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Compact DC Model for Lightly-Doped Short Channel Triple-Gate MOSFETs

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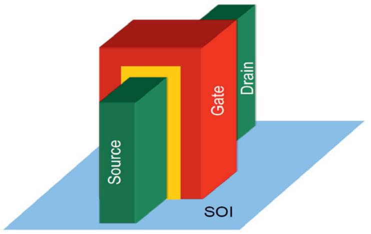
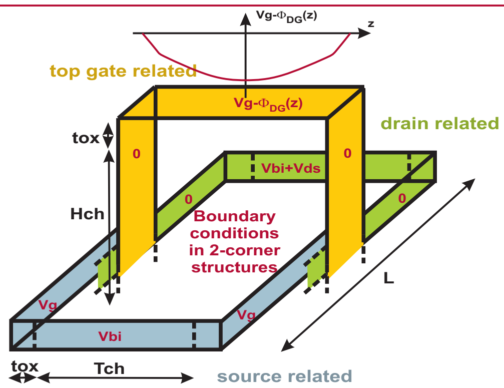
- The model is based on an analytical solution of 3D Poisson's equation by the conformal mapping technique.
- 3D Laplace equation is solved in subthreshold regime and thereof the profile of the potential barrier in the channel is calculated.
- For triple-gate devices the influence of the top gate is included.
- BOX influence and quantum confinement are neglected.



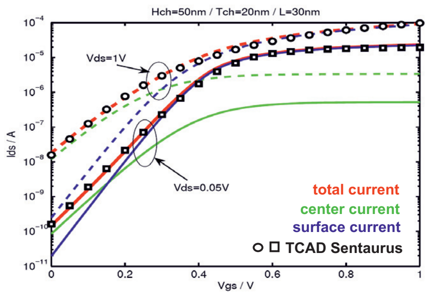


3D Analytical Model for the Electrostatics

- The device structure is decomposed into three 2-corner structures with individual boundary conditions:
  source related - drain related - top gate related
- From superposition of these three solutions the channel potential at the barrier has been solved in analytical closed form.
- By radical simplification of the solutions published in [1] analytical compact model equations have been derived.

Current Calculation

- The channel current below threshold is derived from the profile of the potential barrier.
- Above threshold a surface channel current is assumed, using a threshold voltage based description derived from the 3D potential solution.
- A simple field-dependent mobility model and a model for the saturation voltage is introduced.
- The shift of the most-leaky path in the channel cross section of a short channel device from the bottom center (subthreshold) to the surface (above threshold) is taken into account by superposing the center current with the surface current in a charge-based current equation [2,3].



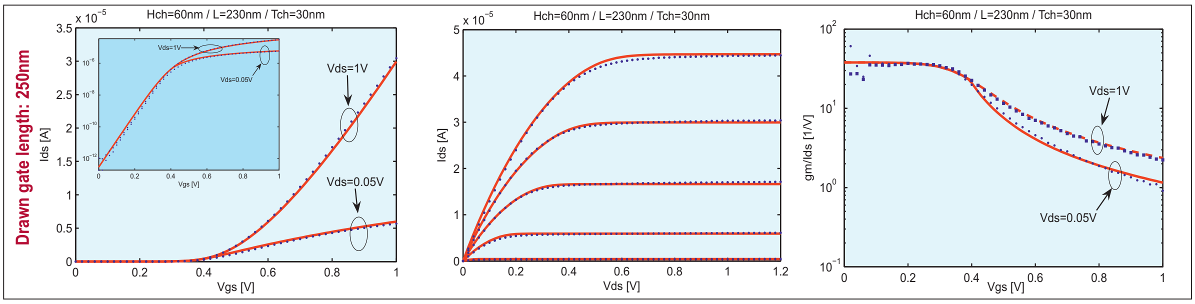
$$I_d = \mu W \left[\frac{2V_{th}}{L - x_{min}} \left(Q_{id,sth} - Q_{is,sth} \right) - \frac{\left(Q_{id,str}^2 - Q_{is,str}^2 \right)}{4LC_{ox}'} \right]$$

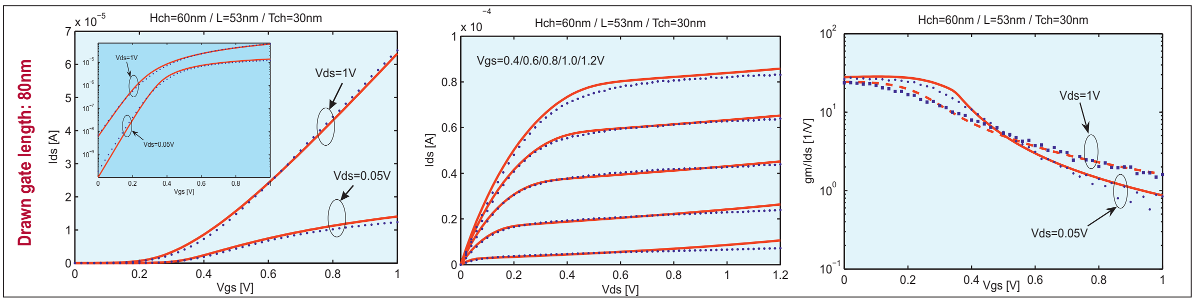
Model Compared to Measurements

- Due to a close link to device structure the model requires a minimum number of fitting parameters while keeping physical insight.
- The model is in good agreement with TCAD down to L=22nm (with reasonable Tch=10nm).
- Comparisons with measurements confirm a high accuracy down to a fin thickness of 30nm and effective channel length of 60nm.

Model Parameters

Device:		L_{drawn}=250nm	L_{drawn}=80nm		
Structural	L	230	53	[nm]	effect. channel length
	T_{ch}	30	30	[nm]	channel thickness
	H_{ch}	60	60	[nm]	channel height
	t_{ox}	2	2	[nm]	oxide thickness (SiO_2)
Mobility	μ_0	260	180	[cm^2/Vs]	low-field mobility
	θ	0.72	1.35	[ ]	fitting E_{normal} μ
	v_{sat}	$1.45 \cdot 10^7$	$1.2 \cdot 10^7$	[cm/s]	saturation velocity
	E_p	10^5	10^6	[V/cm]	pinch-off electric field
Misc.	N_b	10^{15}	10^{15}	[cm^{-3}]	substrate doping
	V_{fb}	-0.327	-0.327	[V]	flatband voltage
	V_{bi}	0.85	0.85	[V]	built-in voltage s/d
	ϕ_i	0.6954	0.6954	[V]	inversion potential V_{th}





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[2] Ortiz- Conde A, Garcia-Sanchez FJ, Muci J, Malobabic S, Liou JJ. A review of core compact models for undoped double-gate SOI MOSFETs. IEEE TED 2007;54(1)

[3] Kloes A, Weidemann M, Schwarz M. Analytical current equation for short channel SOI multigate FETs including 3D effects. Solid-State Electron 2010;54

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