Victory Mesh

SILVACO

Meshing and Solid Modeling

Overview

Victory Mesh provides users with power functionality to mesh and refine exiting 2D and 3D TCAD structures, as well as solid modeling capabilities to generate new 2D and 3D structures.

Executable from within the Deckbuild TCAD graphical user interface, Victory Mesh accepts input such as:

- Silvaco standard structure file format (.str) in 2D and 3D
- Saved status from Victory Process semiconductor process simulator in 2D and 3D

Victory Mesh outputs can be:

- Visualized within TonyPlot (2D) & TonyPlot3D (3D)
- Exported to semiconductor device simulators Victory Device, Atlas, and Clever
- Exported in standard formats (e.g. .stl and .vtk) to 3rd party software

Device Meshing - Victory Mesh provides a selection of schemes for meshing of devices:

- Delaunay (unstructured sampling)
- Conformal (semi-structured Cartesian-based sampling)

Device Refinement (Remeshing) - Victory Mesh includes a number of Delaunay refinement schemes, both general and TCAD-specific:

- Uniform
- Impurity
- Junction
- Interface
- Shape
- Approximation Distance
- Quality

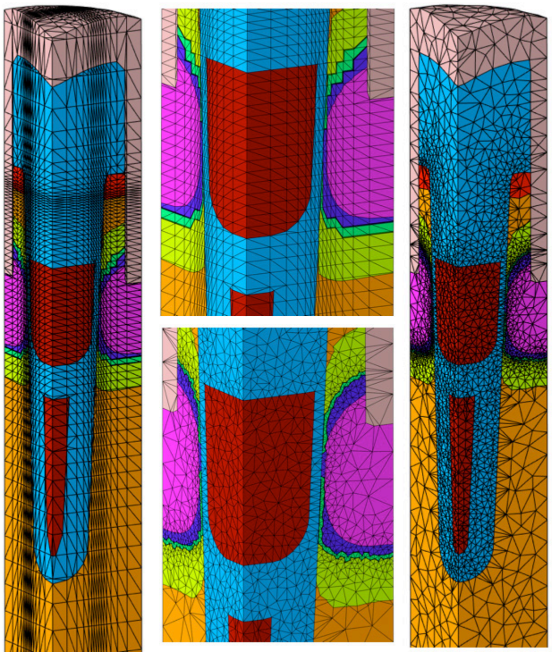
Solid Modeling - Victory Mesh contains a number of features to generate devices directly within the Victory Mesh engine:

- Shape Generation
- Geometric Transformation
- Mirror
- Join
- Crop
- Slice
- Combine
- Splice

Mesh Generation and Remeshing

Victory Mesh takes raw geometrical data from Victory Process as input and produces a mesh that is suitable for device simulations in Victory Device, Atlas, and Clever.

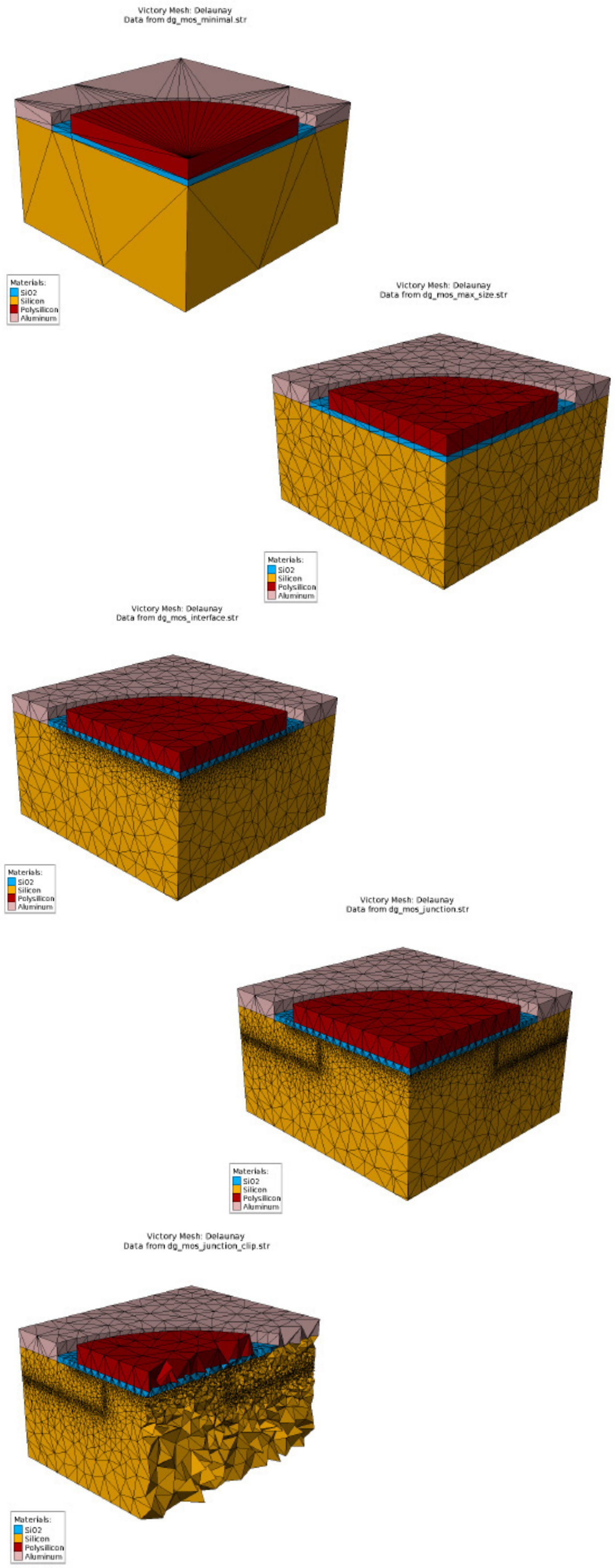
There are two basic types of mesh structure that can be output from Victory Mesh and both of these mesh types can be used in Silvaco device simulators.



