Notes for Lecture 18

Bipolar Junction Transistor

In this lecture, we covered some basics of the bipolar junction transistor (BJT). The covered materials were pretty much one to one with chapter 10 (10.1, 10.5) and chapter 11 (11.1.4). The information there is *not* repeated here, and you are invited to simply read those book sections.

As a general remark, having understood the *pn* junction physics thoroughly, now it should be rather easy to follow the literature going beyond what we covered, including that of the BJT (e.g. 11.1.1-11.1.3) or other subjects. Take time to read this quite readable textbook, as you find it necessary/motivating to do so in the future.

Two notes.

A general and sharper discussion of current through a *pn* junction can be found in Appendices 2 and 3. Consider these as a sort of summary of what we did in LN 15 and 16. Be sure to read them!

One additional thing that we discussed in this class, as a general topic related to the current, was this rather simple question: among the three typical speeds, v_d, v_T (thermal velocity as defined in Problem 1(c) of HW #6; or v_F if we are considering a metal), and c' (speed of light in medium $c' = c/n$ where n is the index of refraction[1]), which one determines the speed at which the current propagates? The answer is c'. Note that $c' \gg v_T \gg v_d$. How come? It is because the current is really an electromagnetic wave phenomenon. I.e., it is the propagation of photon. The current does involve charge carriers participation, but how charge carriers move does not limit the propagation of the other component – the photon – that is driving force of the current. Also, note that the drift velocity can be very small like 1 mm/s. Such a slow

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[1] Not $c/\sqrt{n}$, as might have been written in class, I think. Note that $n \approx \sqrt{K_s}$.

speed of current is definitely not what we experience in everyday lives.

For the propagation speed of the current, I use this sort of analogy. Imagine that Superman flies from west coast to east coast in a very short time. All school children are watching him fly. Superman waves at them, and the children get excited and follow them. Namely, Superman is causing a disturbance of children, in the form of a coordinated movement along one direction. How fast this disturbance, the analogy of the current, propagates is definitely not limited by the slowness of kids relative to Superman. In this analogy, Superman is photon, and kids are charge carriers. The fact that light slows down in a medium might be understood as the slowing down of Superman as he recognizes children and waves at them as he zooms by.