



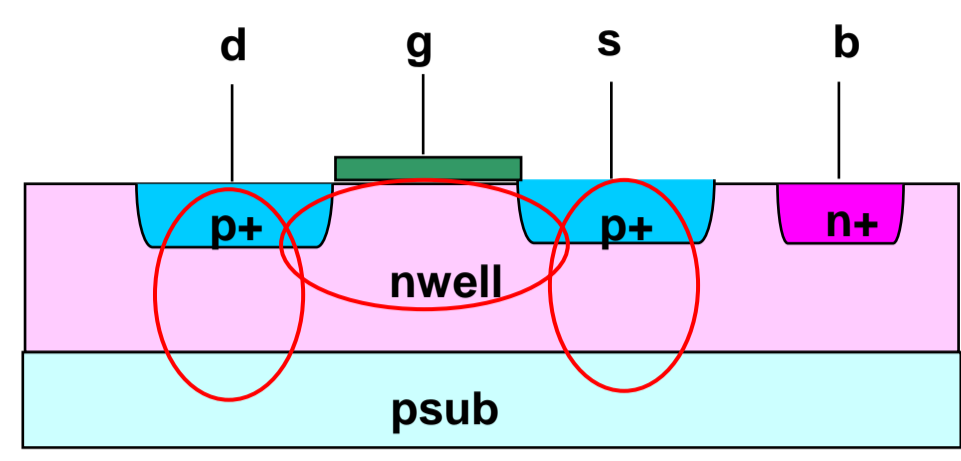
Modeling of gate length dependent leakage in MOSFETs

Stanislav Banáš, Dušan Prejda

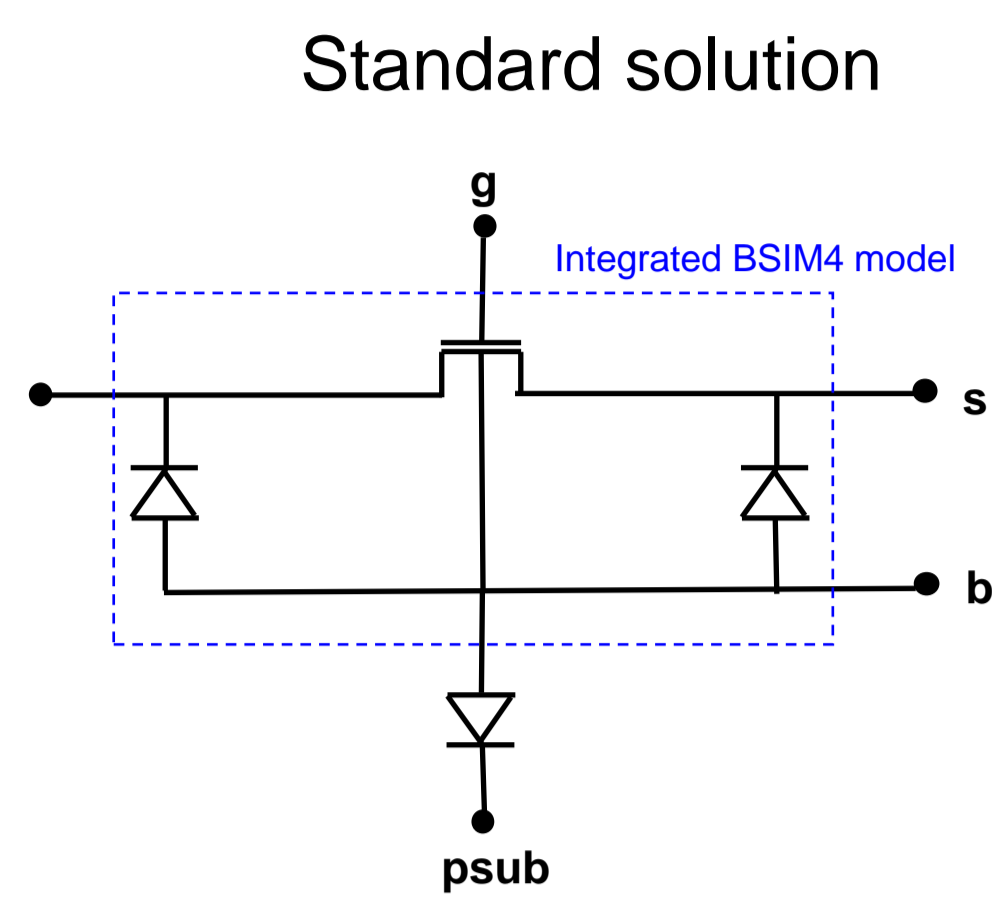
SCG Czech Design Center, ON Semiconductor Czech Republic,
B. Němcové 1720, 756 61 Rožnov pod Radhoštěm, Czech Republic

