

# MOSFET Exercise

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Simulate a MOSFET device structure, schematically shown in the figure below. In your calculations use the appropriate model for low field mobility description in silicon inversion layers, Shockley-Read-Hall generation-recombination process (not that relevant for MOSFET operation), velocity saturation effect and impact ionization model due to Selberherr. The oxide thickness of the device being simulated equals 1.0 nm. For the substrate doping assume  $10^{19} \text{ cm}^{-3}$ . The junction depth is 0.24  $\mu\text{m}$  and the total device depth, measured from the Si-SiO<sub>2</sub> interface, is 0.1  $\mu\text{m}$ . Assume body doping of  $10^{19} \text{ cm}^{-3}$ . Vary the gate voltage from 0.8 V to 1.6 V, in 0.2 V increments. For each gate voltage value, do a drain voltage sweep from 0 V to 1.6 V. Perform the following set of simulation runs:

- ◆ **Punchthrough:** Exclude the impact ionization process from the theoretical model. Calculate the output characteristics of the device for channel lengths 50 nm and 20 nm. Comment on the results obtained.
- ◆ **Series Resistance:** Exclude the impact ionization process and use the two different values for the source and drain doping densities ( $8 \times 10^{19}$  and  $10^{20} \text{ cm}^{-3}$ ). This will demonstrate the role of the series resistance effects on the device output characteristics. Also, discuss the role of the DIBL effect in the device output characteristics.
- ◆ **Impact Ionization:** Investigate the role of the impact ionization process on the device performance, by including the Selberherr's model for impact ionization. In these simulation runs assume that the doping of the source and drain regions equals  $10^{20} \text{ cm}^{-3}$ . Include both electrons and holes in the simulation model.

