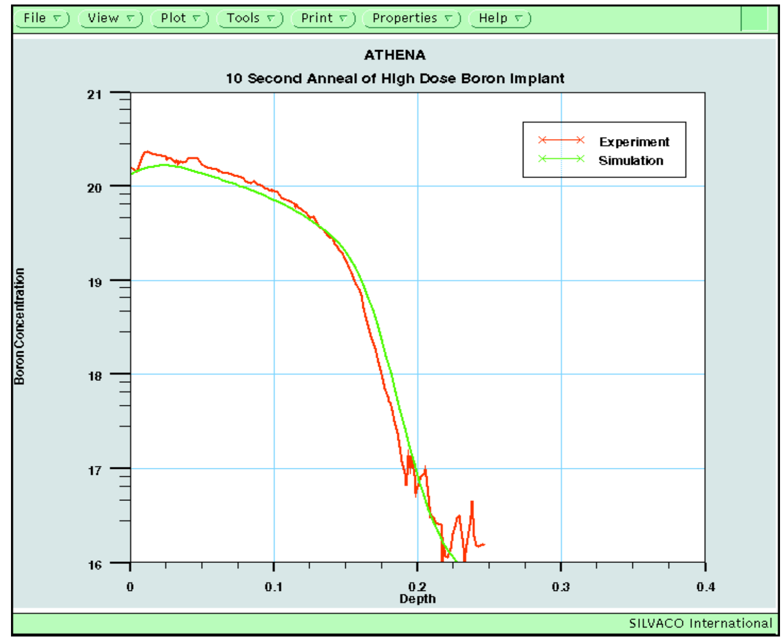
Silicides



- SSuprem4 provides unique capabilities for the simulation of silicide processes
- It models the two-dimensional formation of silicides, dopant redistribution and diffusion in the silicide layer
- Final structure from a self-aligned silicidation (salicide) process
- Point defect injection into the silicon caused by silicide growth is shown

RTA Simulation





The two diffusion profiles shown highlight the Rapid Thermal Annealing (RTA) simulation capabilities offered by SSuprem4. The figure on the left shows a low-temperature transient enhanced diffusion of Boron. The significantly enhanced diffusion rate in the first five seconds is apparent. The figure on the right shows the comparison with experimental data for a very short high-temperature anneal of a PMOS source/drain profile.

Physical Models and Features - Diffusion

- Impurity diffusion fully coupled with point defect diffusion
- Oxidation and silicidation enhanced/retarded diffusion
- Rapid thermal annealing and Transient Enhanced Diffusion (TED)
- High concentration effects
- TED effects due to implant induced point defects and {311} interstitial clusters
- Rapid thermal annealing
- Grain based polysilicon diffusion model
- Transient impurity activation model
- Model for impurity dose loss at silicon/oxide interface

Physical Models and Features - Implantation

- Experimentally verified Pearson and dual Pearson implant models
- Non-Gaussian depth-dependent lateral implant
- distribution functions
- Extended implant moments tables with energy, dose, rotation and oxide thickness variations
- User-defined or Monte Carlo extracted implant moments
- Seamless interface to Monte Carlo implantation module

Physical Models and Features - Silicidation

- Models for titanium, tugsten and platinum silicides
- Silicidation enhanced diffusion in underlying silicon
- Diffusion and reaction limited growth rates
- Reactions and boundary motion on Silicide/metal and silicide/ silicon(polysilicon) interfaces
- Accurate material consumption model
- Independent rates for silicon and polysilicon materials

Physical Models and Features - Oxidation

- Compressive and visco-elastic stress-dependent models
- Separate rate coefficients for silicon and polysilicon materials
- HCL and pressure enhanced oxidation models
- Impurity concentration dependent effects
- Robust formulation models deep trenches and undercuts
- Accurate models for simultaneous oxidation and lifting of floating polysilicon regions

Physical Models and Features – Deposition, Etching, Epitaxy

- Deposition and etch specification via MaskViews layout editor
- User defined and automatic non-uniform deposition grid specification
- Special algorithm for conformal deposition on highly non-planar structures
- 2-D epitaxy simulation including auto-doping capability
- Automatic detection of non crystalline substrates during epitaxy. Polysilicon is deposited in these regions
- Seamless interface with physical etching and deposition models of Elite

Physical Models and Features – Structure and Grid Manipulation

- Structure mirroring
- Structure stretch
- Relaxation of grid density
- Grid adaptation during implant and diffusion
- Seamless interface with DevEdit™ for interactive or automatic structure and grid adaptation

Conclusions

- A comprehensive process simulation set is included in the base module
- Other, more specific modules, can be seamlessly integrated into the base program. These modules are simply activated by key words detected in the input file. Monte-Carlo implant, optolithographic solver for optical interference effects in photoresist, relaistic etching, realistic deposition, CMP etc.
- Very easy to use, accurate and great graphics
- Support if you need it