Diffusion Lesson

Lesson Topic: Diffusion

Objective of Lesson: To get an introduction to diffusion of particles and random thermal motion.

Reading Assignment: Section 3.2

Discussion Questions:

1. Are carriers motionless when there is no concentration gradient?
2. Come up with your own example of diffusion in your everyday life.

Homework: None

What do you need to know for the exam?

1. Carriers diffuse from what to what?

Summary
Diffusion is a process whereby particles redistribute as a result of their random thermal motion. This motion can result in current flow.

Diffusion
Diffusion is a fascinating mechanism for carriers to get around because there is no real force pushing the electrons and holes around; they just move around at random and that can result in a significant flow of current.

Diffusion is a process whereby particles redistribute as a result of their random thermal motion. The analogy most of us use is the bottle of perfume, sitting in the corner of the room. The bottle is opened and one-by-one everyone in the room eventually smells the perfume. There is no wind pushing the molecules around the room; the particles move around randomly with no apparent individual purpose. Because there are more particles near the bottle, there is a net flow away from the bottle. The bottle provides a continuous source of new molecules, maintaining the gradient of concentration of the perfume. It is the gradient of concentration, combined with random thermal motion, which drives the flow of particles from regions of high concentration to regions of low concentration.

The text gives an analogy at the beginning that is useful for understanding. It then discusses the hot-probe experiment—something still used every day in the semiconductor industry. The hot-probe experiment is also a lot like the perfume bottle analogy. The next sub-section provides the equations that are used for calculating currents due to diffusion. We don’t bother deriving the equations—though they are not that hard to derive—you just get to have them and accept them. The equations,

$J_{p_{diff}} = -qD_p \nabla p$
and $J_{n_{diff}} = qD_n \nabla n$
are not complicated. They start with a physical constant (a true constant), followed by a material constant (a "constant" that varies depending on doping concentration and temperature), and end with a three-dimensional gradient. They have opposite signs because of the opposite charge—one for holes and one for electrons. Note that without a gradient, there is no diffusion. There must be a change in concentration for diffusion to occur.

Later we will find that gradients are created by varying doping concentrations, applying external voltages, or shining light—those are the most common ways. We will then learn how to solve a variety of problems that involve the diffusion of carriers.

That is all for now.

Definitions:

Diffusion: The angular redistribution of radiation by a scattering, reflecting or refracting system, ideally producing an isotropic distribution of intensity, the gradual mixing of the molecules of two or more substances, as a result of random thermal motion.

Thermal motion: Motion due to temperature. "Thermal" means of, pertaining to, using, producing, or caused by heat.