A NEW METHOD FOR SIMULATION OF ETCHING AND DEPOSITION PROCESSES

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Accurate simulation of etching and deposition processes requires three-dimensional models and algorithms for wafer topography evaluation. We present a new approach for topography simulation which is based on morphological filter operations for advancing the etch front.

The primary advantage of cell-removal methods is the topological stability during simulation. These algorithms can easily handle arbitrary structures and do not have the looping problem encountered in surface-advancement methods [1] [2] [3]. We use an array of rectangular cells for geometry representation, where each cell is characterized as etched or unetched. The material is defined through an identifier assigned to each cell. Material boundaries need not be explicitly represented. To advance the etch front we perform adaptive spatial filter operations along the surface boundary. During etching, cells within the filter are etched away, while cells outside stay unchanged. These filter operations are based on Minkowski algebra which allows one to simulate topography processes by use of the fundamental morphological operations of erosion and dilation, as they are termed in image processing [4]. In general, filters are ellipsoids, in case of isotropic movement of surface points filters are spheres, although there is no restriction on the filter shape. Thus, the simulation of etching with preferred etch directions such as in crystalline etching is also possible. The main axes of each filter are related to the simulation time step and to the local etch rates. The etch front at a given time step is obtained by the envelope of the filtered cells. With our method we avoid the inherent inaccuracy of the original cell algorithm [5], which in two dimensions produces an octagon instead of a circle during uniform etching from a single point, as shown in Figure 1.

Filter operations at material boundaries are performed using composite filters. In general, interfaces lead to an abrupt change in etch rates. For this reason, filter operations are always performed selectively on a given material, which means that only cells of the same material as the actual cell material are etched away during one filter operation. For a given time step, all cells which have to be filtered are stored dynamically in a linked list together with rate information. At the beginning of a simulation step, the linked list consists only of surface cells. Etching and deposition steps process the list. Filters which extend over a material boundary will add cells to that list, and are subsequently processed by additional filter operations. The etch rates for these filter operations depend on etch rates of both sides of the interface and on how far a filter reaches into the other material.

On the following page we present simulation results both in two and three dimensions. Figure 2 shows a deposition from a hemispherical vapor source. The growth rate of the evaporated film at each point is strongly dependent on the surface topology. As a result of shadowing, the growth rate varies in time. Figure 3 shows anisotropic etching with a mask. The topmost layer is a mask that etches slowly with respect to the underlying layers. Through the lateral etch rate of the second layer etching under the mask takes place. Figure 4 shows the correct movement of the etch front during etching at several layers starting from a planar geometry. As one can see, we are not restricted to a layered geometry. Three dimensional applications can be seen in Figure 5 and Figure 6. Figure 5 shows isotropic deposition to simulate a chemical vapor deposition process and Figure 6 shows an anisotropic etching process with a strong directional rate to simulate trench etching.

REFERENCES

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[5] F. H. Dill et al., *Modeling Projection Printing of Positive Photoresists*, IEEE Trans. ED, Vol. 22, pp. 456-464, 1975

