Chapter 6: Body Current Models

In addition to the junction diode current and gate-to-body tunneling current, the substrate terminal current consists of the substrate current due to impact ionization (I_{ii}), and gate-induced drain leakage current (I_{GIDL}).

6.1 I_{ii} Model

The impact ionization current model in BSIM4 is the same as that in BSIM3v3.2, and is modeled by

(6.1.1)

$$I_{ii} = \frac{ALPHA0 + ALPHA1 \cdot L_{eff}}{L_{eff}} \left(V_{ds} - V_{dseff} \right) \exp\left(\frac{BETA0}{V_{ds} - V_{dseff}} \right) \cdot I_{dsNoSCBE}$$

where parameters $ALPHA0$ and $BETA0$ are impact ionization coefficients; parameter $ALPHA1$ is introduced to improves the I_{ii} scalability, and

(6.1.2)

$$I_{dsNoSCBE} = \frac{I_{ds0} \cdot NF}{1 + \frac{R_{ds} I_{ds0}}{V_{dseff}}} \left[1 + \frac{1}{C_{clm}} \ln\left(\frac{V_A}{V_{Asat}} \right) \right] \cdot \left(1 + \frac{V_{ds} - V_{dseff}}{V_{ADIBL}} \right) \cdot \left(1 + \frac{V_{ds} - V_{dseff}}{V_{ADITS}} \right)$$

6.2 I_{GIDL} *and* I_{GISL} Model

The GIDL/GISL current and its body bias effect are modeled by [9]-[10]

(6.2.1)

$$I_{GIDL} = AGIDL \cdot W_{effCJ} \cdot Nf \cdot \frac{V_{ds} - V_{gse} - EGIDL}{3 \cdot T_{oxe}} \cdot \exp\left(-\frac{3 \cdot T_{oxe} \cdot BGIDL}{V_{ds} - V_{gse} - EGIDL} \right) \cdot \frac{V_{db}^3}{CGIDL + V_{db}^3}$$

$$I_{GISL} = AGIDL \cdot W_{effCJ} \cdot Nf \cdot \frac{-V_{ds} - V_{gde} - EGIDL}{3 \cdot T_{oxe}} \cdot \exp\left(-\frac{3 \cdot T_{oxe} \cdot BGIDL}{-V_{ds} - V_{gde} - EGIDL} \right) \cdot \frac{V_{sb}^3}{CGIDL + V_{sb}^3}$$

where *AGIDL*, *BGIDL*, *CGIDL*, and *EGIDL* are model parameters and explained in Appendix A. *CGIDL* accounts for the body-bias dependence of I_{GIDL} *and* I_{GISL}. W_{effCJ} and *Nf* are the effective width of the source/drain diffusions and the number of fingers. Further explanation of W_{effCJ} and *Nf* can be found in the chapter of the layout-dependence model.

