

Macro Model for Drift/Diffusion Effects in Short-Channel Undoped Schottky Barrier DG-MOSFETs

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Overview

Current SB-DG-MOSFET

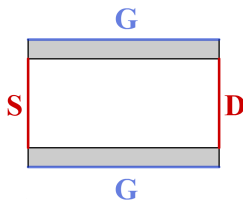
Transfer Characteristics

Output Characteristics

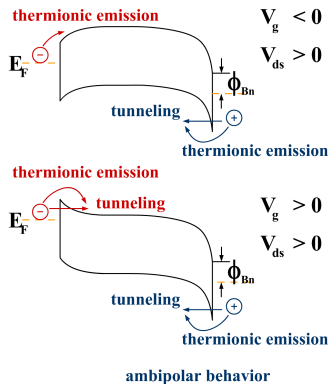
Conclusion & Take Aways

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- High scalability
- Good process compatibility
- Low access resistances



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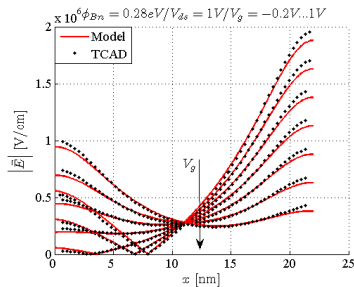
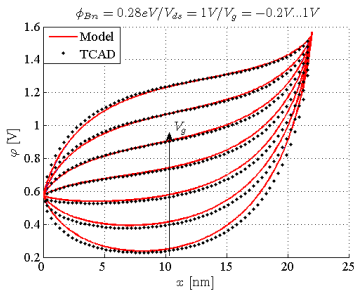
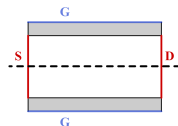
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- Conformal Mapping technique
- Analytical framework for potential and electric field



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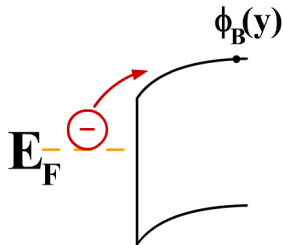
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$$J_{therm}(y) = A^* T^2 \exp\left(-\frac{q\phi_B(y)}{kT}\right) \left[1 - \exp\left(\frac{-qV_{ds}}{kT}\right)\right]$$

$$I_{therm} = \int_0^{w_{ch}} \int_{t_{ox}}^{t_{ox}+t_{ch}} J_{therm}(y) \cdot dy \cdot dz$$

Overview

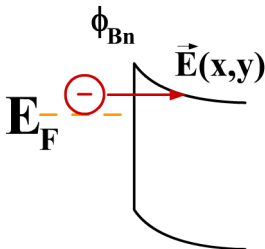
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$$J_{tun}(y) = \frac{A^* T}{k} \int_0^{l_{ch}} T(\vec{E}, x, y) f_m(\xi(x)) [1 - f_s(\xi(x))] \frac{\partial \xi}{\partial x} dx$$

$$J_{tun}(y) = \frac{q \mu_n N_C}{kT} \int_0^{l_{ch}} |\vec{E}(x, y)| \cdot T(\vec{E}, x, y) \cdot f_m(\xi(x)) [1 - f_s(\xi(x))] \frac{\partial \xi}{\partial x} dx$$

$$I_{tun} = \int_0^{w_{ch}} \int_{t_{ox}}^{t_{ox} + t_{ch}} J_{tun}(y) \cdot dy \cdot dz$$

