Materials Science & Engineering Master's Defense

Algebraic Multigrid Poisson Equation Solver

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abstract

From 2D planar MOSFET to 3D FinFET, the geometry of semiconductor device is getting more and more complex. Correspondingly, the number of mesh grid points increases largely to maintain the accuracy of electron transportation and heat transfer simulations. Alternating conventional uniform mesh with non-uniform mesh, the number of grid points could be reduced. However, the problem of how to solve governing equations on non-uniform mesh is imposed to the numerical solver. Moreover, if a device simulator is integrated into a multi-scale simulator, the problem size will be further increased. Consequently, there exist two challenges for the current numerical solver. One is to increase the functionality to accommodate non-uniform mesh. The other is to solve governing physical equations fast and accurately on a large number of mesh grid points.

This research first discusses a 2D planar MOSFET simulator and its numerical solver, pointing out its performance limit. By analyzing the algorithm complexity, Multigrid method is proposed to replace conventional Successive-Over-Relaxation method in a numerical solver. A variety of Multigrid methods (standard Multigrid, Algebraic Multigrid, Full Approximation Scheme, and Full Multigrid) are discussed and implemented. Their properties are examined through a set of numerical experiments. Finally, Algebraic Multigrid, Full Approximation Scheme and Full Multigrid are integrated into one advanced numerical solver based on the exact requirements of a semiconductor device simulator. A 2D MOSFET device is used to benchmark the performance, showing that the advanced Multigrid method has higher speed, accuracy and robustness.

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