ON Semiconductor

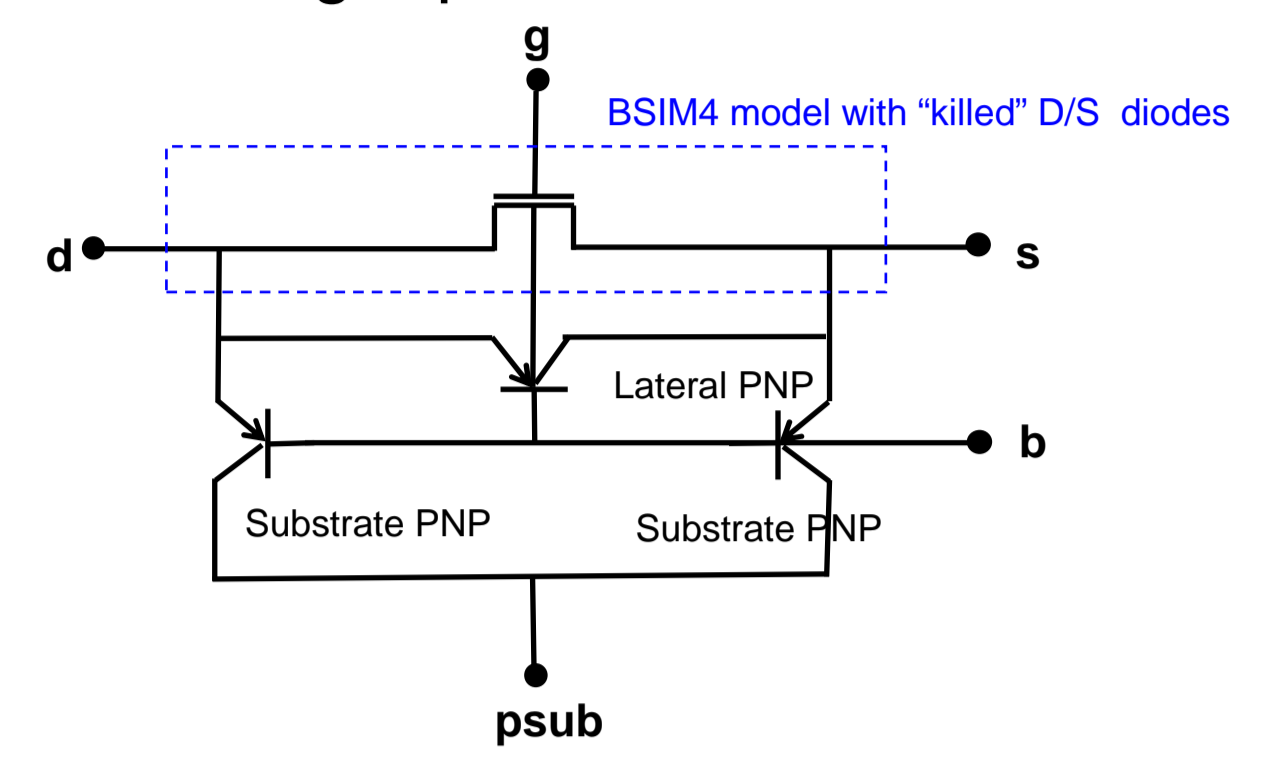
1. Modeling of isolated MOSFET (demonstrated on PMOS in Nwell)



Injection to the substrate and lateral channel injection is not considered in the standard BSIM model



