

Continuity Equation in Semiconductor

DR..KK.SAINI, SALMA KHAN, YOGESH CHAUHAN, SANDEEP CHAUHAN

ELECTRONICSS AND COMMUNICATION

DRONACHARYA COLLEGE OF ENGINEERING

kk.saini@ggnindia.dronacharya.info

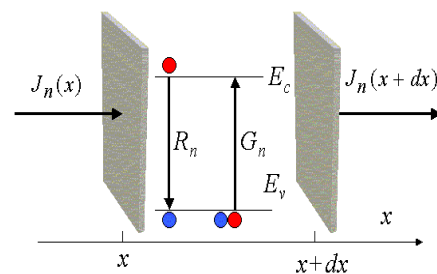
ABSTRACT:-

The continuity equation is basically describes the transport of a conserved quantity. This equation is a stronger, local form of conservation law which says ‘‘ ENERGY CAN NEITHER BE CREATED,NOR BE DESTROYED’’. It moves from one place to another. In terms of semiconductors, we can say that it satisfies the condition that particles should be conserved. Electrons and holes cannot mysteriously appear or disappear at a given point, but must be transported to or created at given point via some type of carrier action. This equation gives us the relation between the incoming and outgoing charge carriers with the generation and recombination of carriers.

II.Introduction

Continuity equation

In semiconductors, we can say that continuity equation describes the change in carrier density over time is due to the difference between the incoming and outgoing flux of carriers, plus the generation and minus the recombination.



Electron currents and possible recombination and generation processes

Continuity equation in 1D

The rate of change of the carriers between x and $x + dx$ equals the difference between the incoming flux and the outgoing flux plus the generation and minus the recombination

$$\frac{\partial n(x,t)}{\partial t} A dx = \left(\frac{J_n(x)}{-q} - \frac{J_n(x+dx)}{-q} \right) A + (G_n(x,t) - R_n(x,t)) A dx$$

where $n(x,t)$ is the carrier density, A is the area, $G_n(x,t)$ is the generation rate and $R_n(x,t)$ is the recombination rate.

This equation can be formulated as a function of the derivative of the current:

$$\frac{\partial n(x,t)}{\partial t} = \frac{1}{q} \frac{\partial J_n(x,t)}{\partial x} + G_n(x,t) - R_n(x,t)$$

for electrons

$$\frac{\partial p(x,t)}{\partial t} = -\frac{1}{q} \frac{\partial J_p(x,t)}{\partial x} + G_p(x,t) - R_p(x,t)$$

for holes

This is continuity equation in 1D.

Similarly we can write the equation for 2-D and 3-D,

CONTINUITY EQUATION IN 4D

The equation can be written for four dimension as follows

Let we take four dimensions as x,y,z,w with respect to time 't', so the continuity equation become.

$$\frac{\partial n(x,y,z,t)}{\partial t} = \frac{1}{q} \nabla \cdot \vec{J}_n(x,y,z,t) + G_n(x,y,z,t) - R_n(x,y,z,t)$$

Diffusion equation:

The time-dependent diffusion equations for electrons in p-type material and for holes in n-type materia

$$l \frac{\partial p(x,t)}{\partial t} = D_p \frac{\partial^2 p_n(x,t)}{\partial x^2} - \frac{p_n(x,t) - p_{n0}}{\tau_p}$$

The general solution to these second order differential equations are:

$$n_p(x \leq -x_p) = n_{p0} + C e^{-(x+x_p)/L_n} + D e^{(x+x_p)/L_n}$$

$$p_n(x \geq x_n) = p_{n0} + A e^{-(x-x_n)/L_p} + B e^{(x-x_n)/L_p}$$

where L_n and L_p are the diffusion lengths given by:

$$L_n = \sqrt{D_n \tau_n}$$

$$L_p = \sqrt{D_p \tau_p}$$

$L_p = (D_{pp})^{1/2}$ associated with minority carrier holes in n-type materials

$L_n = (D_{nn})^{1/2}$ associated with minority carrier electrons in p-type materials

III.CONCLUSION

We use the continuity equation in different fields. Here, we use it to describe the movement of charge carriers in semiconductors. We conclude that the change in carrier density is actually related to the flux difference between incoming and outgoing carriers. It increases with the increase in no. of generation and decreases with increase in recombination of charge carriers.

ACKNOWLEDGMENT

I would like to take this opportunity to express my profound gratitude and deep regard to my Sir. Dr .KK. Saini for his exemplary guidance, valuable feedback and constant encouragement throughout the research .His valuable suggestions were of immense help throughout my work.His perceptive criticism kept me working to make this paper in better way .Working under his was an extremely knowledgeable experience for Me. I would also like to give my sincere gratitude to my brother and friends who filled in the survey, without which this research would be incomplete.

REFERENCES

1. Pinto, M. R., Rafferty, C. S., & Dutton, R. W. (1984). *PISCES II: Poisson and continuity equation solver*.
2. Selberherr, S. (1984). *Analysis and simulation of semiconductor devices* (p. 308). Wien; New York: Springer.
3. Forghieri, A., Guerrieri, R., Ciampolini, P., Gnudi, A., Rudan, M., & Baccarani, G. (1988). A new discretization strategy of the semiconductor equations comprising momentum and energy balance. *Computer-Aided Design of Integrated Circuits and Systems, IEEE Transactions on*, 7(2), 231-242.
4. Snowden, C. M. (1986). *Introduction to semiconductor device modelling* (p. 117). Singapore: World Scientific.