Conformal (left) - User specified structured Cartesian mesh.
Delaunay (right) - Automated feature and quantity-dependent unstructured mesh.

Features

- User-defined mesh (Conformal) or automatic parameter defined (Delaunay) in either 2D or 3D
- Delaunay mesh can be automatically generated to prioritize any number of:
  - o Specific volumetric materials
  - o Specific interface material combinations
  - o Specific distances from interfaces
  - o Specific volumetric quantities
  - o Specific physical locations
- Flexibility to choose mesh type and density to suit specific simulation needs



Example structure showing Delaunay meshing with automatic refinements by: max element size, interface refinement, junction refinement. Cut-away slice shows internal mesh refinement within structure.

Solid Modeling

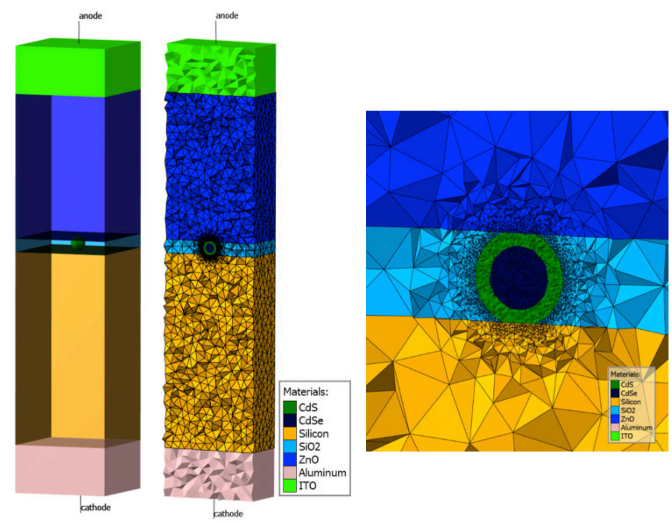
Victory Mesh contains support for generating various types of shapes in 2 and 3-dimensions, such as:

- 2D – Triangle, Rectangle, Circle, etc.
- 3D - Cone, Cuboid, Cylinder, Ellipsoid, Pyramid, Sphere, etc.

Shapes are generated consisting of a user-specified material. These shapes can subsequently be used in other commands such as REFINE, CROP and JOIN. Each type of shape can be generated by an individual command. The syntax is designed to be as consistent as possible between 2- and 3-dimensions. The dimension of the result is usually implied by the dimension of the points used as parameters to define the shape.

Application Example – Quantum Dot

Quantum dots are of interest in recent LED technology. The formation of a quantum dot within traditional etch/deposit engines is not practical. However, solid modeling techniques can be used to greatly simplify their creation. Victory Mesh can be used to quickly and easily generate a quantum dot using a number of solid modeling commands. The structure uses Delaunay meshing to create highly detailed mesh near the quantum dot and its interfaces as well as a much coarser mesh in areas of less importance.

