SYSTEMS PRODUCTS
LOGICAL PRODUCTS
PHYSICAL IMPLEMENTATION
SIMULATION AND ANALYSIS
LIBRARIES
TCAD

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

Taurus-Process

Multidimensional Process Simulation

Taurus-Process is a complete program for semiconductor process simulation. Taurus-Process simulated all important fabrication steps used to manufacture semiconductor devices. Processe devices can be simulated for a full 3-dimensional structure, or in 1 or 2 dimensions. Typical processes simulated are deposition, etching, ion implantation, diffusion and oxidation. Taurus-Process has a direct interface to Taurus-Device™ for electrical and thermal device characterization.

TAURUS-PROCESS HELPS YOU:

- Predict 1D, 2D, and 3D geometry and impurity profiles generated by a fabrication proces
- Create correct structures for 1D, 2D and 3D device characterization with Taurus-Device.
- Investigate the effect of variations in the fabrication process.
- Design new advanced bipolar or MOS processes.
- Analyze the mechanical stresses developing in your device during processing.
- Specify and use new equations and models.

1D-2D-3D PROCESS SIMULATION

Taurus-Process is the most complete simulator available for 1D, 2D and 3D process simulatior

Simulating 3D effects has become necessary to completely describe and understand the fabric process and operation of many state-of-the-art semiconductor devices. With Taurus-Process, complete process flows can be simulated, including implantation, deposition, etch, diffusion anc oxidation of 3D structures. Specific 3D process effects, such as LOCOS and STI corners, can a be studied.

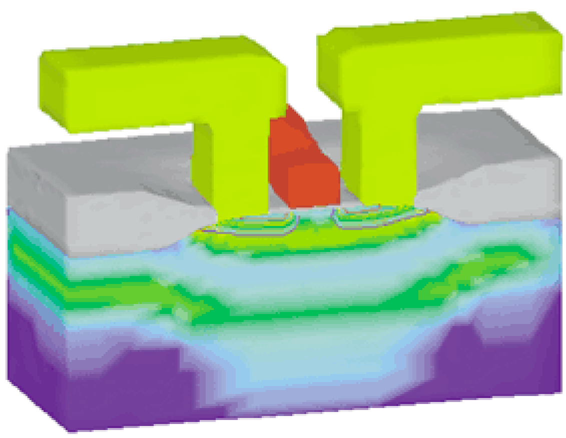

Figure 1: Complete simulation of a retrograde well process for a quarter-micron MOSFET. The figure shows the MOSFET structure after metal etching (with TEOS isolation removed for bette viewing.