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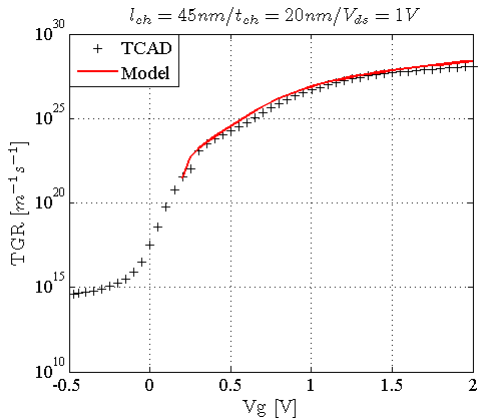
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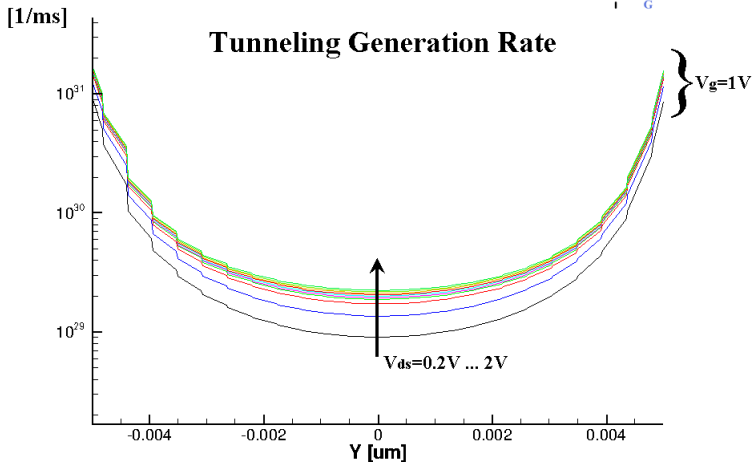
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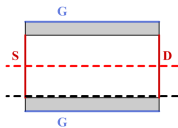
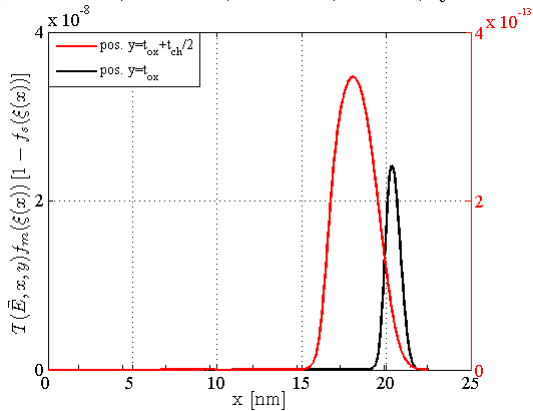
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$$\phi_{Bn} = 0.28eV/t_{ch} = 45nm/t_{ch} = 20nm/V_{ds} = 1V/V_g = 0V$$



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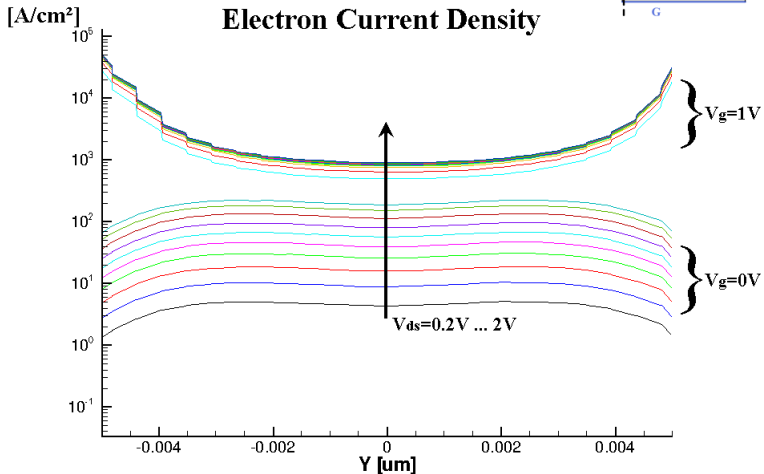
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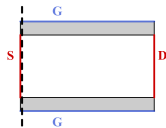
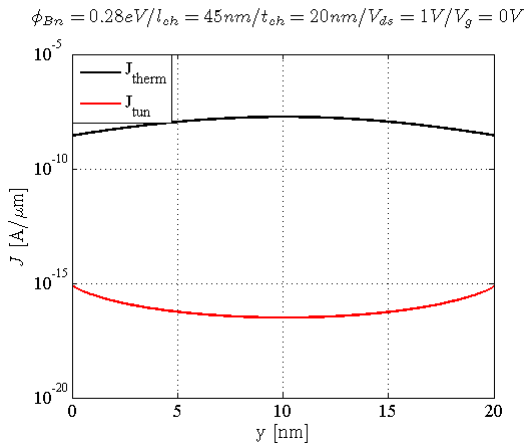
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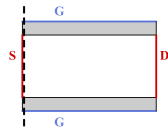
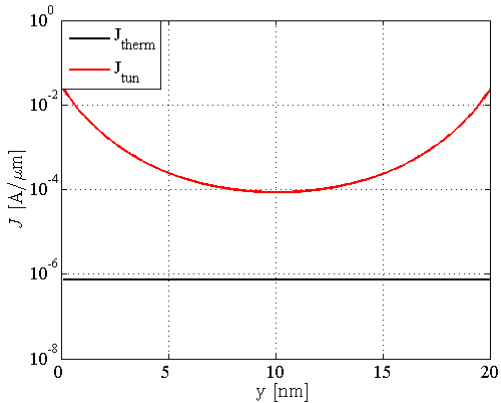
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$$\phi_{Bn} = 0.28eV/l_{ch} = 45nm/t_{ch} = 20nm/V_{ds} = 1V/V_g = 1V$$



