A Closed-Form Compact Model for Symmetric Double-Gate MOSFETs

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Introduction

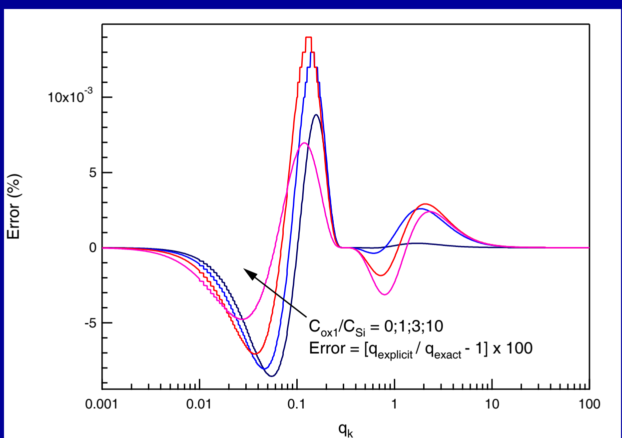
- We present an explicit model for the undoped DG MOSFET under symmetrical operation.
- This compact model is physics-based and fully analytical. It is dedicated to circuit design & simulation.
- A robust algorithm for computing the mobile charge density has been carried out. As a result, there are no iteration loops anywhere in the model.
- The model relies on the EKV formalism originally developed for bulk MOSFETs.

Numerical inversion algorithm

- In this work, for the first time, we propose an explicit model for the symmetric DG MOSFET that is simple, continuous and computationally efficient [2].
- An implicit formulation of our DG MOSFET compact model can be found in [1]. This original model is efficient and accurate but requires an iterative procedure to compute the mobile charge density, which is generally considered to be time consuming. In addition, such an implicit formulation may cause some convergence problems within circuit simulators.
- The implicit model is based on a fundamental relationship between charge densities and potentials, given by [1]

$$v_g^* - v_{ch} - v_{to} = 4 \cdot q_g + \ln\left[q_g \cdot \left(1 + q_g \cdot \frac{C_{ox1}}{C_{Si}} \right) \right] \qquad (1)$$

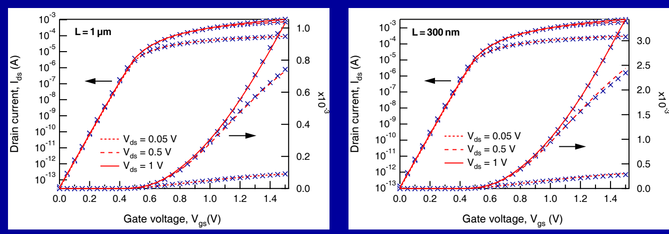
- The numerical inversion of Eq. 1 leads to an analytical solution for charges vs. terminal voltages. So we can straightforwardly obtain the current and the transcapacitances as well [3].
- Our new algorithm allows to greatly reduce the computation time without loss of accuracy as shown below.



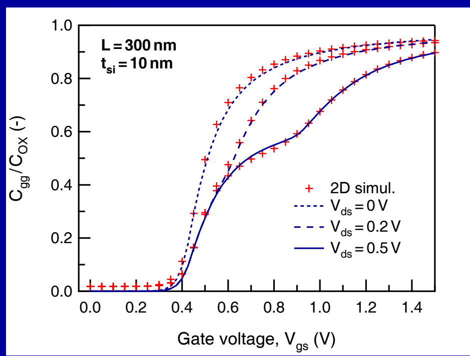
Computation of the error between the exact value of the normalized mobile charge q_{exact} and its approximate explicit solution $q_{explicit}$.

Comparison with 2D simulations

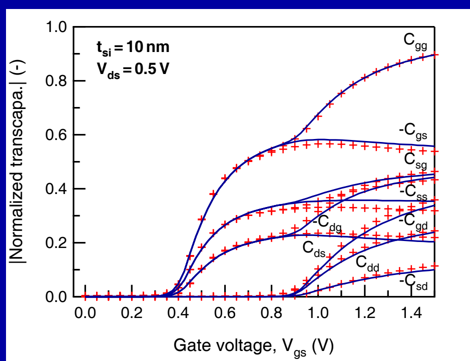
➔ Drain current vs gate voltage for different V_{ds} voltages (crosses: 2D simulations, lines: model). Mobility reduction due to transverse electric field is taken into account. Technological data: t_{ox}=2nm and t_{si}=10nm.



➔ Input gate capacitance with respect to total gate oxide.



➔ Transcapacitance matrix as a function of gate voltage.



Conclusion

- A closed-form approximation of Eq. 1 suitable for compact modeling of the DG MOSFET has been developed.
- Computation time is no longer an issue and the accuracy of the original implicit formulation was preserved.
- The new model describes accurately and continuously both static & dynamic characteristics without any fitting parameter.
- The VHDL-AMS code of the model is already operational [2].

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[1] J.-M. Sallese *et al.*, *Solid-State Electronics*, vol. 49, no. 3, pp. 485–489, 2005.
[2] F. Prégaldiny *et al.*, *submitted to International Journal of Numerical Modelling, 2005.*
[3] F. Prégaldiny *et al.*, *submitted to Solid-State Electronics, 2005.*