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Homework 8

For this assignment I wrote a program in C++ to determine the threshold voltage, electric fields at the Si/SiO_2 interface on either side, and the depletion region's thickness. The program as an executable can be found at this link here if you would like to try it. One thing to note is that the rounding is slightly off in the program, due to the data types of the variables. However, the values do not differ by any substantial amount from the pre-calculated examples.

The mathematics portion of this program was pulled from my work on Homeworks 6 and 7. To recap, here are the used equations:

$$V_t = \phi_{sT} + \gamma\sqrt{\phi_{sT}} - \phi_{bi}$$

$$x_d = \frac{\epsilon_s}{C_{OX}}\left(\sqrt{1 + \frac{4 * \phi_{bi}}{\gamma}} - 1\right)$$

$$\mathcal{E}_{OX} = \frac{qN_A x_d}{\epsilon_{OX}}$$

$$\mathcal{E}_s = \mathcal{E}_{OX}\frac{\epsilon_{OX}}{\epsilon_s}$$

$$\phi_{bi} = \chi + E_g + kTln\left(\frac{N_A}{n_v}\right) - W_M$$

$$\gamma = \frac{\sqrt{2 * \epsilon_s * q * N_A}}{C_{OX}}$$

$$C_{OX} = \frac{\epsilon_{OX}}{x_{OX}}$$

By experimenting in my program, I found that the body doping concentration to best reach a 1 V threshold voltage was 1.49×10^{18} cm^{-2} when the metal's work function was at 3.1 eV, and 8.29×10^{17} cm^{-2} when W_M is 3.65 eV. Following is a table with the important values:

	N_A (cm^{-2})	V_t (V)	x_d (cm)	$\mathcal{E}_{OX}$ (V/m)	$\mathcal{E}_s$ (V/m)
$W_M = 3.10$	1.49×10^{18}	1.000	2.12×10^{-6}	1.47×10^{6}	4.89×10^{5}
$W_M = 3.65$	8.29×10^{17}	1.001	2.58×10^{-6}	9.93×10^{5}	3.31×10^{5}

The main thing to note is how doping concentration and the electric field at the silicon/silicon oxide interface increases greatly as the metal work function decreases. That means that the total charge per unit area will also have to increase. This means more current passes through the MOSFET structure. The other change is that the depletion region thickness also increases with a lower metal work function.