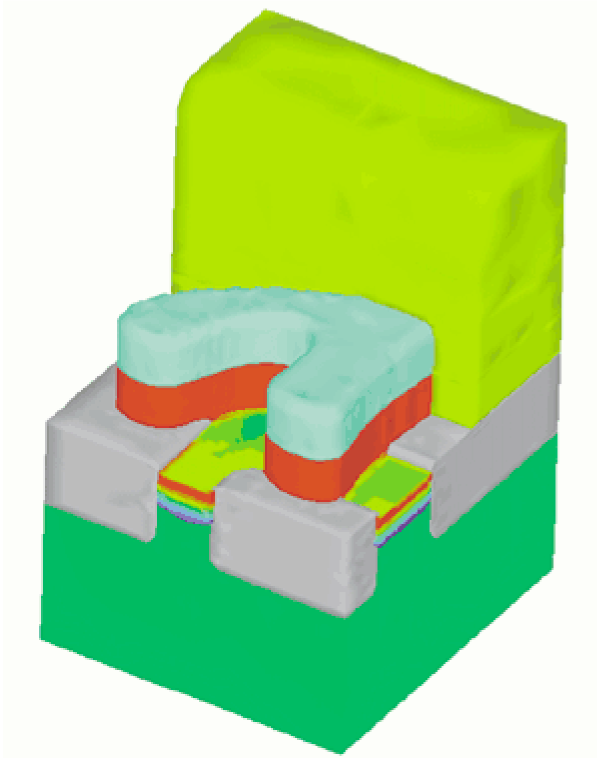

Figure 2: Quater-micron SRAM cell with shallow trench isolation (STI) after four tilted LDD impla Arsenic profile in silicon is shown by the rainbow colors. Complex geometry of the poly gate an thick photoresist make it necessary to simulate it as a three-dimensional structure to account fo implant shadowing for process simulation. There are 35k nodes for this structure.

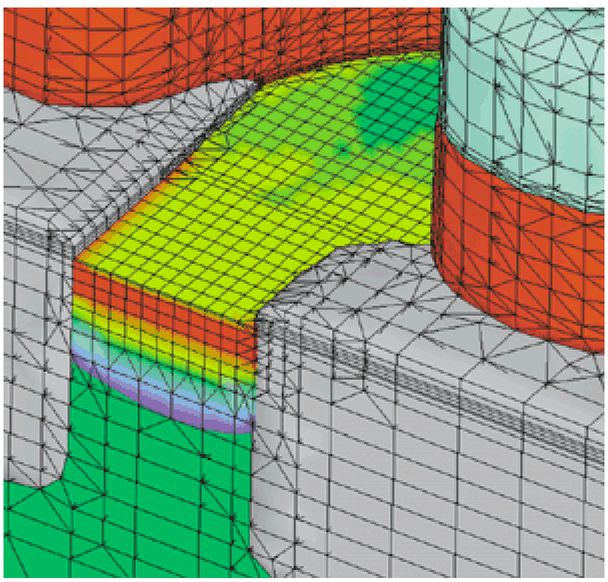

Figure 3: Mesh detail from the SRAM in figure 2.

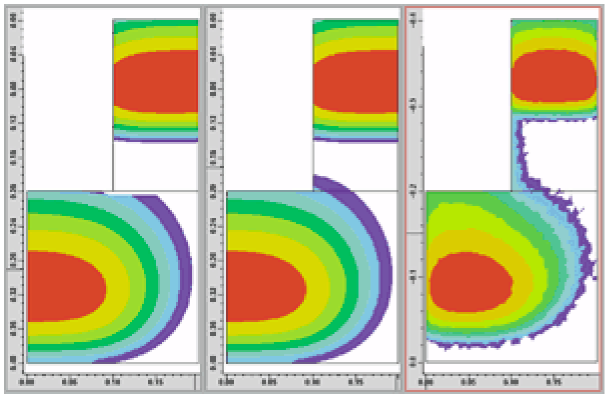

Figure 4: The advanced analytical implantation algorithm and the calibrated models make the Taurus-Process implantation much faster and more accurate than conventional models. The le panel shows an implanted profile under the mask etch simulated by the conventional models, tl middle panel shows results with the Taurus-Process advanced model, and the right panel show the Monte Carlo simulation results.

MESH GENERATION

Efficient automatic mesh generation greatly facilitates the simulation process in Taurus-Proces Three mesh packages are available: a complete 1D-2D-3D quadtree-octree mesh, a 2D bound conforming mesh and a 3D advanced unstructured mesh with boundary layers. A level set boundary description allows the construction of optimal meshes for any type of structure and fo efficient moving-boundary simulations.