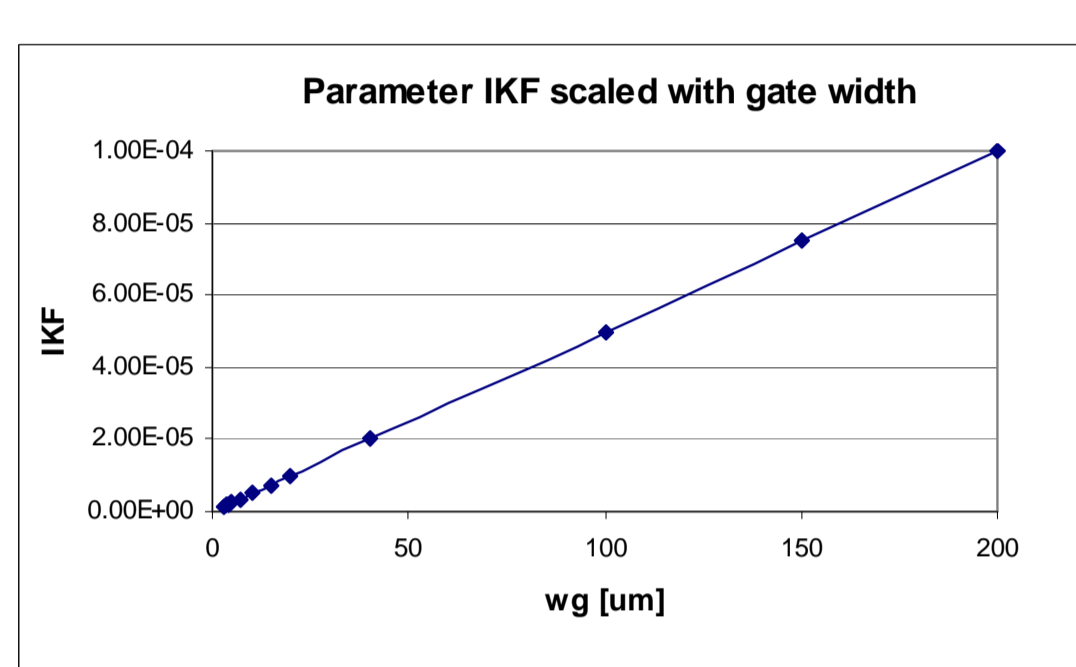
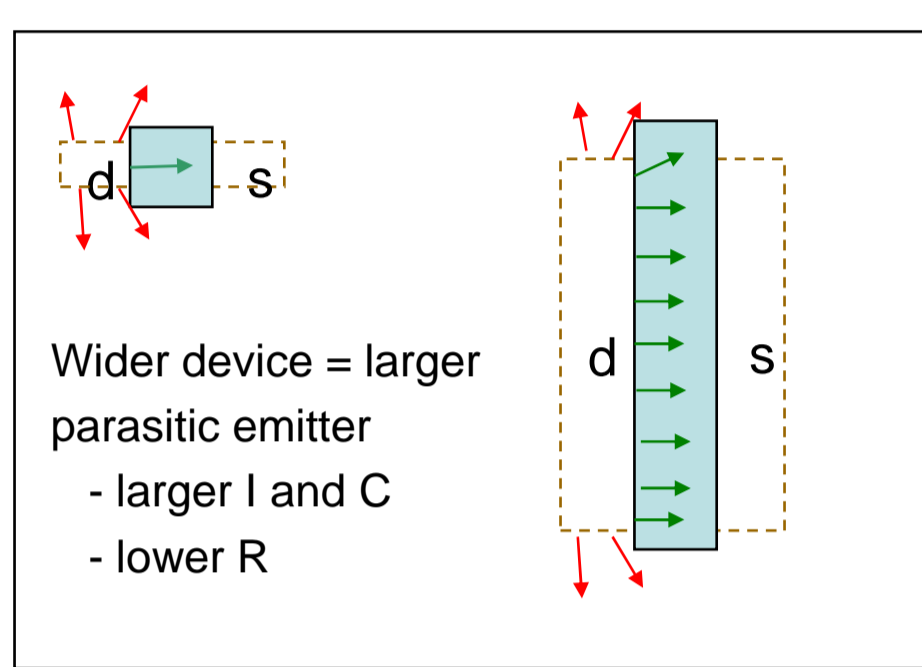
Proposed improvement – using 3 parasitic Gummel-Poon models



