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Three-Dimensional Simulation of Semiconductor Devices

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Preface

The three-dimensional device simulation has become a necessary tool for the design and investigation of complex device structures. The evolution of the three-dimensional simulation tools is directly linked to the scaling of the devices and the increasing complexity of dynamic random access memory (DRAM) cells. Scaling of MOSFET devices led to a three-dimensional geometry with effects which cannot be handled by two-dimensional simulations anymore. With increasing integration density in DRAMs the third dimension had to be utilized to realize the storage capacitor. The resulting leakage problems have to be investigated and the cell design optimized by means of three-dimensional simulations.

This book is intended for senior undergraduate students in applied physics, electrical engineering and computational physics, as well as for scientists and engineers involved in semiconductor device research and development. It is also intended for software engineers and all those who are concerned with simulation.

The book will give an overview on the problems and activities concerning three-dimensional device simulation, without the claim of being a classical textbook. It starts from the classical semiconductor equations, discusses the physical models used in device simulation, describes the discretization and some numerical methods for solving the differential equations. The application of the three-dimensional simulation to VLSI device engineering is illustrated by a few specific examples. These examples have been calculated by utilizing the simulator SITAR (SIemens Trench cell AnalyzeR), which has originally been developed for a master's thesis to investigate leakage in the 4 Megabit trench capacitor cell. In the

meantime, this simulation tool has been and still is successively extended to meet the demands of new device structures.

In the course of developing the program and writing the book many people have assisted us and offered their support. We would first like to express our appreciation to the management of Corporate Research and Development of Siemens AG for providing us with the opportunity in developing the simulator during the MEGA project. We would like to thank especially Dr. K. Merten, Dr. A. Wieder, Dr. A. Gilg and H. Bierhenke for their steady interest and encouragement from the very beginning, Dr. U. Bürker, Dr. H. Jacobs and all our collegues for their support, Dr. W. Müller and Dr. L. Kusztelan of the Siemens Semiconductor Division for providing us with important technological data and for many fruitful discussions. Furthermore, we send our thanks to Prof. Dr. F. Koch for his helpful care and supervising during the master's thesis of one of us (W.B.). We greatly acknowledge the critical reading of the manuscript by Miss M.C. Neiderhell. We are further indebted to our publishers, Birkhäuser Verlag, especially to B. Zimmermann, for giving us the opportunity to publish and the encouragement during writing this book. A part of the book has been written during a research stay of one author (R.K.) at the Superclean Room of the Tohoku University in Sendai. Last but not least we want to thank the Tohoku University for providing the time preparing parts of this book.

W. Bergner and R. Kircher

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