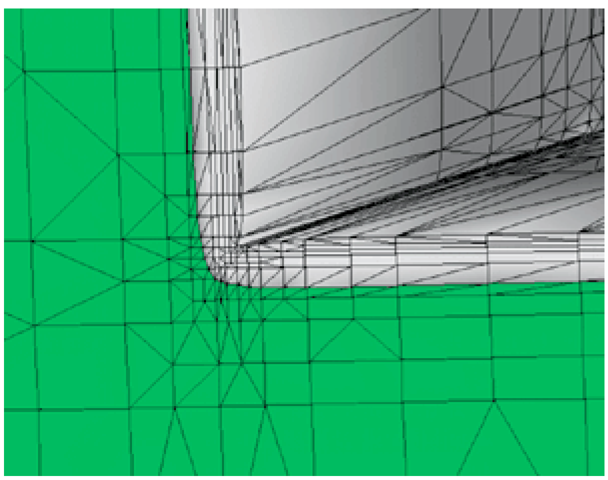

Figure 5: Corner of an STI trench.

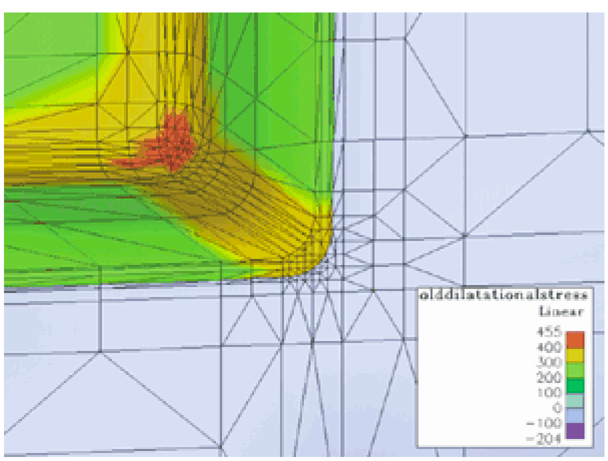

Figure 6: Rounded corners in a trench, Color shading shows the dilational component of the mechanical stress generated by the mismatch in thermal expansion of the silicon and oxide.

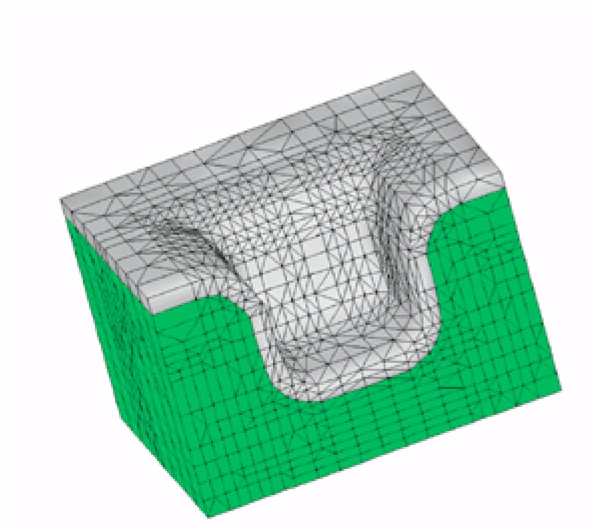

Figure 7: The mesh generation allows for specification of arbitrary geometries, e.g. different tre configurations with different rounding of edges.

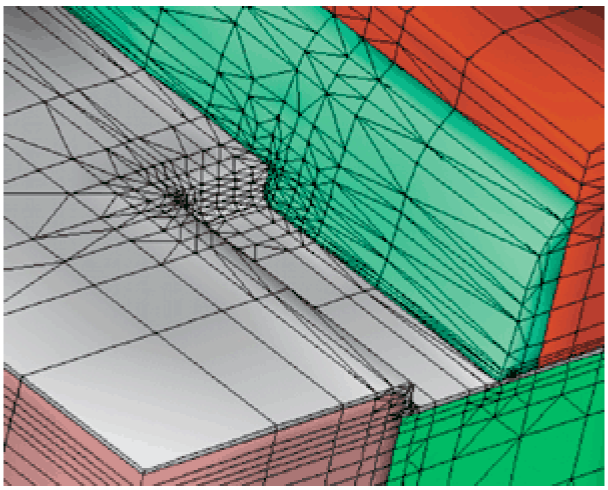

Figure 8: Mesh detail from an STi (shallow trench isolation) structure showing the nitride space (light blue), polysilicon (red), oxide (gray), TEOS (brown) and silicon (green).

