

## A Novel Method to Describe 3D Device Structures

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## ABSTRACT

To realize general purpose 3D process and device simulators, the shape description method with the following two characteristics is essential. First is an excellent ability to describe complicated device structures. Second is easy handling of any device structure changes caused by the fabrication processes. A new method with these properties is proposed and applied to a shape generator for a 3D device simulator.

In this method, a "triangular prism" shape element is introduced. Any shaped layer is divided vertically into triangular prisms along the triangular mesh on the x-y plane. Each generated prism has a triangular face on its top and bottom, and three vertical side faces. Top and bottom faces are not necessarily horizontal. To describe triangular prisms, ordinary shape elements: face, edge (line segment) and vertex are also introduced and data structures hierarchically describing their connections are constructed.

Any 3D shape can be accurately described using the triangular prisms and data structures mentioned above. Triangular prisms also contribute to easy operation for 3D shape modification, because device structure changes through fabrication processes are mainly in the z direction and thus can be represented precisely as surface vertical movement at each mesh point. Updating data subsequent to a device structure change is effectively accomplished due to the elaborate data structure. This excellent ability to represent and modify 3D device structures promises general purpose 3D process and device simulators.

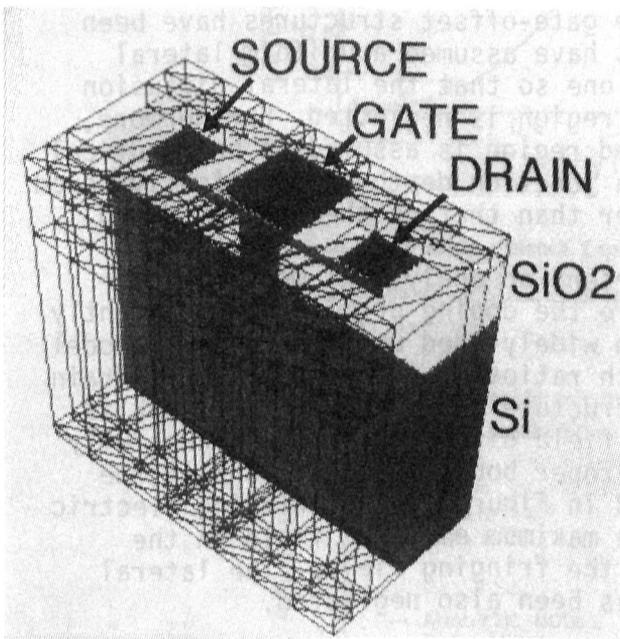
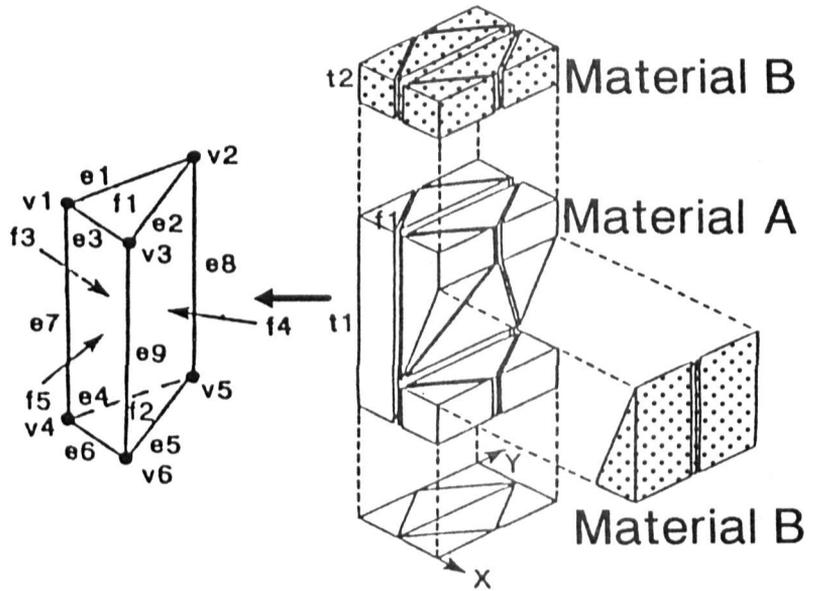
A 3D shape generator based on this method was developed. By using this tool, complicated device structures, such as overhang in trench structures and partial SOI structures[1], can be easily constructed. Usefulness of this method is demonstrated by applying the shape generator to a 3D device simulator.

## REFERENCES

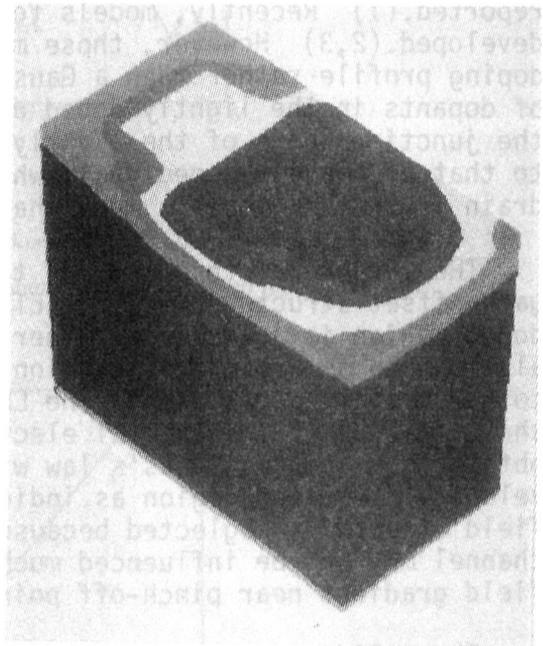
[1]T.Kubota et al., IEDM Tech. Dig., pp.344-347, 1987.

Fig.1 3D shape division into triangular prisms.

Each layer is represented as a set of generated prisms. Each prism is described by hierarchical data structures from prisms through vertices. For example,  $t1 \rightarrow (f1, f2, f3, f4, f5)$ ,  $f4 \rightarrow (e2, e4, e5, e8)$ ,  $e2 \rightarrow (v2, v3)$ . Data structures from vertices through prisms are also created to update data structures effectively. For example,  $v1 \rightarrow (e1, e3, e7, \dots)$ ,  $e1 \rightarrow (f1, f3, \dots)$ ,  $f1 \rightarrow (t1, t2)$ .



(a)



(b)

Fig.2 Application to 3D device simulation for the TOLE structure[1]. (a)Device structure. (b)Potential distribution.

A tetrahedral mesh system with 10000 mesh points was created which fits the device structure. Static characteristics are calculated in 60 seconds per one bias point, using an SX-2 super computer.