CHAPTER 1: Introduction

1.1 General Information

BSIM3v3 is the latest physics-based, deep-submicron MOSFET model for digital and analog circuit designs from the Device Group at the University of California at Berkeley. BSIM3v3 has been extensively modified from its previous release (BSIM3 Version 2.0). Amongst the new advancements are:

- A single I-V expression to describe current and output conductance characteristics from subthreshold to strong inversion as well as from the linear to the saturation operating regions. Such a formulation guarantees the continuities of Ids, Gds, Gm and their derivatives throughout all Vgs, Vds and Vbs bias conditions. In addition, all previous kinks and glitches at device operation boundaries are eliminated.
- New width dependencies for bulk charge and source/drain resistance (Rds). This greatly enhances the accuracy in modeling narrow width devices.
- ΔW and ΔL dependencies for different Wdrawn and Ldrawn devices. This improves the model's ability to fit a variety of W/L ratios with a single set of parameters.
- A new capacitance model has been formulated to address the concern and to improve the modeling of short and narrow geometry devices.
- Lastly, BSIM3v3 includes a new relaxation time model for characterizing the non-quasi-static effect of MOS circuits for improved transient modeling.

In the mist of all these new features, BSIM3v3 still retains the same physical underpinnings of BSIM3 Version 2.0. For example, his new model still has the extensive built-in dependencies of important dimensional and processing parameters (e.g. channel length, width, gate oxide thickness, junction depth, substrate doping concentration, etc.). This allows users to accurately model the MOSFET over a wide range of channel lengths as well as channel widths for present as well as future technologies. Furthermore, BSIM3v3 still relies on a coherent pseudo-2D formulation to model various short-channel and high field effects such as the following:

- threshold voltage roll-off,
- non-uniform doping effect,
- mobility reduction due to vertical field,
- carrier velocity saturation,
- channel-length modulation,
- drain induced barrier lowering,
- substrate current-induced body effect,
- subthreshold conduction, and
- parasitic resistance effect.

Meticulous care has been taken to mesh the above model enhancements with high levels of accuracy and minimum simulation costs. In addition, the enhanced expressions yield more continuous behavior and should also help to facilitate faster SPICE convergence properties.

1.2 Organization of Manual

The manual will introduce BSIM3v3's capabilities in the following manner:

- Chapter 2 will highlight the physical basis and arguments used in deriving BSIM3v3's I-V equations.
- Chapter 3 will combine these various BSIM3v3 equations for different operational regimes in a unified I-V model.
- Chapter 4 will present the new capacitance model.
- Chapter 5 will detail the inclusion of the new model for transient modeling called the NQS (Non-Quasi-Static) Model.
- Chapter 6 will discuss SPICE model file extraction.
- Chapter 7 will provide results of some benchmark tests applied on the model to illustrate its general robustness (no discontinuities).
- Chapter 8 will conclude with the noise model.
- Chapter 9 will describe the MOS diode model.
- Finally, the Appendix will list all model equations and references used throughout this manual. In addition, model parameters which can be binned during parameter extraction will also be listed.