2. Lateral parasitic BJT

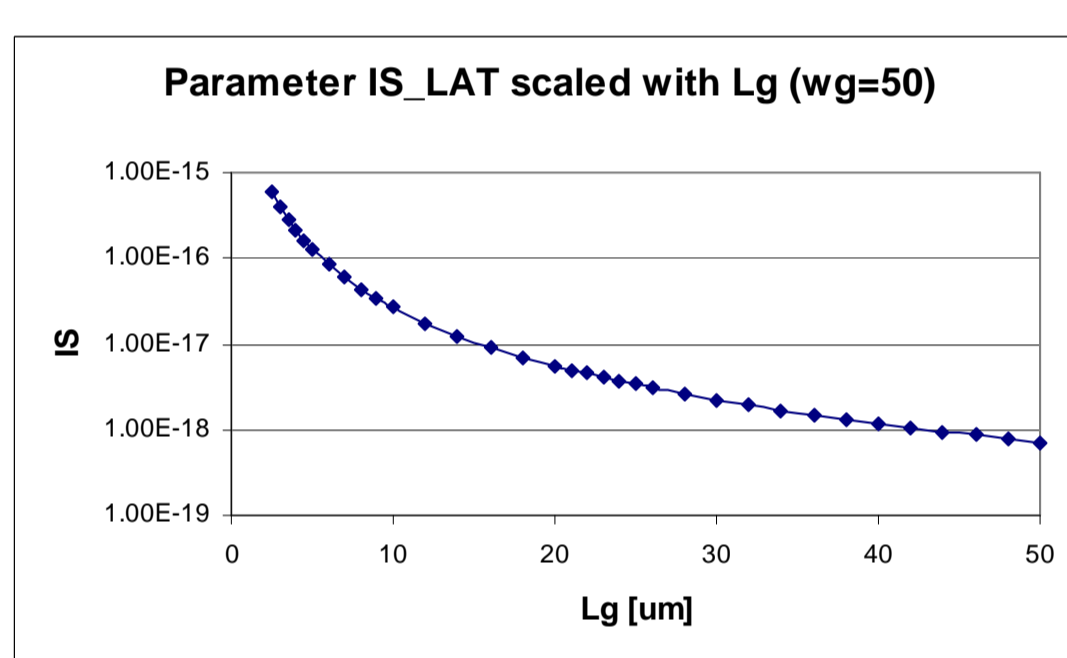
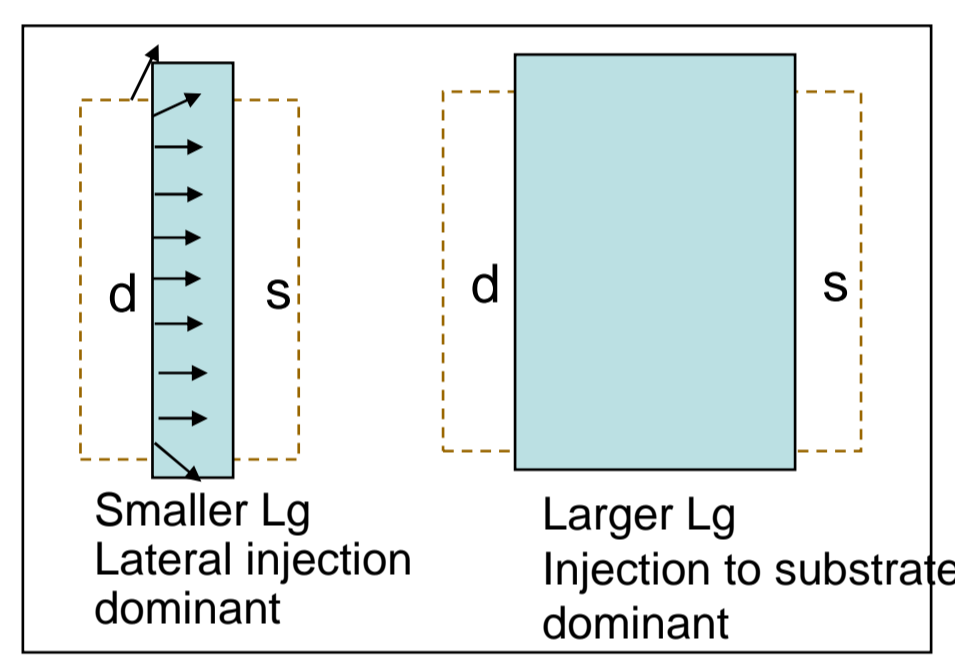
For all MOSFETs