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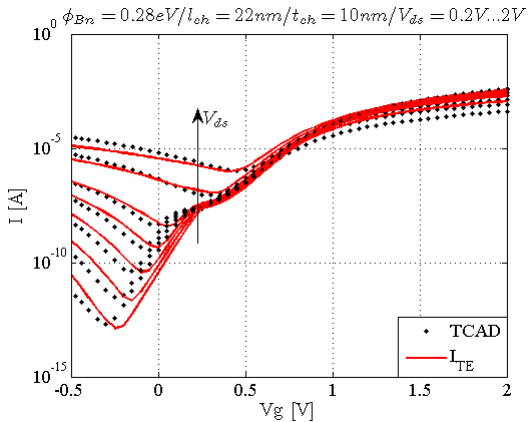
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$$I_{TE} = I_{tun} + I_{therm}$$



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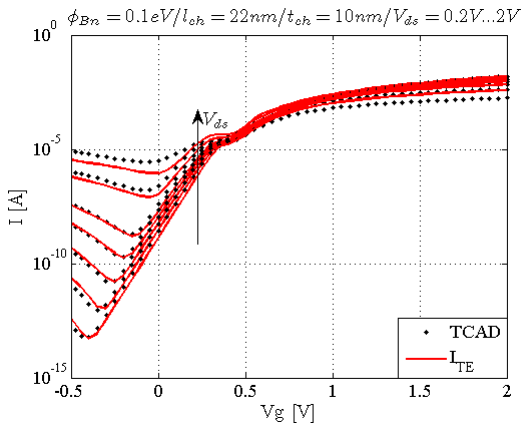
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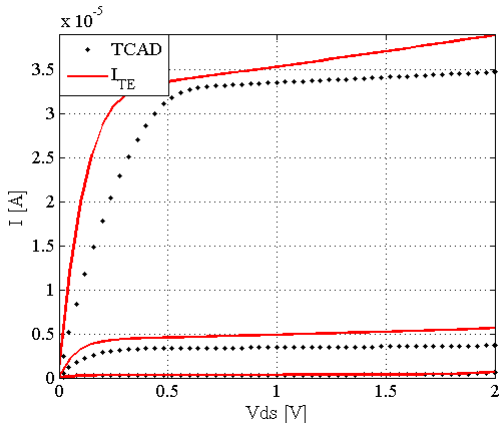
$$I_{TE} = I_{tun} + I_{therm}$$



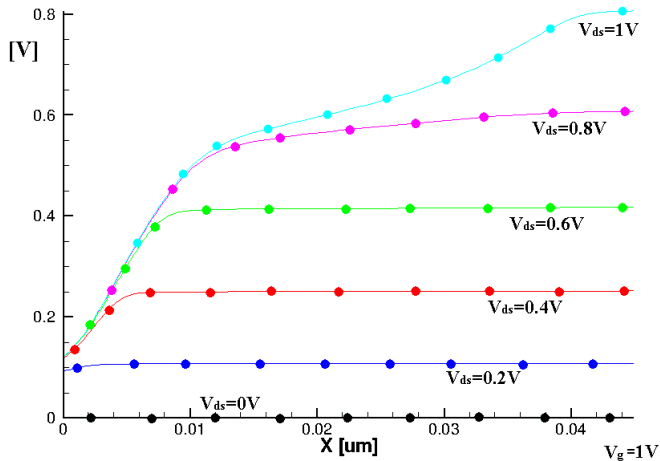
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$$I_{TE} = I_{tun} + I_{therm}$$

$$\phi_{Bn} = 0.28 eV / l_{ch} = 45 nm / t_{ch} = 20 nm / V_g = 0.5 V \dots 0.9 V$$