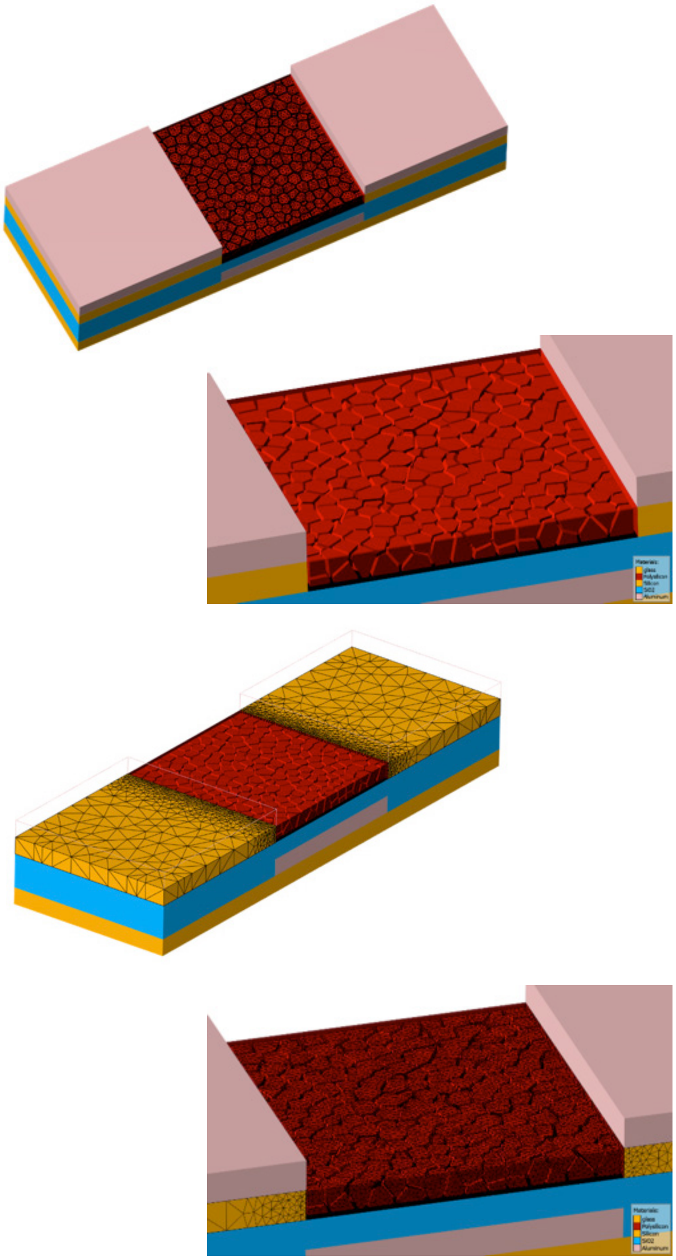


Transparent view of semiconductor regions to make the quantum dot visible. Mesh slice view to internal mesh of the structure. Close view showcasing the fine detail resolution of the mesh.

Application Example – Grain Generation

Laser Annealing processes, such as Excimer Laser Annealing (ELA) are used to convert amorphous silicon to polycrystalline silicon and enhance carrier mobility. The poly-Si structure (grain boundary) is dependent on the laser wavelength, pulse width and spatial beam.

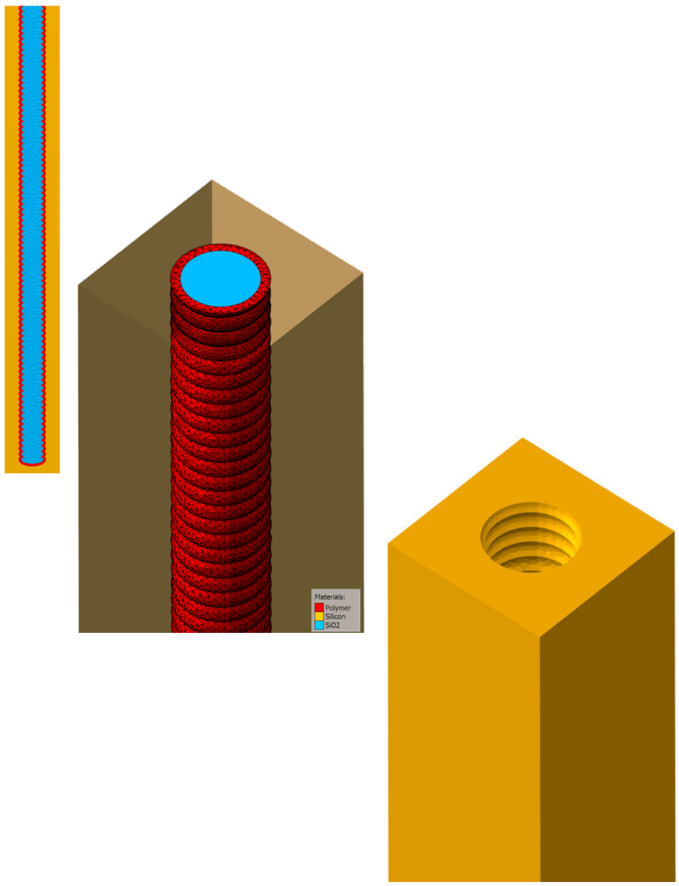
Victory Mesh can emulate grain boundaries formation using a Voronoi discretization. This Grain Generation Example extends beyond the work published in the Simulation Standard article: 3D TFT Simulation of Grains and Grain Boundaries, Vol 29, No. 1 Jan-Mar 2019. Here the grain sizes are varied in all directions.



