Preface

In recent years the field of compact MOSFET modeling for circuit simulation has entered into a remarkable transition phase. The traditional approach, represented by the series of the BSIM model standards and based on the threshold voltage of the MOSFET combined with a piece-wise modeling of different operating regions, has been widely displaced from the agenda of active research groups in compact modeling. All currently pursued new approaches are based instead on the drift-diffusion approximation and are centered on either the inversion charge or the surface potential of the MOSFET channel. Some of the resulting new compact MOSFET models are already on the verge of productive usage in industrial applications with the surface-potential-based models taking the lead position. Consequently, surface-potential-based models are predicted to become the future main stream in the productive application of the IC industry.

Aggressive scaling down of device sizes is causing enhanced complexities in device characteristics, which require very sophisticated device physics to understand as well as to model. The main complexity is caused by the 2-dimensional effects, which were negligible in the past. The quantum mechanical effect is also becoming increasingly important. To model all these newly important effects, the most straightforward approach is to follow their underlying physics. For consistency of this well understandable approach, the basis of the model has to follow the device physics as well. All device features are induced by the potential distribution along the channel, which is represented by the surface potential as the physical basis of a compact model.

The described changes represent indeed a revolutionary movement for the compact modeling community, which has been rather stable and conservative with respect to the applied modeling approaches. This change of compact modeling concepts opens at the same time the possibility of a merger with the technology CAD (TCAD) field, which usually targets the problems of technology and device optimization. Thus the newly emerging compact models are expected to increasingly become real bridges between fabrication technology and resulting integrated circuits, because compact model parameters are indeed closely corresponding to the physical parameters of the fabrication technology.

This textbook describes the device physics of observed MOSFET phenomena and the modeling approach of the surface-potential-based MOSFET model HiSIM (Hiroshima-university STARC IG-FET Model). HiSIM is the result of research work pioneering the application of the surface-potential modeling to MOSFETs fabricated with advanced technologies which was carried out as a cooperation between Hiroshima University and the Semiconductor Technology Academic Research Center (STARC).

Contributors for the cooperation between Hiroshima University and STARC are
D. Navarro, N. Sadachika, M. Miyake, Y. Takeda, G. Suzuki, S. Hosokawa, T. Mizoguchi, S. Jinbou, N. Nakayama, S. Chiba, K. Konno, Y. Mizukane, T. Warabino, K. Machida, T. Yoshida, H. Ueno, K. Hisamitsu, H. Kawano, D. Kitamaru, T. Honda, S. Matsumoto, S. Mitani, D. Miyawaki, H. Nagakura, S. Nara, M. Nishizawa, T. Okagaki, S. Ohshiro, Y. Shiraga, K. Suematsu, M. Suetake, M. Tanaka, Y. Tatsumi, T. Yamaoka at Hiroshima University

and

T. Ohguro, T. Iizuka, M. Taguchi, S Kumashiro, T. Yamaguchi, K. Yamashita, S. Odanaka, N. Shigyo, R. Inagaki, Y. Furui, S. Miyamoto, S. Hazama at STARC

The basic concepts of the modeling approach used for developing HiSIM and the resulting modeling equations up to the version HiSIM2.4.0, are explained in detail. For this purpose the physics behind HiSIM is illustrated with the help of 2D-device simulations and is used to extract the resulting essential MOSFET properties in simple analytical form.

There is of course still room for further improvements and remaining insufficiencies exist, which require continuing modeling efforts. We analyse such problems and give an overview of resulting future development requirements.

Hopefully, this textbook will serve the developers as well as the users of compact models in industry and academia as a reference source for the practical application of the surface-potential approach to the development of MOSFET models for circuit simulation. In this way we together with all contributors wish to help and facilitate the development of even more reliable and powerful compact models for present and future advanced device structures.

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