ABACUS: MOSFET Assignment on Diffusion

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Objective:

The goal of this assignment is to make familiar the students the required doses in the diffusion step of fabrication of semiconductor devices to get certain values of the volume doping densities.

Assignment:

Consider the case of a two-dimensional diffusion from a finite source through a mask that is schematically shown in Figure 1(a). The width of the diffusion windows is *a* and the separation between the two diffusion windows equals *b*. Assume that the diffusion processes through the two diffusion windows are independent processes. For the description of the 2D diffusion profile use the result given below:

$$N(x,y,t) = \frac{Q}{2\sqrt{\pi Dt}} \exp\left(-\frac{x^2}{4Dt}\right) e(y)$$

$$e(y) = erfc\left(\frac{y-a/2}{2\sqrt{Dt}}\right) - erfc\left(\frac{y+a/2}{2\sqrt{Dt}}\right)$$

If the diffusion process from a finite source occurs in an *n*-type substrate, and using $\sqrt{Dt}$ =0.5 μm, *a*=2*b*=5 μm and N_D=10^{15} cm^{-3}, what should be the total dose of acceptor impurities *Q*, so that the situation from Figure 1(b) occurs.

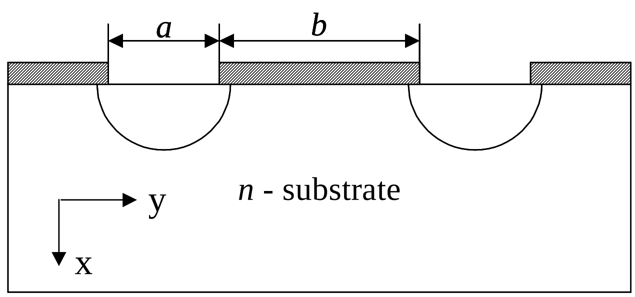

Figure 1 (a)

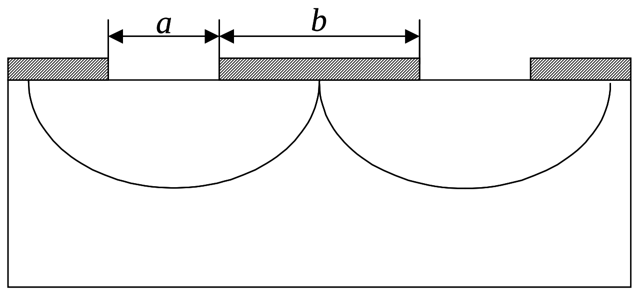

Figure 1 (b)

Here is some clarification for solving this problem:

- First, the substrate on which the diffusion process takes place is an *n*-type substrate and we are performing diffusion of *p*-type impurities, i.e. $N(x,y)=N_A(x,y)$. The goal is to create a *p*-type diffusion island.
- The expression given in the assignment is for the case of diffusion from one diffusion window (let's say the left diffusion window from Figure (a)).
- The situation shown in Figure (b) corresponds to the case when the two junctions merge (curved line denotes the position of the junction, i.e. the location where the net doping concentration is zero).
- Here are some useful expressions that you might consider when solving this problem, in addition to what you already have in the notes that you have gotten from the copy center:

$$erf(z) \approx \frac{2}{\sqrt{\pi}}\left\{ z - \frac{z^3}{3 \cdot 1!} + \frac{z^5}{5 \cdot 2!} - \frac{z^7}{7 \cdot 3!} + \ldots \right\}$$

Some limiting cases are the following ones:

(1) $z \ll 1$, for which:

$$erf(z) \approx \frac{2z}{\sqrt{\pi}}$$

(2) $z \gg 1$, in which case:

$$erfc(z) \approx \frac{1}{\sqrt{\pi}} \frac{1}{z} \exp\left(-z^2\right)$$

Also, here is the relationship between the error function and the complemen-tary error function that you might find to be useful:

$$erfc(z) = 1 - erf(z) \ .$$