Three Dimensional Simulation of Ion Implantation

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A three-dimensional (3D) Monte Carlo simulation tool for ion implantation has been developed and implemented in the process simulator PROMIS [1]. Starting from an already existing two-dimensional (2D) code which contains some extensions for special 3D structures [2], a general 3D module has been developed. The boundaries between different segments are defined by planar faces. In addition, curved boundaries are allowed which are defined by arcs in planes parallel to the surface (see Fig. 1). A superposition method [2] is used to allow for the simulation of a large number of ions in order to get good statistics in reasonable computation times. As most of the simulation time is usually consumed in order to detect whether the particles cross a boundary, special attention was payed to the efficiency of these geometric checks. The algorithm and the techniques for speeding up the computation will be explained in the paper.

As an example we present in Fig. 3 and Fig. 4 the results of a 7° tilted and continously rotated Arsenic implantation into the oval trench shown in Fig. 1. About 50 million particles have been simulated, derived from the computation of 40000 independent trajectories. The simulation took about 12 hours on a DECstation 5000. Almost no difference is found as compared with 2D simulations, in particular, in the middle of the trench. This is due to the fact that for 2D computations the trench is assumed to be infinitely long (see Fig. 2). This condition is sufficiently satisfied in the middle of the structure. On the other hand 3D effects were detected for structures containing small details such as little edges or nooks and for implantations without beam rotation. This indicates that full 3D simulations are indispensable for the analysis of ion implantation in realistic structures.

References

[1] P. Pichler *et al.*, *Simulation of Critical IC-Fabrication Process*, IEEE Trans. on Electron Devices, ED-32, pp.1940-1953, 1985.

[2] G. Hobler and S. Selberherr, *Monte Carlo Simulation of Ion Implantation into Two- and Three-Dimensional Structures*, IEEE Trans. on CAD, Vol. 8, No. 5, pp. 450-459, 1989.

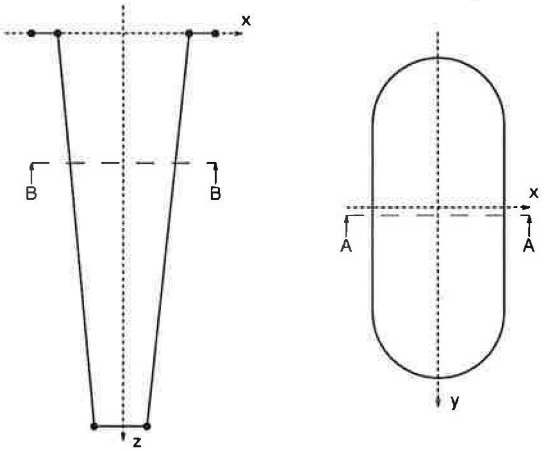

Figure 1: Geometry of simulated 3D trench, side and top view

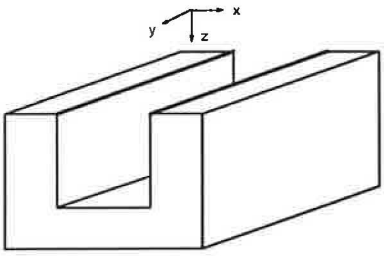

Figure 2: Geometry of a 2D trench

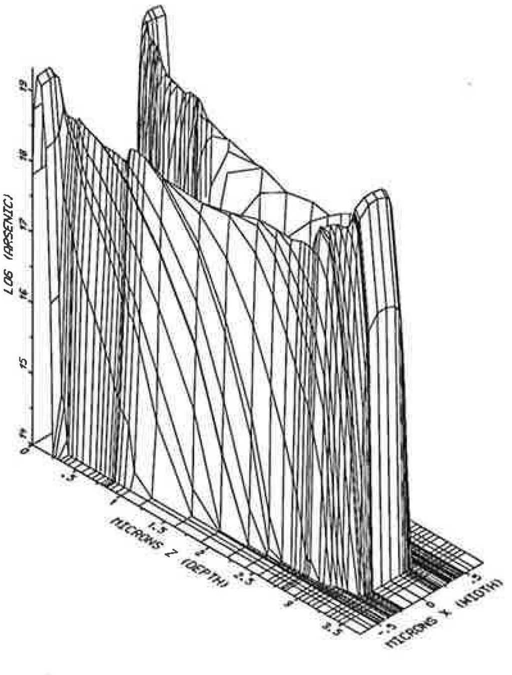

Figure 3: Cross section A – A in the middle of the trench, parallel to x/z-plane

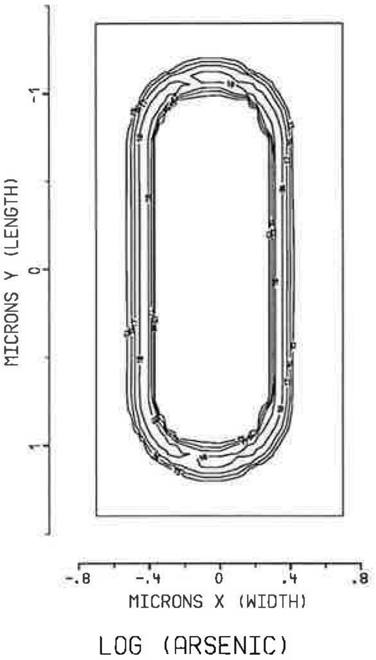

Figure 4: Cross section B – B, parallel to x/y-plane