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BSIM4.5.0 UPDATES

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BSIM4.5.0 New Features

- ❑ Mobility coulomb scattering effect and channel length dependence
- ❑ Scalable substrate resistance model ($r_{bodyMod} = 2$)
- ❑ Improved impact ionization(II) model with thermally-assisted impact ionization besides normal II mechanism
- ❑ XGW, NGCON instance parameters for gate resistance model (XGL still model parameter)
- ❑ TVOFF, TVFBSDOFF temperature dependence
- ❑ $tempMod = 2$ for $\Delta V_{th}(DITS)$, $V_{fbzb}(T)$, gate tunneling model with T replaced by TNOM
- ❑ DELVTO instance parameter



Mobility Model for BSIM4.5.0

Mobility Coulomb Scattering Model and L_{eff} dependence

- mobMod = 0

$$m_{eff} = \frac{U0 \cdot f(L_{eff})}{1 + (UA + UC V_{bseff}) \left(\frac{V_{gsteff} + 2V_{th}}{TOXE} \right) + UB \left(\frac{V_{gsteff} + 2V_{th}}{TOXE} \right)^2 + UD \left(\frac{V_{th} \cdot TOXE}{V_{gsteff} + 2V_{th}} \right)^2}$$

- mobMod = 1

$$m_{eff} = \frac{U0 \cdot f(L_{eff})}{1 + \left[UA \left(\frac{V_{gsteff} + 2V_{th}}{TOXE} \right) + UB \left(\frac{V_{gsteff} + 2V_{th}}{TOXE} \right)^2 \right] (1 + UC \cdot V_{bseff}) + UD \left(\frac{V_{th} \cdot TOXE}{V_{gsteff} + 2V_{th}} \right)^2}$$

- mobMod = 2

$$m_{eff} = \frac{U0 \cdot f(L_{eff})}{1 + (UA + UC \cdot V_{bseff}) \left[\frac{V_{gsteff} + C_0 \cdot (V_{TH0} - V_{FB} - \Phi_s)}{TOXE} \right]^{EU} + UD \left(\frac{V_{th} \cdot TOXE}{V_{gsteff} + 2V_{th}} \right)^2}$$

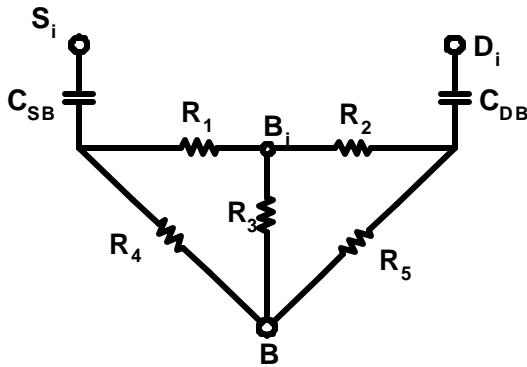
Where: $f(L_{eff}) = 1 - UP \cdot e^{-L_{eff} / LP}$

The model is backward compatible with UP=0.0, UD=0.0



Scalable Substrate Resistance Model

$$R_X = R_{X_HORI} \parallel R_{X_VERT} \quad \text{where} \quad R_{X_H(V)} = R_0 L^a W^\beta NF^?$$



5 Resistor Network

	HORIZONTAL CONTACT				VERTICAL CONTACT			
	R_0	a	b	g	R_0	a	b	g
R_1	1	2	3	4	NR	NR	NR	NR
R_2	1/5	2/6	3/7	4/8	NR	NR	NR	NR
R_3	5/9	6/10	7/11	8/12	9/13	10/14	11/15	12/16
R_4	13/17	14/18	15/19	16/20	17/21	18/22	19/23	20/24
R_5	13/25	14/18	15/19	16/20	17/26	18/22	19/23	20/24

- R1, R2 need not differentiate contact arrangements.
- R4 and R5 expected to have similar scaling laws.



