2D PROCESS SIMULATION WITH ACCURATE DOPANT AND STRESS PROFILES CALCULATIONS

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The size reduction of the silicon integrated structures goes with a complexity increase of topological configurations and a wider range of processed materials. The conjunction of these trends naturally leads to the generation of higher mechanical stresses during the processing [1]. Due to the well known drawback of such stresses on the final device electrical behavior, the new generation of process simulators has to treat the mechanical stresses as standard calculation outputs for almost all the process steps.

The major numerical difficulty in addressing both the mechanical calculations and the dopant simulations is the choice of the spatial discretisation. Usually, in 2D process simulation, the doping profiles are computed on grids with linear shape function. In the opposite way, the mechanical problems included in the oxidation simulation are solved on quadratic elements. This higher discretisation scheme is required to correctly treat the oxide incompressibility when a viscous behavior is assumed. The simultaneous management of this two kinds of discretisation is not straight forward for complex topologies and can lead to very high C.P.U. time requirement.

In the proposed approach, the inclusion of the mechanical calculations is shown in the case of stress dependent oxidations. Both the oxide and the nitride layers are considered as Maxwell visco-elastic material, an Eyring's plasticity is moreover assumed for the oxide. The stress field acts on the oxidation rate, oxidant diffusivity and oxide plasticity according to the models summarized by Sutardja et al.[1].

The same finite element mesh, composed of P1 3 noded triangles, using linear shape function is used for both the diffusion (dopants, point defects and oxidants) and the mechanical (stress dependent oxide motion) problems. Fine meshes can be generated and used during all the simulations with reasonable C.P.U. time consumptions. In counter part, the stresses are constant within each element and the obtention of accurate solutions need to treat them at the nodal location by considering the mean value on the surrounding elements. Each time the topology is updated, the meshes are completely regenerated for all the layers and the stresses (and the dopants) are interpolated and relaxed from the old mesh to the new one.

The efficiency of the whole procedure is demonstrated by the following 4 figures that give typical simulation results. The figure 1 shows a typical mesh at the end of a SWAMI oxidation simulation. The figures 2 and 3 display the bulk pressure field in the case of a trench and a buried LOCOS oxidations, respectively. Finally, the figure 4 shows a channel stopper doping obtained after a poly-buffered LOCOS simulation.

[1] S.M. Hu, "Stress-related problems in silicon technology", J. Appl. Phys., Vol. 70 (5), 15 Sept 1991.

[2] P. Sutardja, W. Oldham and D.B. Kao, 'Modeling of stress-effects in silicon oxidation including the non-linear viscosity of oxide', IEDM Tech. Digest, pp. 264-267, 1987.

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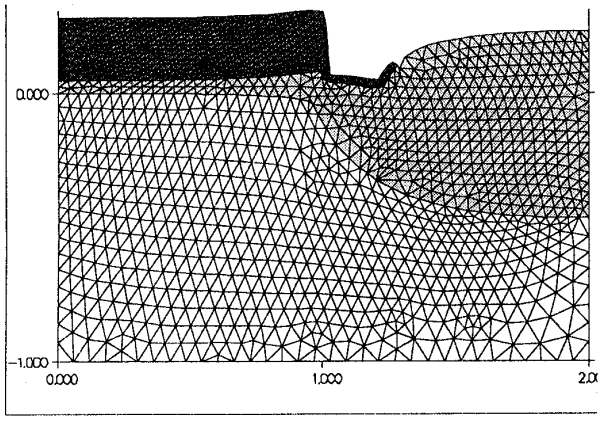

Figure 1: Mesh obtained at the end of a stress dependent SWAMI oxidation simulation.

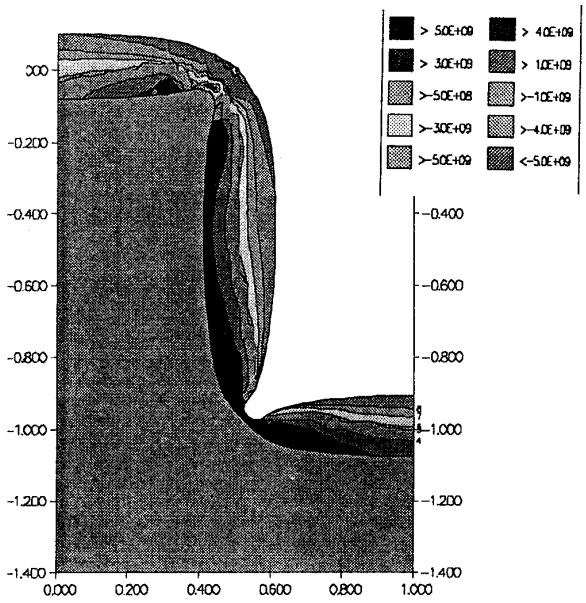

Figure 2: Bulk pressure profile at the end of a low temperature high pressure trench oxidation.

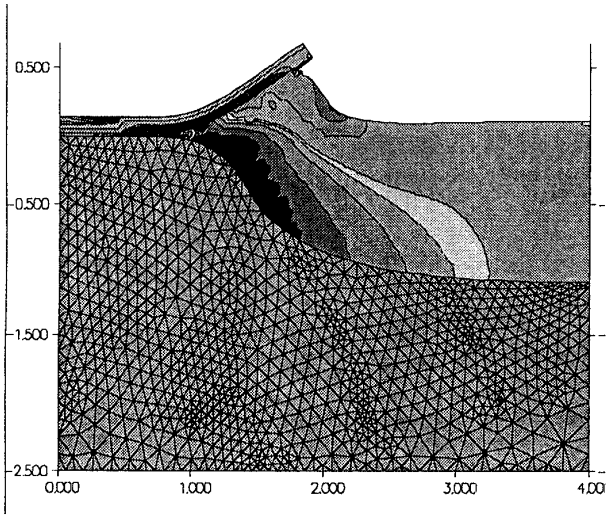

Figure 3: Bulk pressure profile for a full recessed LOCOS.

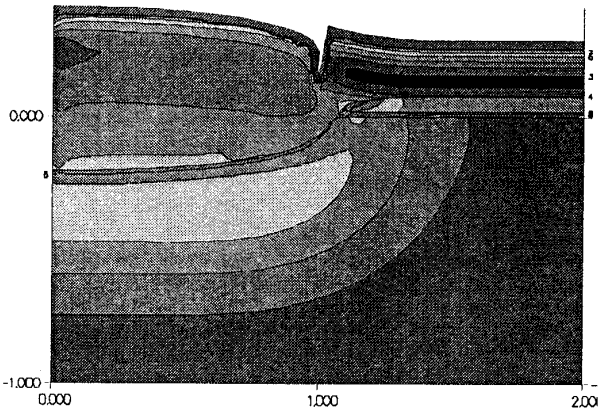

Figure 4: Boron profile in the case of a Poly-Buffer Oxide.