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Design method of diffusion resistors

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The present paper presents the design method of resistors for monolithic integrated circuits. The following elements have been considered during the analysis:

1. Gaussian distribution of impurities in diffusion layers.
2. Lattice and impurity scattering are of crucial significance in transport phenomena.
3. The fact of incoplete impurity ionization at higer impurities concentration and the dependence of ionization range from temperature.

The dependence of $R_{\square}L_d$ product from impurity surface consentration and temperature after taking into account the previoulsy accepted assumption has been calculated by means of a computer from derived expression:

$$R_{\square}L_d = \frac{1}{2q\int_0^{\infty}\mu(n,T)\,n(T,z)\,dz} \qquad /1/$$

Figure 1 presents the temperature sensitivity of diffusion resistors as a function of $R_{\square}L_d$.

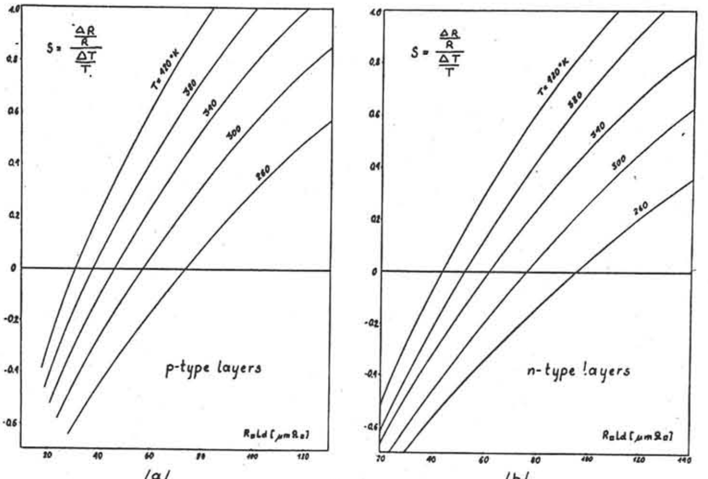

Fig. 1

The other problem is a change of diffusion layer resistivity during the drive-in process.

The starting point analysis was the assumption that the impurity charge which occurs in the diffusion layer in silicon, is reduced by the impurity charge, which has came into the oxide in the cours of oxidation.

The number of impurities getting into oxide is decreasing during the oxidation time. Concentration of impurities in oxide is:

$$N_{SiO_2} = N^o \frac{k_1}{\sqrt{\frac{Dt}{D_1 t_i} + 1}} = N^o \frac{k_1}{\sqrt{\frac{Dx^2}{BLd_1^2} + 1}} \qquad /2/$$

Parameter k_1 contains the segregation coefficient $m = \frac{N_s}{N_{SiO_2}}$ and $\frac{N_o}{N_s}$ rate which slightly increase with the oxidation speed. Parameter k_1 is a weak function of $\sqrt{\frac{D}{B}}$. In this analysis k_1= constans was assumed which was measured experimentaly. Such proceeding can be simply taken from the fact that various segregation coefficients were published by various authors.

The charge of impurities on oxide by integration of /2/ is as follows:

$$Q_{SiO_2} = k_1 N^o Ld_1 \sqrt{\frac{B}{D}} \, \mathrm{arsh} \frac{Ld}{Ld_1} \qquad /3/$$

Finaly the correction factor is expressed by the relation:

$$g_Q = 1 - K \sqrt{\frac{B}{D}} \, \mathrm{arsh} \frac{Ld}{Ld_1} = 1 - K \sqrt{\frac{B}{D}} \, \mathrm{arsh} \sqrt{\frac{D}{B}} \frac{x}{Ld_1} \qquad /4/$$

The correction factor resulting from the change of effective carrier mobilities is:

$$g_\mu = \left(\frac{Ld}{Ld_1} + 1\right)^{\frac{1}{2}a} = \left(\sqrt{\frac{Dt}{D_1 t_1}} + 1\right)^{0.12} \qquad /5/$$