2.1. Linear Dependency on Wg



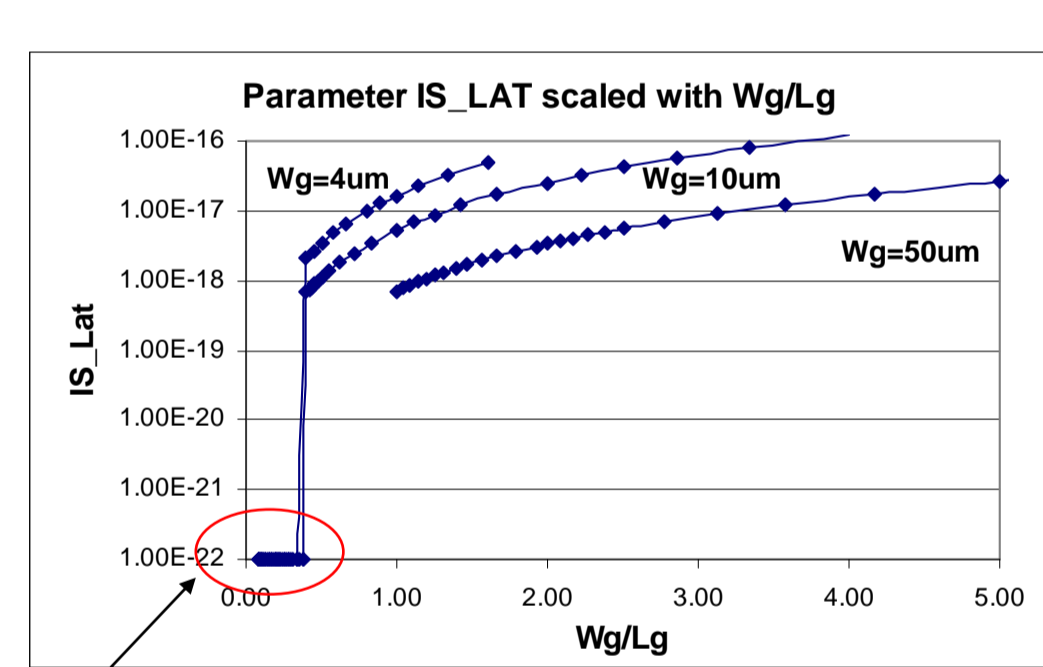
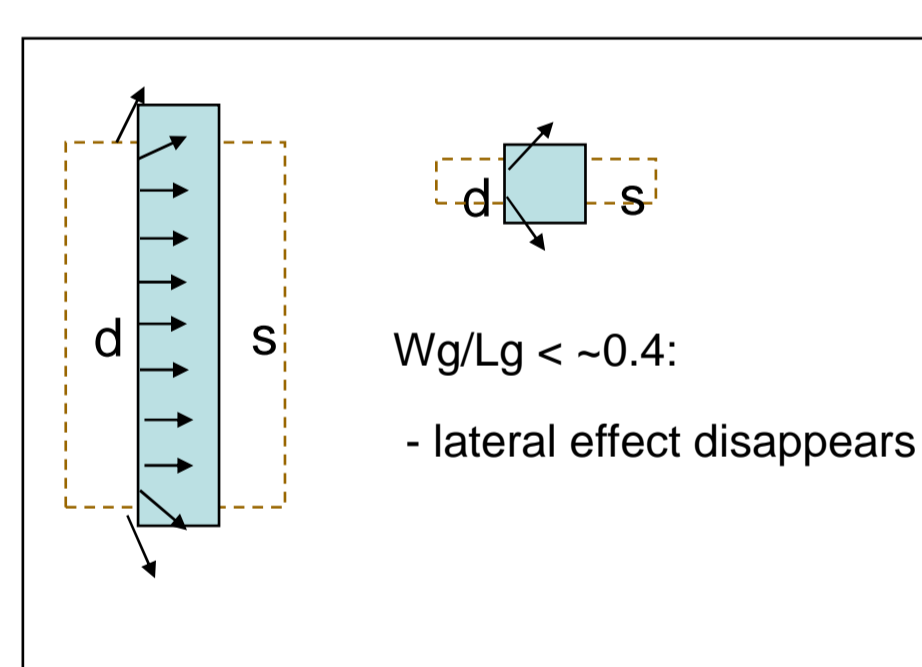
$$IKF = \text{ikfa_lat} \cdot AE + \text{jkfp_lat} \cdot PE + \text{ikf_lat} \quad RE = re_lat / AE \quad \dots \text{etc}$$

