CHARGE-BASED DEFINITION OF THRESHOLD VOLTAGE FOR UNDOPED BODY MOSFET

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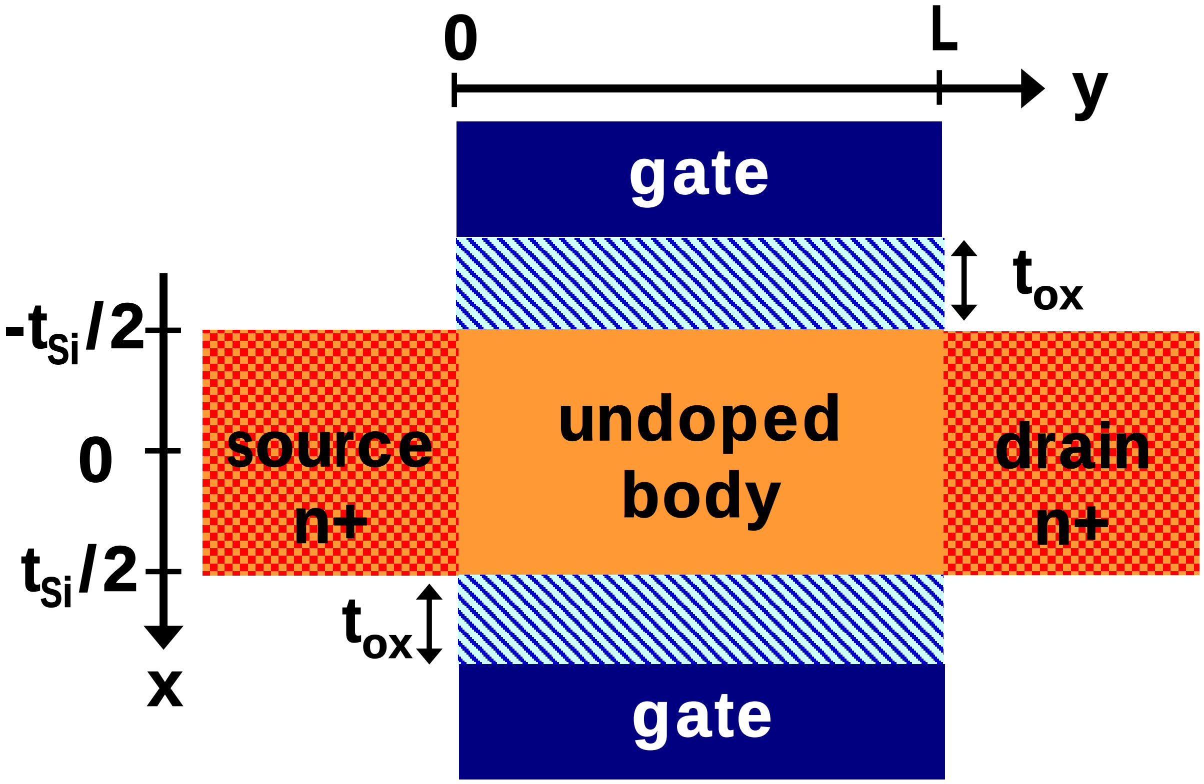
Desirable features of threshold voltage definition for undoped body MOSFETs:

Physical meaning

Unambiguity in the extraction procedure

Proper description of the dependence on t_{Si} and t_{ox}

Intrinsic symmetric dual gate MOSFETs



From Taur's model[1, 2]:

$$\phi_S(y) = V_C(y) - 2\phi_t \ln\left[\frac{t_{Si}}{4\beta L_{Di}} \cos(\beta)\right]$$

$$Q'_e = -C'_{ox}(V_G - V_{FB} - \phi_S) = -4C_{Si}\phi_t\beta \tan\beta$$

Threshold voltage: $V_{T0} = V_{FB} + \phi_{ST} - Q'_{eT}/C'_{ox}$

[1]Y. Taur, IEEE Transactions on Electron Devices, vol. 48, no.12, 2001.

[2]Y. Taur et al, IEEE Electron Device Letters, vol. 25, no.2, 2004 .