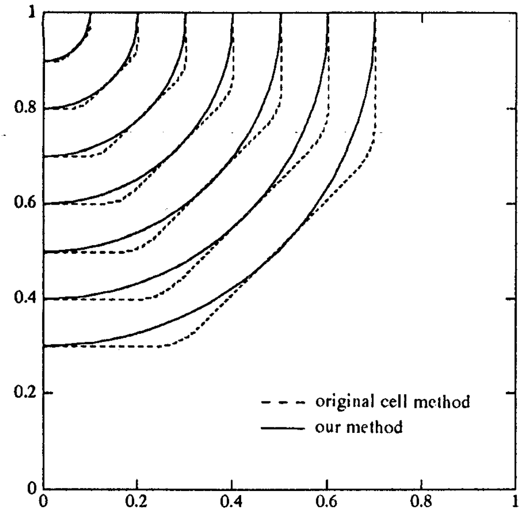

Figure 1: Comparison with original cell method

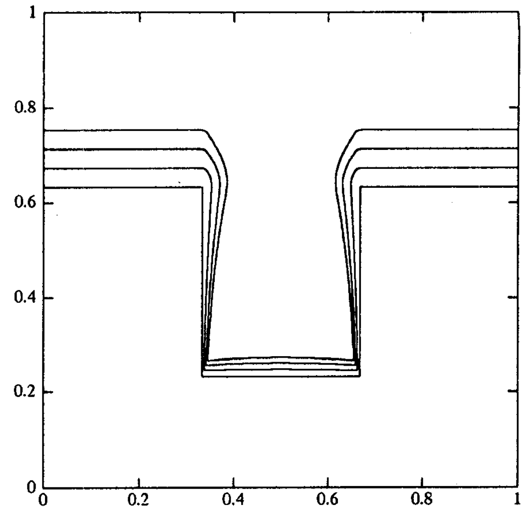

Figure 2: Deposition from hemispherical vapor source

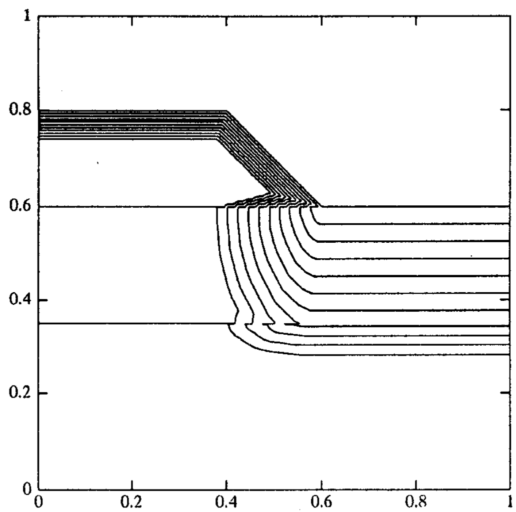

Figure 3: Etching with a mask

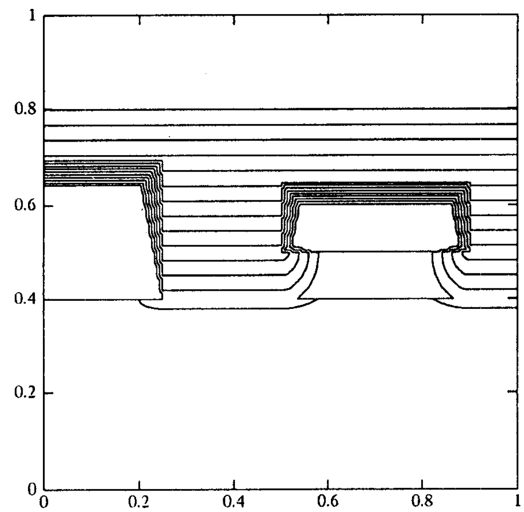

Figure 4: Etching at different layers

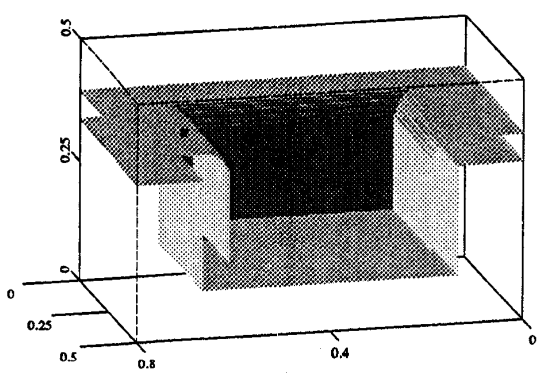

Figure 5: Isotropic deposition to simulate CVD Process

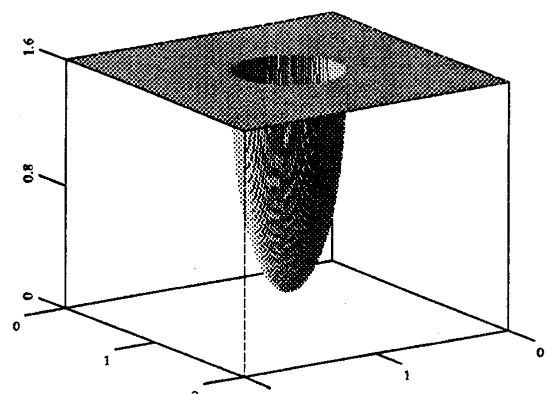

Figure 6: Etching of a trench