2.2. Nonlinear Dependency on Lg



$$IS = (js_lat \cdot Wg) / (Lg^{Lexp}) \quad Lexp \sim 2..3$$

2.3. Nonlinear dependency on Wg/Lg



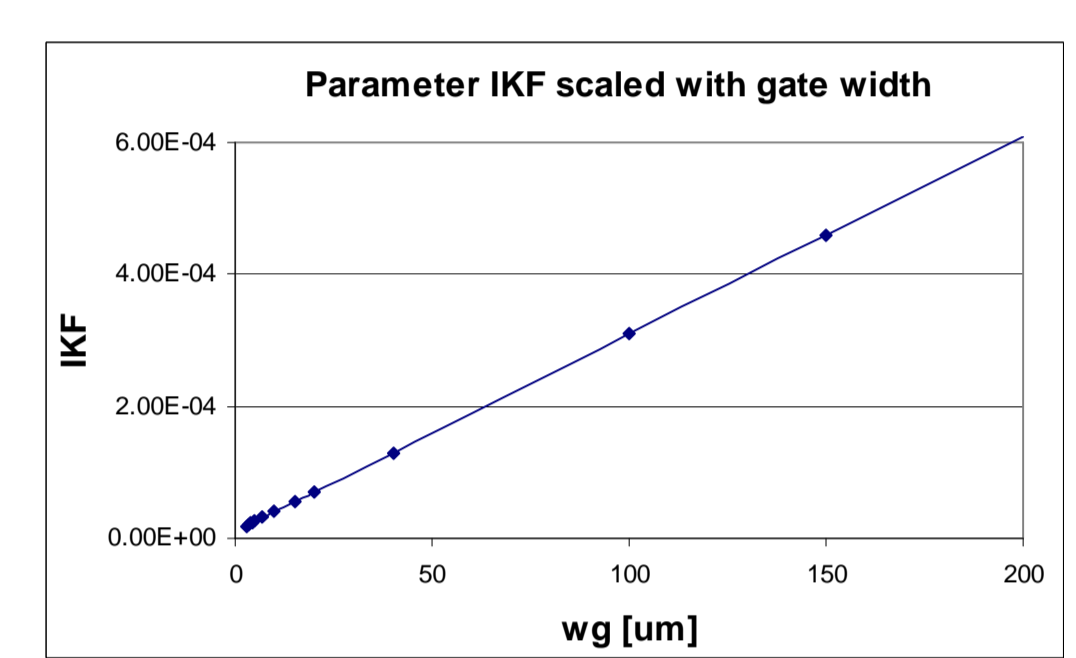
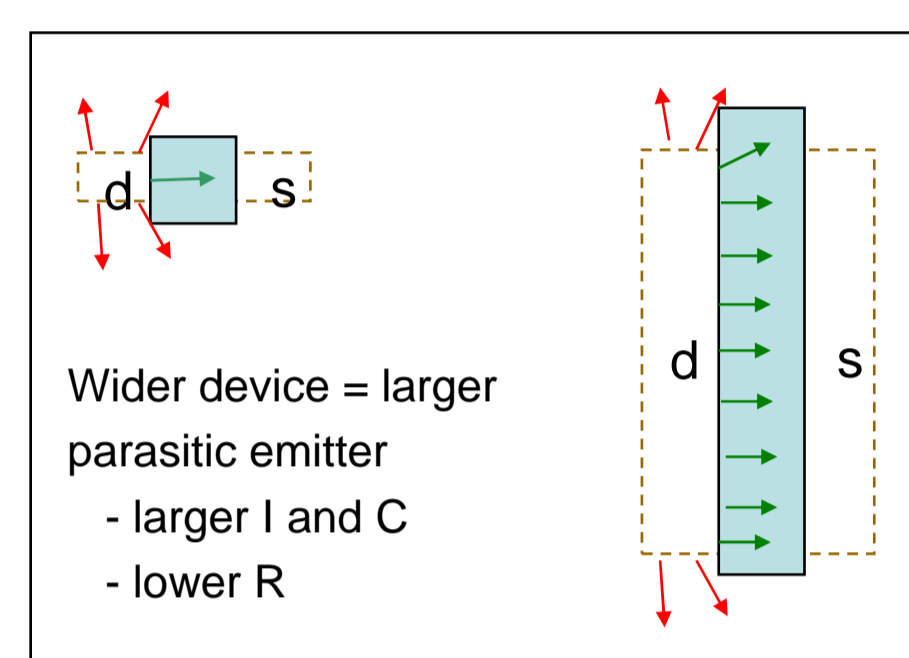
$$IS = (js_lat \cdot Wg) / (Lg^{Lexp}) \cdot (\text{sign}(\text{int}(Wg/Lg) + (1 - \text{Limit}))) + 1e-22 \quad \text{Limit} \sim 0.4$$

IS switched off for Wg/Lg < (Limit)

3. Substrate parasitic BJTs

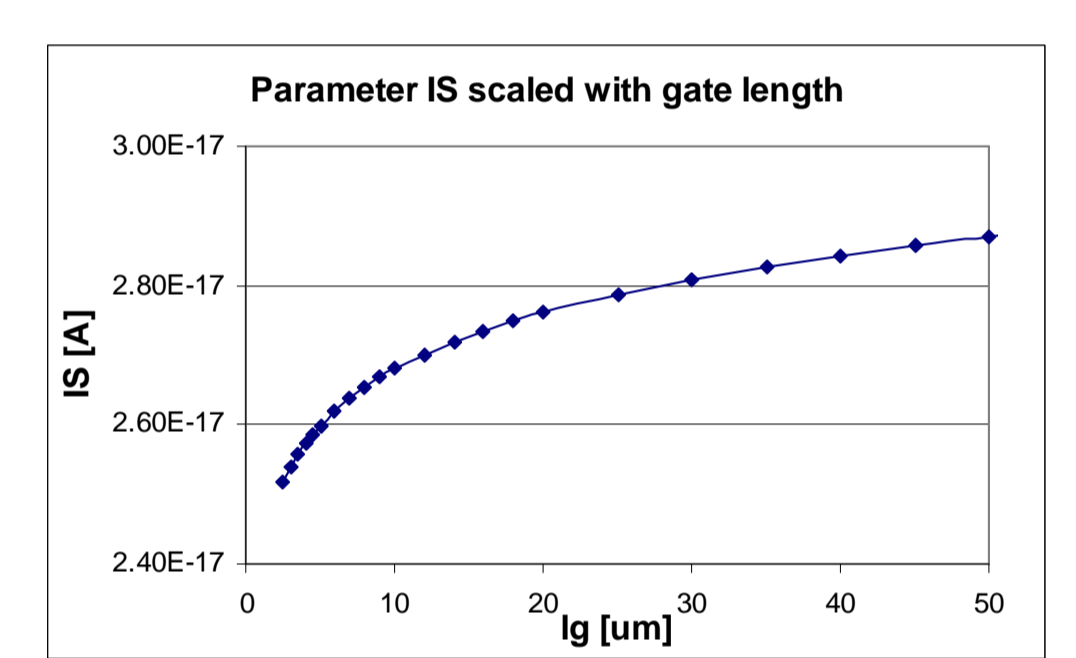
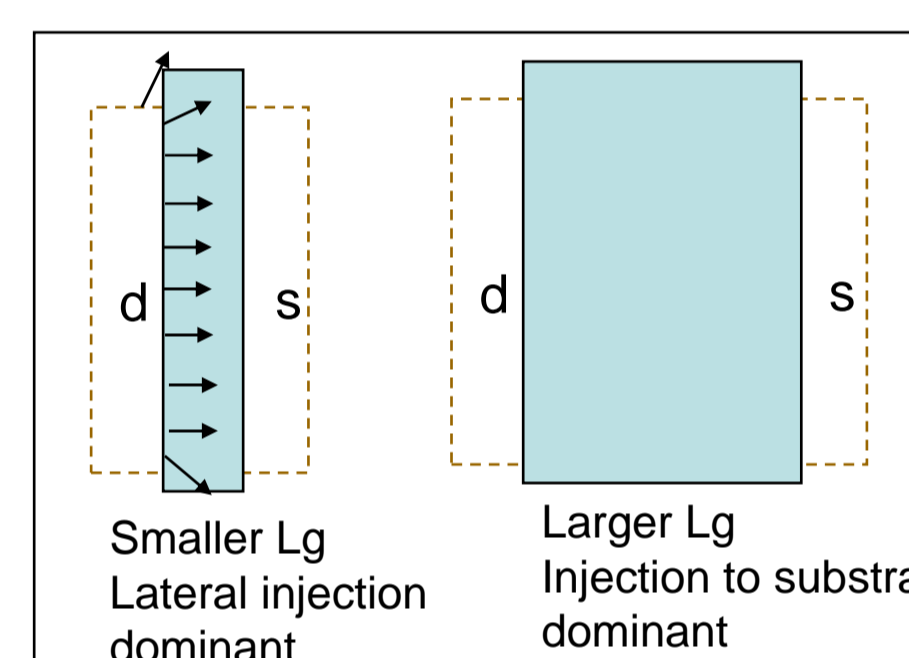
Only for isolated MOSFET, e.g. PMOS in Nwell