Intrinsic symmetric dual gate MOSFETs

$$I_D = I_{Ddrift} + I_{Ddiff} = -2\mu W Q'_e \, dV_C / dy$$

$$I_{Ddiff} = 2\mu W \phi_t \, dQ'_e / dy$$

$I_{Ddrift} = I_{Ddiff}$ ⇒ $$-\frac{\partial Q'_e}{\partial V_C}\frac{1}{Q'_e} = \frac{\partial Q'_e}{\partial V_G}\frac{1}{Q'_e} = \frac{1}{2\phi_t}$$

⇕

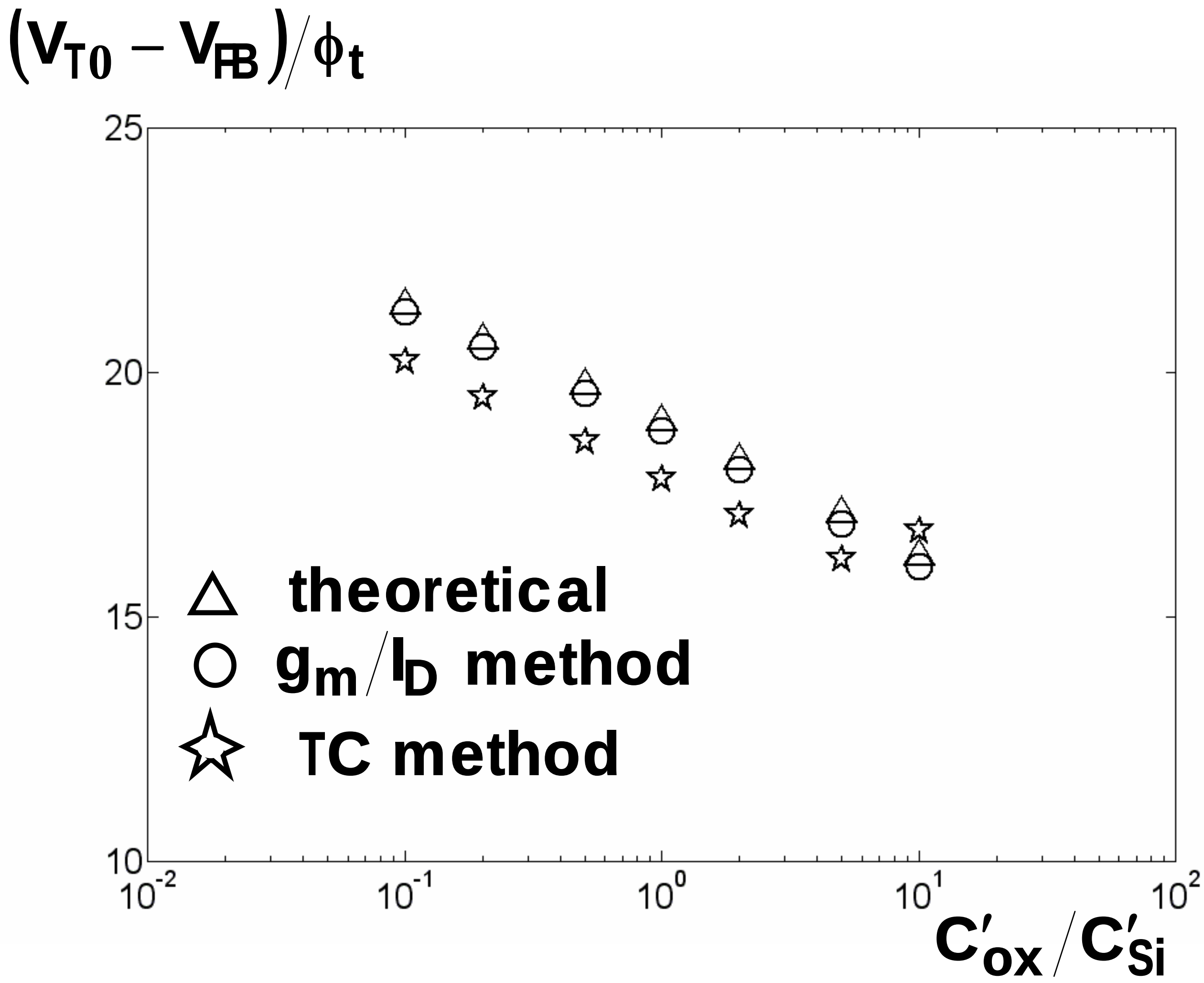
$$\frac{g_m}{I_D} \cong \frac{1}{2}\left(\frac{g_m}{I_D}\right)_{max}$$ ⇐ $$\frac{\partial Q'_e}{\partial V_G}\frac{1}{Q'_e} \cong \frac{g_m}{I_D}$$ ⇐ linear region

Intrinsic symmetric dual gate MOSFETs

$$\frac{\partial Q'_e}{\partial V_G}\frac{1}{Q'_e} = \frac{1}{2}\left(\frac{\partial Q'_e}{\partial V_G}\frac{1}{Q'_e}\right)_{max}$$

$$\tan\beta_T\left(\tan\beta_T + \beta_T + \beta_T \tan^2\beta_T\right) = \frac{C'_{ox}}{2C'_{Si}}$$

Simulation results



Conclusion

The charge-based definition conciliates a phenomenological criterion ($I_{Ddrit} = I_{Ddiff}$) and a simple extraction methodology (g_m/I_D).