Impact Ionization Model for BSIM4.5.0

$$I_{SUB} = ALPHA \cdot I_{ds, MOSFET} \cdot \exp\left(\frac{V_{diff}}{BETA2 + BETA1 \cdot V_{diff} + BETA0 \cdot V_{diff}^2}\right)$$

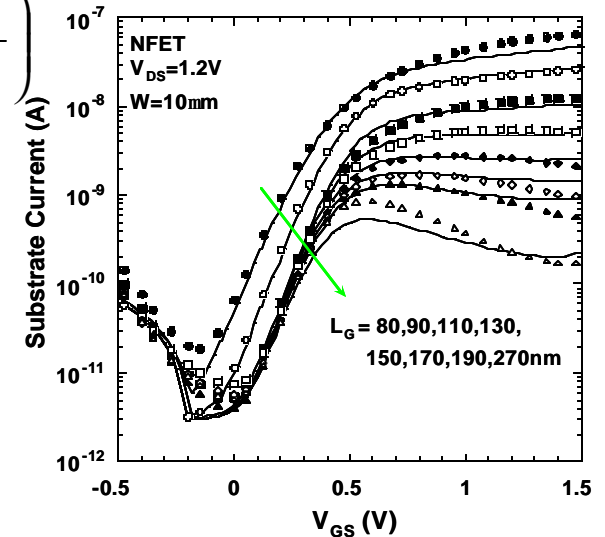
$$V_{diff} = V_{ds} - V_{dsatii}$$

$$V_{dsatii} = V_{gsStep} + \left[VDSATII0 \left(1 + TH1 \left(\frac{T}{T_{nom}} - 1 \right) \right) - \frac{LII}{L_{eff}} \right]$$

$$V_{gsStep} = \left(\frac{ESATII \cdot L_{eff}}{1 + ESATII \cdot L_{eff}} \right) \left(\frac{1}{1 + SH1 \cdot V_{gsteff}} + SH2 \right) \left(\frac{SHI0 \cdot V_{gsteff}}{1 + SHID \cdot V_{ds}} \right)$$

Parameter Extraction Tip:

- ❑ Physical extraction to these impact ionization parameters will help the mathematical robustness
- ❑ Global fitting can cause the issue





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Charge-Thickness Model C_{GG} Continuity

$$(V_{gsteff,CV} - j_d)_{eff} = 0.5 \cdot \left[(V_{gsteff,CV} - j_d - 0.001) + \sqrt{(V_{gsteff,CV} - j_d - 0.001)^2 + V_{gsteff,CV} \cdot 0.004} \right]$$



DELVTO: an Instance Parameter

if v_{th0} is given:

$$V_{th0} = V_{th0} + DELVTO;$$

if v_{th0} is not given,

$$V_{fb} = V_{fb} + DELVTO;$$

$$V_{th0} = V_{fb} + \phi + k_1 * \sqrt{k_1}$$



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New Temperature Mode (TempMod = 2)

Share the same temperature equations as for TempMod=1

AND:

From:

$$\Delta V_{th}(DITS) = -nv_t \cdot \ln \left(\frac{L_{eff}}{L_{eff} + DVTP0 \cdot (1 + e^{-DVTP1V_{ds}})} \right)$$

To:

$$\Delta V_{th}(DITS) = -nv_{tnom} \cdot \ln \left(\frac{L_{eff}}{L_{eff} + DVTP0 \cdot (1 + e^{-DVTP1V_{ds}})} \right)$$

Vfbzb(T)

$$V_{fbzb}(T) = V_{fbzb}(TNOM) - \left(KT1 + \frac{KT1L}{L_{eff}} \right) \cdot \left(\frac{T}{TNOM} - 1 \right)$$

Igate(T)

T is replaced by TNOM



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BSIM4.5.0 Bug Fixes

Bug Description	Reporter	Bug Fix	Files
CTM(capMod=2) CV discontinuity	Geoffrey J. Coram Analog Device	Smoothing (Vgsteff - DeltaPhi)	b4ld.c;
Trap-assisted tunneling continuity and typo	Peter Lee, Renesas Laurens Weiss, Infinion		b4ld.c;
Diode model MJXX	Peter Lee, Renesas	Check and set them to 0.99 if MJXX>0.99	b4check.c
Gate current parameter default value	Peter Lee, Renesas		b4set.c
Flicker noise negative ΔL_{CLM}	Selim, Mohamed Mentor Graphics	Set $\Delta L_{CLM}=0.0$ if it is less than 0.0	b4noi.c



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BSIM4.5.0 Beta Version Will Be Available Sept. 24, 2004

Welcome Your Testing Feedback!