Grains can be formed within a region via Victory Mesh per user specification of grain properties. Resulting structure can then be electrically characterized in TCAD device simulation.

Application Example – Scalloped Sidewall

Deep Reactive Ion Etching (RIE) process is commonly used to etch deep, nearly vertical, pillars. Silvaco's process simulator (Victory Process) can simulate the Deep Reactive Ion Etching process, however the simulation time associated with this type of detailed process analysis can be time-consuming for very deep trenches. If a user is interested in the device simulation instead, Victory Mesh can be used to quickly generate the geometrical shapes of this process directly using solid modeling commands.



Cutplane of the whole structure (left).
View showing the trench interior (center).
View showing the silicon etch shape without the trench filling (right).

Application Example – Textured Solar Cell

To enhance light absorption, solar cells have been manufactured with textured surfaces. For crystalline silicon, anisotropic etching with enhanced etch rates along preferential low index directions generates complex surface pyramids. This is computationally costly to perform in process simulation. An alternative approach is to use solid modeling. This texture solar cell is generated using the Victory Mesh solid modeling commands. The structure is also remeshed in Victory Mesh using Delaunay remesh scheme to refine on dopants and the oxide interface. The mesh can then be loaded in Silvaco's Device Simulators for device characterization.

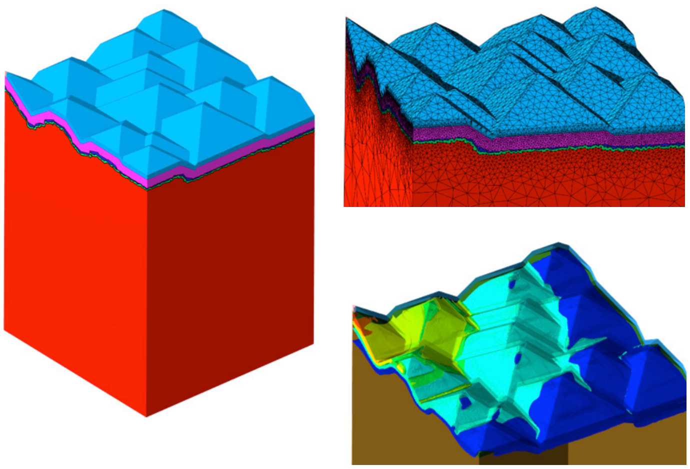
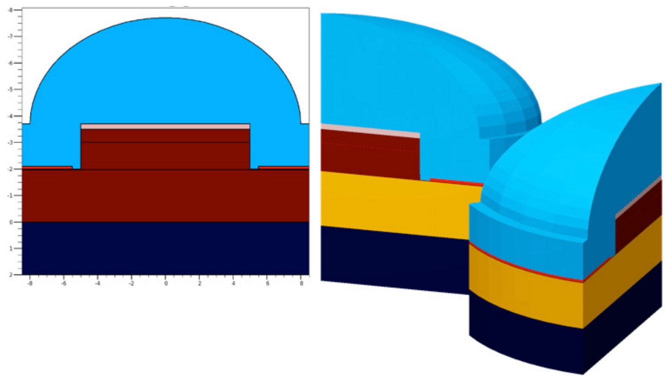


Image of the full structure made in Victory Mesh. Image showing Delaunay refinement on dopant and interfaces. Image of the structure imported into Victory Device and showcasing spreading current density throughout the textured surface.

Application Example – MicroLED

A typical micro LED structure contains many tightly spaced layers of material. These devices are relatively simple to generate within standard etch/deposit process engines. However, the cap stage is more complex. Victory Mesh can generate a micro LED entirely using solid modeling commands. This LED also contains a realistic cap stage. The mesh can then be loaded in Silvaco's Device Simulators for device characterization.



Using the solid modeling engine, a multi-layer GaN LED with capping layer can be generated.

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