SURFACE POTENTIAL BASED MODEL FOR SURROUNDING-GATE MOSFETs

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For extending the scalability of CMOS technology below the technological node of 45 nm, multiple-gate structures are being investigated for adequately control short-channel-effects (SCE) [1]. Among these multiple-gate structures, the cylindrical surrounding-gate (SGT) structure presents the best control of SCE and can be scaled to the shortest channel length possible for a given gate oxide thickness (Fig. 1). Due to the potential of this novel structure for the microelectronics evolution is crucial to dispose of simple and accurate compact models of SGT-MOSFETs that bridge the gap between circuit design and process fabrication. These models must accurately capture the threshold voltage, which can be adjusted by tuning the gate electrode work-function and by finite body doping.

In this work we propose a simple analytical model for obtaining the current-voltage characteristics of the SGT-MOSFET, based on perturbed solutions of the Poisson's equation, and drift-difussion equation, extending the state of the art by including the body doping effect [2]. The model has two distinctive features: (i) the inversion carriers and the body doping charge (N_A) are considered in Poisson's equation, providing a more general description of the potential than previous models [3] (ii) the current for all the operation regions is described by one continuous function in terms of the surface potential, tracing properly the transition between them without resorting to non-physical fitting-parameters, avoiding the discontinuities across different operation regions encountered in threshold voltage based compact models. It is shown that the current-voltage characteristics obtained with this model agree with three-dimensional numerical simulations for all ranges of gate and drain voltages. The presented long-channel model is ideally suited for being the kernel of a SGT-MOSFET compact model. In order to complete the model, SCE, quantum effects, low and high field transport, noise, and more, should be added.

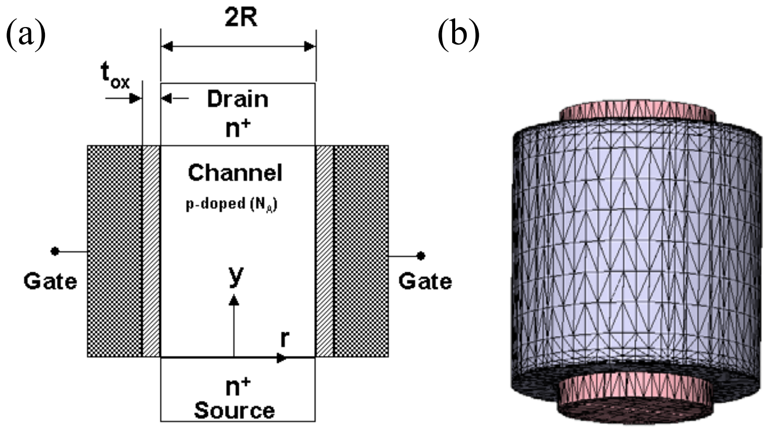

Figure 1: (a) Cross section of the SGT-MOSFET. (b) Complete view of the SGT-MOSFET.

References:

[1] International Technology Roadmap for Semiconductors (2005 Edition).
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