3.1. Linear Dependency on Wg



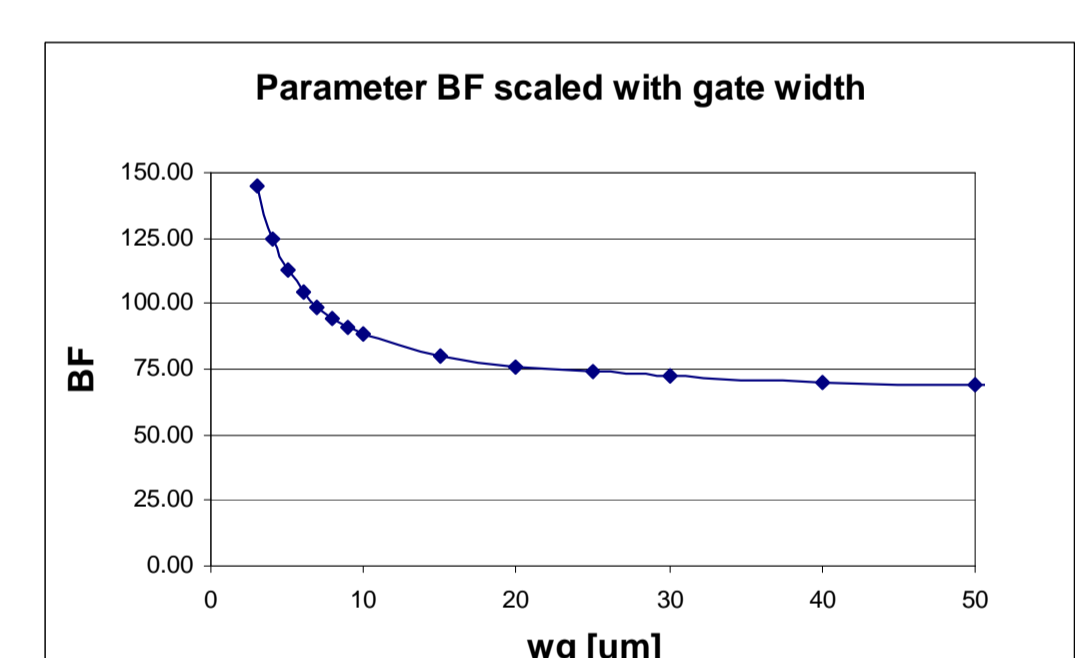
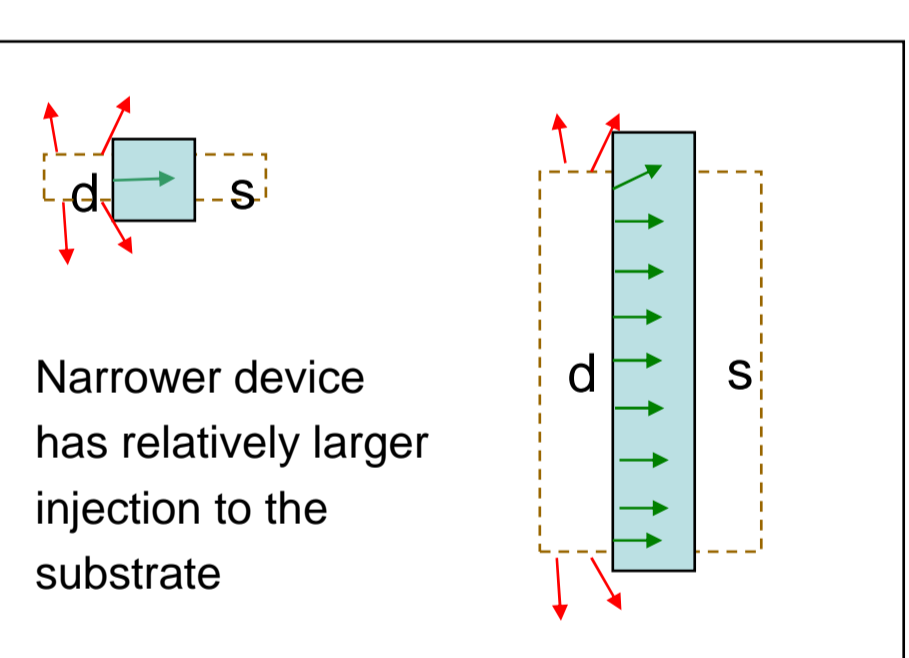
$$IKF = \text{jkfa_vert} \cdot AE + \text{jkfp_vert} \cdot PE + \text{ikf_vert} \quad RE = re_vert / AE \quad \dots \text{etc}$$

