Homework #5
Computational Microelectronics

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1 Results

We have solved the following equation using the Newton's method;

$$N^{+} - n_{int}\sinh\left(\frac{\phi}{V_T}\right) = 0. \tag{1}$$

To solve the equation, we define a function

$$f(\phi) = N^{+} - n_{int}\sinh\left(\frac{\phi}{V_T}\right). \tag{2}$$

Then for each updating of ϕ_i, the step size is written as

$$\delta\phi = \frac{f(\phi_i)}{f'(\phi_i)} = \frac{f(\phi)V_T}{n_{int}\sinh\left(\phi_i/V_T\right)}. \tag{3}$$

Note that the exact solution is given by

$$\phi_{exact} = V_T \operatorname{arcsinh}\left(\frac{N^{+}}{n_{int}}\right). \tag{4}$$

The calculation result is recorded in the file 'sol.dat' with the numerical solution and exact solution. Fig. 1 displays the solutions for given N^{+}. It shows that the numerical solution is almost same as the exact solution, which means that Newton's method is a robust root-finding method.

Meanwhile, The initial guess of the potential is very important. If the initial guess is too far from the real solution, the updated ϕ may diverge; it is because the derivative term, $\sinh\left(\phi_i/V_T\right)$ has very small magnitude near $\phi = 0$. So, if the initial guess is close to 0 and $f(\phi_i)$ is too large, the step size may diverges. One should consider this carefully.

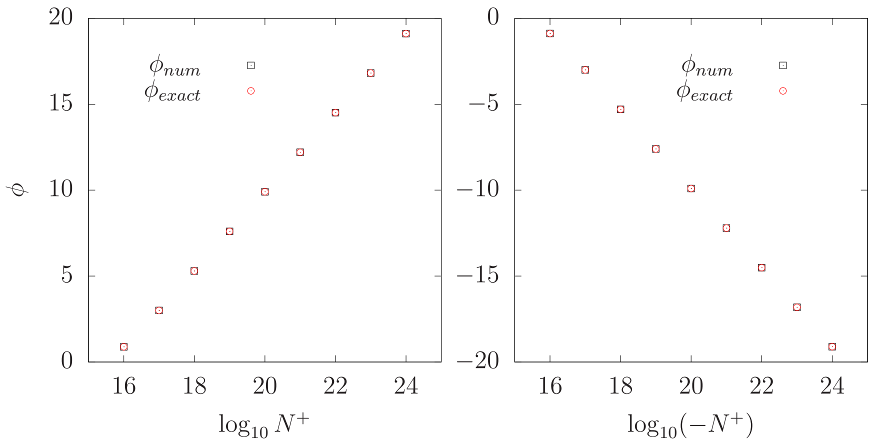

Figure 1: The solution of the equation for different N^+. LEFT : The case that N^+ is positive. RIGHT: The case that N^+ is negative. The numerical solution is displayed as the black square and the exact solution is displayed as the red circle.