HiSIM1.2: The Effective Gate Geometry Determination with the Capacitance Data

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Motivation of this study

• HiSIM-1.2 has no dedicated parameters for the gate capacitance. And the capacitance for the shorter channel devices showed the discrepancy with the measurement in spite of the good DC fitting.

WHY    ????
Motivation of the study: HiSIM-1.2 example
not a bad DC result

solid red: measurements
dashed black: HiSIM-1.2

Ids/Vds @Vbs=0
Vds = 0 -> 1.0V
Vgs = “nearVth”
-> 1.0V

Ids/Vgs@Vds=0.05V
Vgs = 0 -> 1.0V
Vbs = 0 -> -0.5V
Motivation of the study: HiSIM-1.2 example
the incorrect gate capacitance for the shorter channel

The measured peak capacitance values are almost proportional
to the channel length.
A simple fact of HiSIM-1.2

- HiSIM gate capacitance which is derived from the charges depends naturally on the gate area.

The gate geometry correction should be able to modify the capacitance value.
HiSIM-1.2 geometry adjustment: fitting to the peak capacitance

The inversion loses the accuracy for the shorter channel.
Another simple fact of HiSIM-1.2

• The substrate impurity concentration has four variables.

\[ N_{\text{sub}} = \frac{N_{\text{subc}}(L_{\text{eff}} - L_{p}) + N_{\text{subp}}L_{p}}{L_{\text{eff}}} \]

\( N_{\text{subc}}, L_{\text{eff}}, \) and \( L_{p} \) are fixed beforehand.

• The \( N_{\text{subp}} \) is the variable for the weak inversion capacitance of the shorter channel length.
Fixing HiSIM-1.2 pocket concentration parameter

HiSIM-1.2 gate overlap capacitance is implemented incorrectly.
HiSIM-1.2 parameters fixed to the gate capacitance

• HiSIM-1.2 parameters such as geometry, and substrate variables can be determined using the gate capacitance data.

However, the Ids versus Vgs curves to validate the threshold voltage roll up and off aren’t sufficient.
HiSIM-1.2 DC curves fixed to the gate capacitance

The channel length correction is overestimated.
The pocket impurity concentration is underestimated.
Procedure to extract HiSIM-1.2 physical parameters

1. Specify TOX

2. Determine NSUBC, VFBC for a large area gate capacitance

   The initial NSUBP is the same as NSUBC.

3. Determine LP(pocket penetration length) from Vth vs. L.

   LP is a point where the radical Vth roll up starts: about 1 um for the example.
Procedure to extract HiSIM-1.2 physical parameters

4. Determine channel length correction for gate capacitance

5. Fix NSUBP(maximum pocket concentration) for gate capacitance inversion
Procedure to extract HiSIM-1.2 physical parameters

6. Validate Id-Vgs and adjust NSUBP

Try to correct less for the gate geometry parameters

7. Adjust the low field mobility

Ids/Vgs@Vds=0.05V
Vgs = 0 -> 1.0V
Vbs = 0 -> -0.5V
HiSIM-1.2 parameters for the electric field gradient

The scalable parameter effects for Vth vs. L are apparent.

SC3 effect on the Vth roll-off mainly for Vbs
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