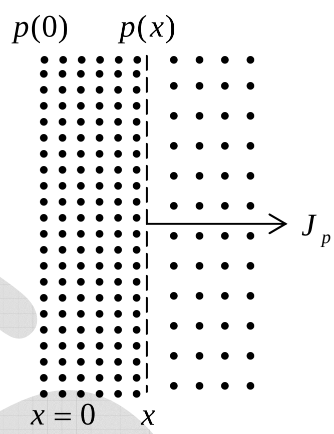
(k) Diffusion Current



In addition to a conduction current, the transport of charges in a semiconductor may be accounted for a mechanism called diffusion. It is possible to have non-uniform concentration of particles in a semiconductor. As indicated in the figure, the concentration p of holes varies with distance x in the semiconductor, and there exist a concentration gradient, $\frac{dp}{dx}$ in the density of the carriers.

The existence of a gradient implies that if an imaginary surface is drawn in the semiconductor, the density of the holes immediately on one side of the surface is larger than the density on the other side. The holes are in random motion as a result of their thermal energy. Accordingly, holes will continue to move back and forth across this surface. We may then expect that, in a given time interval, more holes will cross the surface from the side of greater concentration to the side of smaller concentration than in the reverse direction. This net transport of holes across the surface constitutes a current in the positive x-direction.

Note: It should be noted that this net transport of charge is not the result of mutual repulsion among charges of like sign, but is simply the result of a statistical phenomenon. This diffusion is exactly analogous to that which occurs in a neutral gas if concentration gradient exists in the gaseous container.

The diffusion hole-current density J_p (ampere per square meter) is proportional to the concentration gradient, and is given by: $J_p = -qD_p \frac{dp}{dx}$

where D_p (Square meters/second) is called diffusion constant. Since p decreases with increasing x, then $\frac{dp}{dx}$ is negative and the minus sign needed, so that J_p is positive in the positive x-direction.

Similarly, $J_n = qD_n \frac{dn}{dx}$