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Subject : Electronics (104)

Assignment on.

Diffusion

DIFFUSION AND ION IMPLANTATION

Dopping by diffusion:- The diffusion of impurities is a process similar to the process when excess of carriers are created non-uniformly in a semiconductor which cause carrier gradient. In both cases the diffusion is result of random motion and particle diffusion in the direction of decreasing concentration gradient. The random motion of impurity atom in a solid is limited at low temperatures. This diffusion of dopping impurities into silicon is accomplished at high temperatures.

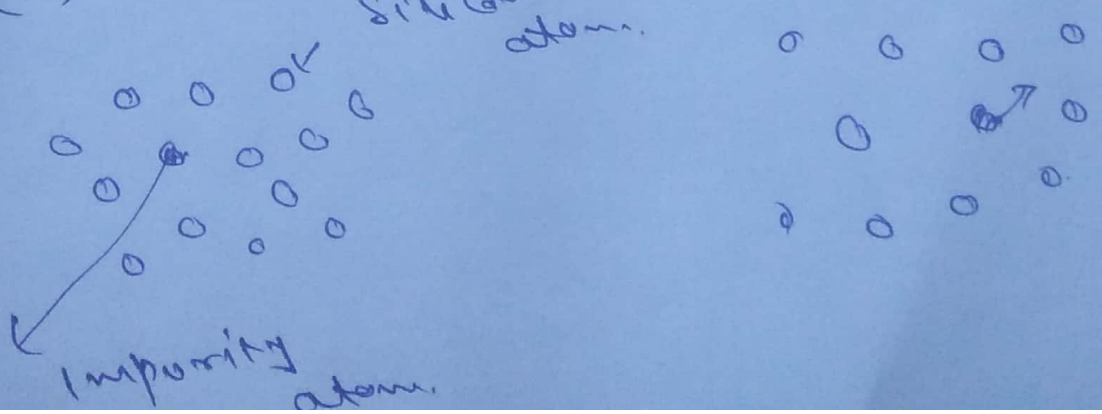
There are mainly two types physical mechanisms by which the impurities can diffuse into lattice. They are

Substitutional Diffusion: At high temperatured many atoms in the semiconductors move out of their lattice site leaving vacancies into which impurity atoms can move. The impurities thus diffuse by this type of vacancy motion and occupy lattice position in the crystal after it is cooled Thus D.D takes place by replacing the

Silicon atoms present Crystal by impurity atoms. In other words impurity atoms diffuse by moving from a lattice Site to a neighbouring one by Substition from a Silicon atom which had vacated a usually occupied Site. or w big.

S.D is applicable to most Common diffusions Such as Boron, Phosphorus and Silicon The dopants are so big & Voided, So the only way They Can enter The Silicon Crystal is to Substitute for a Silicon atom.

Interstitial Diffusion :- In this process the impurities atoms does not replace the silica atoms but instead moved into the interstitial voides in the lattice The main type of impurities diffusing by such mechanism are Gold Copper and Nickle Gold particularly is integrated into Silicon to reduce carriers life time and have useful to increase speed of digital ICs.



Fick's law Governing diffusion distribution Profiles:

The behaviour of diffusion particles is governed by Fick's law which when solved for appropriate boundary Conditions give rise to various doping distributions called profile, which are approximated during actual diffusion process

Fick's first law of diffusion states that the local transfer of solute per unit area per unit time is proportional to the Concentration gradient of

The Solute and ~~diffn~~. defined the proportional Constant as the diffusion Constant of the Solute

Mathematically

$$F = -D \frac{\partial N(x,t)}{\partial x} \quad \text{—①}$$

where f is rate of transfer of Solute per unit area or the diffusion flux density & x is the axis of the direction of flow, t is the diffusion time and D is the diffusion Constant. The negative sign appears due approte direction of matter flow and Concentration gradient i.e The matter

in the direction of decreasing Solute Concentration.

The change of Solute Concentration with time must be the same as the local decrease of the diffusion flux. in the absence of the source

$$\frac{\partial N(x,t)}{\partial t} = -D \frac{\partial N(x,t)}{\partial x} \quad \text{---(2)}$$

Substitute equation (2) in (1).

$$\frac{\partial N(x,t)}{\partial t} = \frac{\partial}{\partial x}\left[D \frac{\partial N(x,t)}{\partial x} \right] \quad \text{---(3)}$$

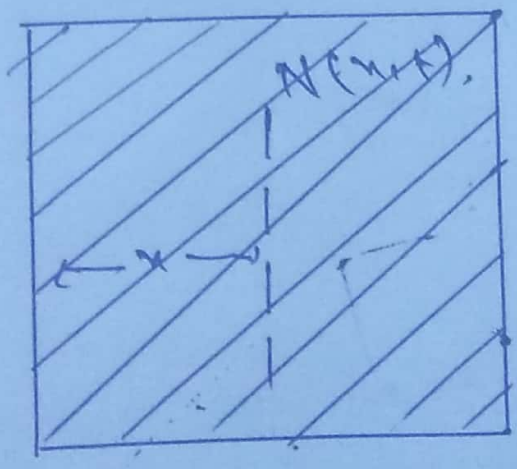
when Concentration of Solute is low The diffusion Constant at a given temperature can be

Considered as Constant and eq. (3) becomes

$$\frac{\partial N(x,t)}{\partial t} = D \frac{\partial^2 N(x,t)}{\partial x^2} \quad \text{---(4)}$$

This is refered as Ficks law of diffusion.

The Solution of this equation gives the impurity Concentration N at some distance x from the origin usually the surface of semiconductor as shown in fig.



Depends upon the boundary Condition equation (4) has two types of Solutions. These Solutions provide two types of impurities distribution namely.

(1) Constant Source diffusion following Complementary error function

(2) Limited Source diffusion following Gaussian distribution function.