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THREE-DIMENSIONAL LEVEL SET ETCHING PROFILE EVOLUTION SIMULATIONS

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Level set method, introduced by Osher and Sethian, is a highly robust and accurate computational technique for tracking of moving interfaces in etching, deposition and photolithography processes [1,2]. It originates from the idea to view the moving front as a particular level set of a higher dimensional function, so the topological merging and breaking, sharp gradients and cusps can form naturally, and the effects of curvature can be easily incorporated. This paper contains simulation results obtained by using simulation package based on the application of the sparse field method for solving level set equations in 3D isotropic and anisotropic etching of silicon. [3, 4]

Results of calculations performed with constant velocity function $R = R_0$ (purely isotropic etching case) are shown in Fig. 1.. It is supposed that only the bottom surface could be etched; i.e. that the top and the vertical surfaces belong to photo-resist layer. Behavior of the etching profile is as expected.

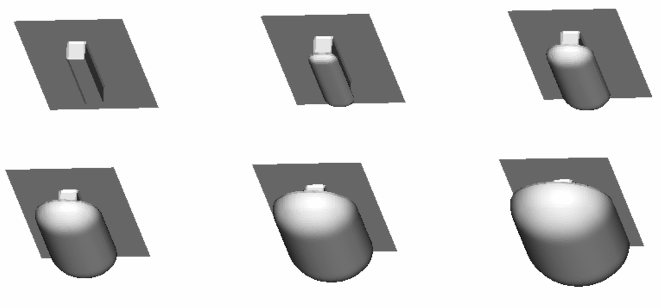

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Fig. 1: Isotropic etching – Feature profiles for $R = R_0$ at six equidistant (reduced) time moments.

Evolution of the etching profile, when etching rate is proportional to cos θ, is presented. In Fig. 2. This is the simplest form of angular dependence that leads to a non-convex Hamiltonian, but it describes the ion enhanced chemical plasma etching process correctly [7]. The angle θ represents the angle between surface normal and vertical direction (z-axes). In this case we expect that the horizontal surfaces move downward, while the vertical ones stay still. This figure shows that it with optimal amount of smoothing gives minimal rounding of sharp corners, while preserving the numerical stability of the calculations. Actually, this is one of the most delicate problems in the etching profile simulations.

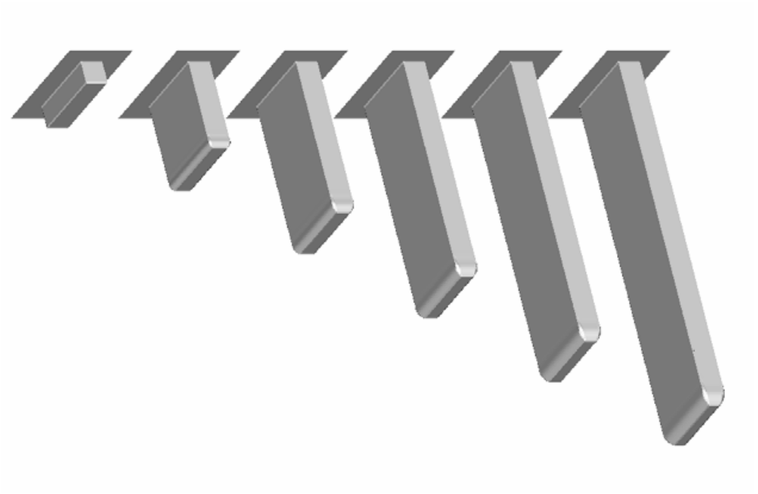

Fig. 2: Anisotropic etching – Feature profiles for $R = R_0 \cos \theta$ at six equidistant (reduced) time moments.

The obtained results show that level set method can be used as an effective tool for wet etching process modelling, and that is a viable alternative to the Cellular Automata method which now prevails in the simulations of the wet etching process.

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Reference

[1] J. Sethian 1998 *Level Set Methods and Fastmarching Methods: Evolving Interfaces in Computational Geometry, Fluid Mechanics,Computer Vision and Materials Sciences* (Cambridge University Press, Cambridge).
[2] S.Osher and R. Fedkiw 2003 *Level Set Method and Dynamic Implicit Surfaces*, (Springer-Verlag, New York, NY).
[3] B. Radjenović, J. K. Lee and M. Radmilović- Radjenović, 2006 *Computer Phys. Comm.* **174** 127
[4] B. Radjenović and M. Radmilović- Radjenović, 2007 *Journal of Physics: Conference Series* **86** 012017.