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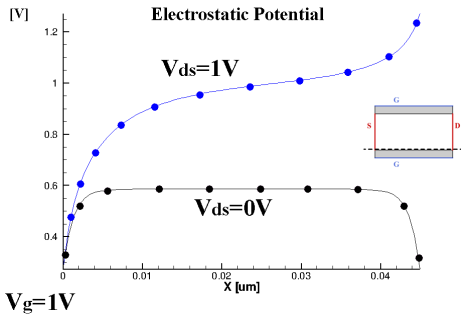
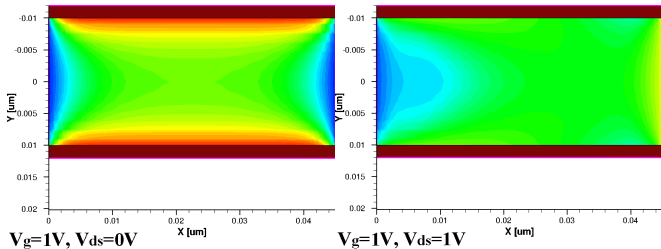
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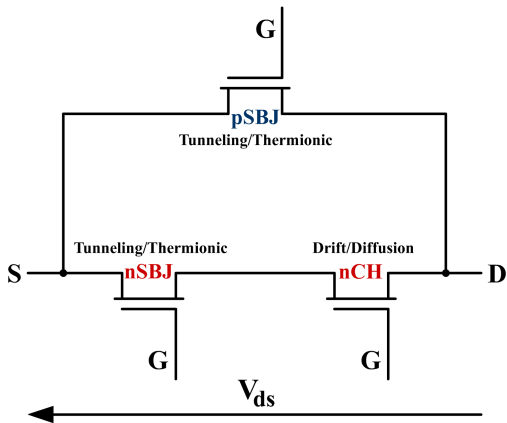
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$$I_{\text{Drift/Diff}} = \mu C_{\text{ox}} \frac{2W}{L} \left(V_g - V_{\text{th}} - \frac{V_{\text{ds}}}{2} \right) V_{\text{ds}}$$



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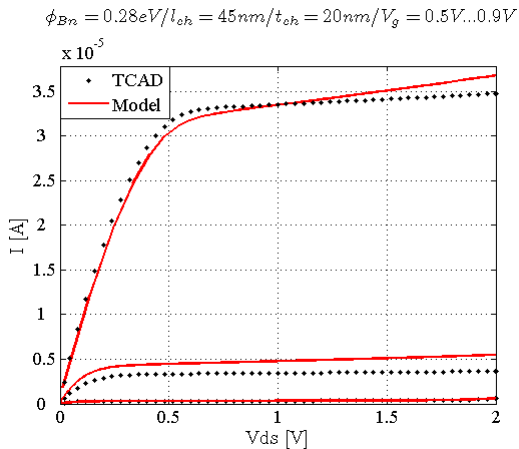
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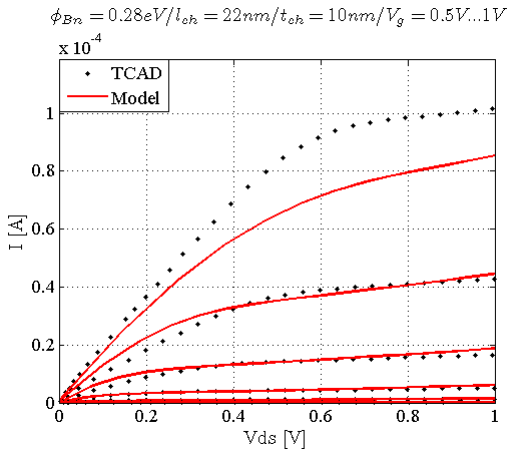
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- 2D analytical solutions of the electrostatics are used for calculating tunneling probability and carrier distributions
- Quasi 2D approach is used for the estimation of tunneling and thermionic current
- Enhanced tunneling current calculation with electric field
- Analysis of current densities show 2D influence
- Macro model introduced to account for Drift/Diffusion effects in the channel
- Results of the model compared to TCAD show an accurate agreement for channel lengths down to 22nm

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Acknowledgment

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