3.2. Nonlinear Dependency on Lg



$$IS = (js_vert1 \cdot \log(Lg) + js_vert2) \cdot AE + is$$

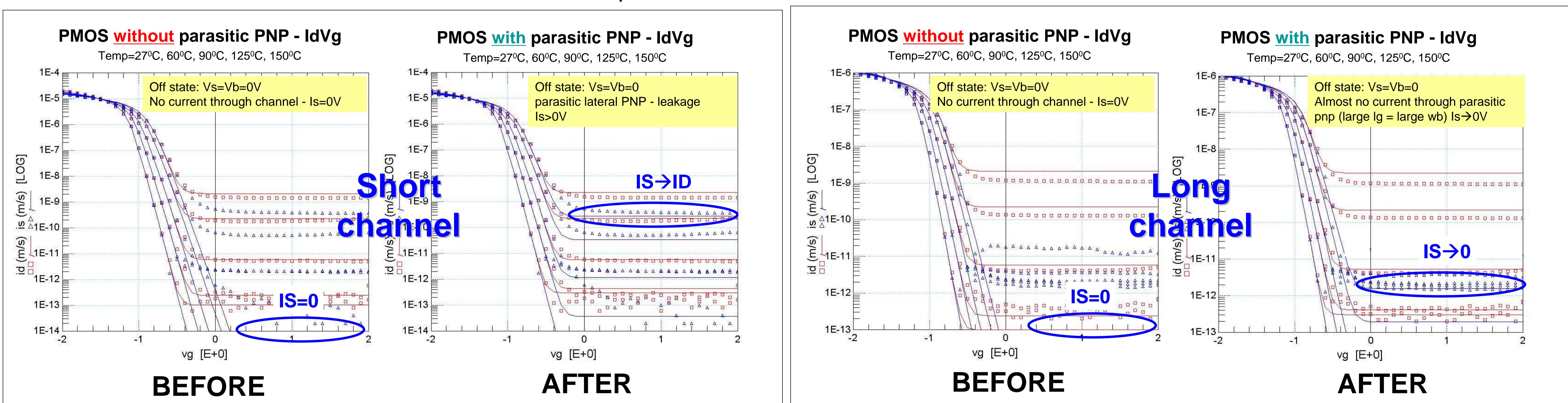
3.3. Nonlinear Dependency on Wg



$$BF = IC/IB = (js_vert \cdot AE + is_vert) / (jbe_vert \cdot AE + ibe_vert)$$

4. Impact into leakage characteristics – gate length dependent leakage controlled by the parasitic lateral BJT

The lateral parasitic PNP is dominant for short devices



5. Conclusion

Extending macromodel of the mosfet by several parasitic bipolar transistors (1 for nonisolated MOSFET, 3 for isolated MOSFET) significantly improves the model accuracy under certain bias conditions. In particular, this macromodel solves the gate length dependency of the leakage current, controlled by the parasitic lateral BJT scalable with gate length.