Homework #2 - September 13, 2002

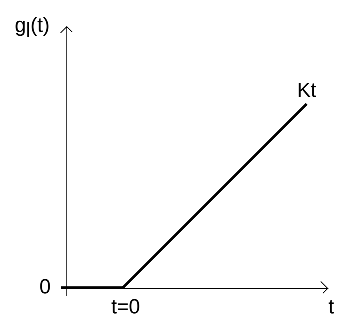
Due: September 20, 2002 at lecture

1. *[40 points]* A p-type Si wafer doped with $N_A = 10^{17}\ cm^{-3}$, has been illuminated with uniformly penetrating radiation that generates $g_l = 10^{20}\ cm^{-3} \cdot s^{-1}$ for a long time. Suddenly, the radiation is turned off. Estimate the electron and hole concentrations and the net recombination rate: a) right before the radiation is turned off, b) 100 ns after the radiation is turned off, c) 50 μs after the radiation is turned off, and d) after steady-state is reached.

2. *[40 points]* An n-type Si wafer doped at a level of $N_D = 1 \times 10^{17}\ cm^{-3}$ is in thermal equilibrium at 300 K in the dark. At $t = 0$, light that causes uniform carrier generation throughout the wafer is turned on. The light intensity increases linearly as a function of time so that the carrier generation rate has the following time dependence:

$$g_l(t) = K\ t \qquad\qquad t \geq 0$$

where K is a constant and t represents time.



a) Derive an analytical expression for the time evolution of the minority carrier concentration in the low-level injection regime. Graph your result.

b) Simplify result obtained in a) above for times much shorter and much longer than the lifetime. Sketch this asymptotic behavior on the graph you obtained in a).

c) If the carrier lifetime of the wafer under low-level injection conditions is 15 μs and $K = 10^{22}\ cm^{-3} \cdot s^{-2}$, calculate the time at which:

- the hole concentration is doubled over the equilibrium value;
- the low-level injection solution stops being applicable.

3. *[20 points]* Derive Equation 3.9. Graph $f(E_i)$ as a function of p_o in a log-log scale for Si at room temperature for values of p_o between 10 and $10^{19}\ cm^{-3}$. Explain the dependence obtained. To do this problem, you will need to first do problem 5 of homework 1.