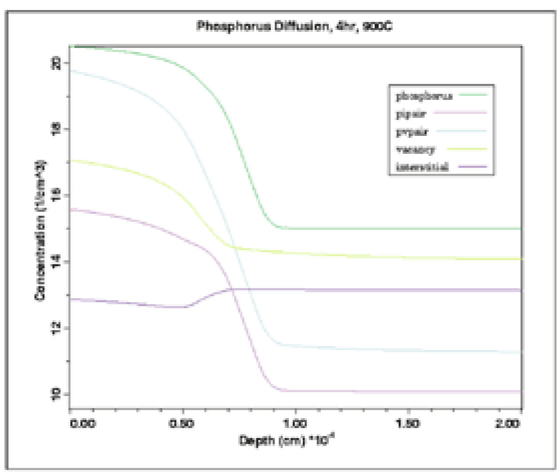

Figure 9: Diffusion using the pair diffusion model (900c, 4h). The Taurus-Process PMEI was us define the 5 coupled partial differentialk equations required by this model (phosphourus, vacan interstitial, Pi-pair and Pv-pair equations).

PHYSICAL MODEL AND EQUATION INTERFACE

As an optional capability, Taurus-Process has a physical model and equation interface (PMEI), which provides an easy and flexible way to define new physical models and partial differential equations. Using the PMEI, a user can do simulations using his own set of models and equatio Areas of particular importance include impurity and defect diffusion, electromigration, mobility, impact ionization and hot carrier modeling, but the PMEI is equally applicable to all partial differential equation simulations.

SIMULATION FEATURES

- Simulation of arbitrarily shaped 1D, 2D and 3D structures.
- Complete process simulation including deposition, etch, ion implantation, oxidation, silicidation, and diffusion.
- Advanced adaptive mesh generation which provides optimal grids with excellent solution structure resolution using a minimum number of mesh points.
- Optional physical model and equation interface, which allows a user to define and solve physical models and partial differential equations.
- Dynamic memory allocation - the size of the simulated problem is limited only by the cap of the computer.
- The solution method may be controlled by the user, i.e. all available or user-defined equations can be solved individually, interactively coupled or fully coupled.
- Large selection of fast, direct and iterative linear solvers.

MODELS:

Implantation:

- Dual Pearson, Pearson and Gaussian analytic models.
- Energy range 0.5 KeV to 10 MeV.
- Energy, dose, tilt, and rotation-dependent channeling.
- Depth-dependent lateral standard deviation, separate for random scattering and channe
- Backscattering model extends the profiles under the masks beyond the limitations of the conventional analytic models.
- Shadowing effects due to wafer tilt and rotation.
- Easy integration of the users' implant moment data into the hierarchical implant data tab
- Implant damage/amorphization model.

Diffusion:

- High-concentration effects (diffusivity enhancement and precipitation).
- Impurity interaction with point defects.
- TED, OED, and ORD effects.
- Impurity interaction via Fremi level, point defects and electric field.

Oxidation:

- Visco-elastic model.
- Robust boundary movement by level set method.
- Parallel oxidation by multiple oxidizing species.
- Initial logarithmic oxidation kinetics in dry oxygen.
- Surface orientation dependence for complex 2D and 3D structures.

Deposition and Etching:

- Robust boundary movement by level set method.
- Conformal deposition.
- Dry etching for polygonal masks in 3D.
- Wet etching.
- Planarizing etching (CMP).

CONFIGURATION

- Platforms: Runs on UNIX workstations from
- Hewlett-Packard and Sun Microsystems.
- Memory: Recommended memory range from 8Mb (1D) to 1Gb (3D).

Taurus-Process is an integral part of the Avant! TCAD environment and interacts with Avant! visualization programs and Taurus-WorkBench™.
