Advanced Topics on Spectroscopy 2020 report 8

To clarify an origin of a Photo Luminescence (PL) spectrum from an n-type semiconductor, a decay curve of the PL at peak energy was observed. Figure 1 and "2020 decay curve.txt" show the decay curve of the PL. As shown in Fig. 1 vertical axis is natural log of PL intensity and horizontal axis is decay time. From the Fig. 1 you can find that the PL constructed with a long life time τ_{L} (sec) and a short life time τ_S (sec) components.

Here, to analyze the PL decay curve, let's consider a transition model as shown in Fig. 2. We assume that the origin of the PL is due to a radiative recombination transition from donor levels of E_S(eV) and E_L(eV) to the grand state, where E_S and E_L denote energy levels of short life time and long life time components, respectively. Population of electrons at the levels of E_S and E_L are n_{S}(t)(1/cm^3) and $n_{\mathrm{L}}(t)$(1/cm^3), respectively, and radiative transition ratio from the levels of E_S and E_L to the ground state are γ_S(1/scc) and γ_{L}(1/scc), respectively. Population of electrons in valence band just after excitation is n_0(1/cm^3), and we assumed that the excited electrons into valence band immediately transit to the levels ofE_S and E_L without any losses, that is $n_0 = n_{\mathrm{S}}(0) + n_{\mathrm{L}}(0)$ at $t = 0$, where $n_{\mathrm{S}}(0) : n_{\mathrm{L}}(0) = \alpha : (1-\alpha)$ and $0 \le \alpha \le 1$. We assumed that there is no non-radiative recombination from the levels of E_S or E_L to the ground state, there is no transition from E_S to E_L and from E_L to E_S, there is no re-excitation from E_S or E_L to valence band, and PL intensity is proportional to$n_{\mathrm{S}}(t) + n_{\mathrm{L}}(t)$.

(1) Derive rate equations of n_{S} and n_{L}.
(2) From problem (1), derive the PL intensity depends on decay time ($I_{\mathrm{PL}}(t)$), where we assumed that $I_{\mathrm{PL}}(0) = 1$.
(3) Estimate τ_{S}, τ_{L}, and α, by fitting the equation derived at question (2) to the "2020 decay curve.txt".
(4) Estimate τ_{S}, τ_{L}, and α. To estimate τ_{S}, τ_{L}, and α, don't use <u>any fitting.</u>

Deadline 2020/7/24 15:00(JST)
Submitting place: mail box at room 406 of the electrical engineering building.

Write your e-mail address which can receive from tanaka@vos.nagaokaut.ac.jp.
If your score is less than 60, I will inform you. If your written address rejected my mail, I will not inform you.

If you resubmit report, your final score of this report is 80% of resubmit report, however, if the final score is higher than 60, your final score of this report is 60. You can resubmit only one time.

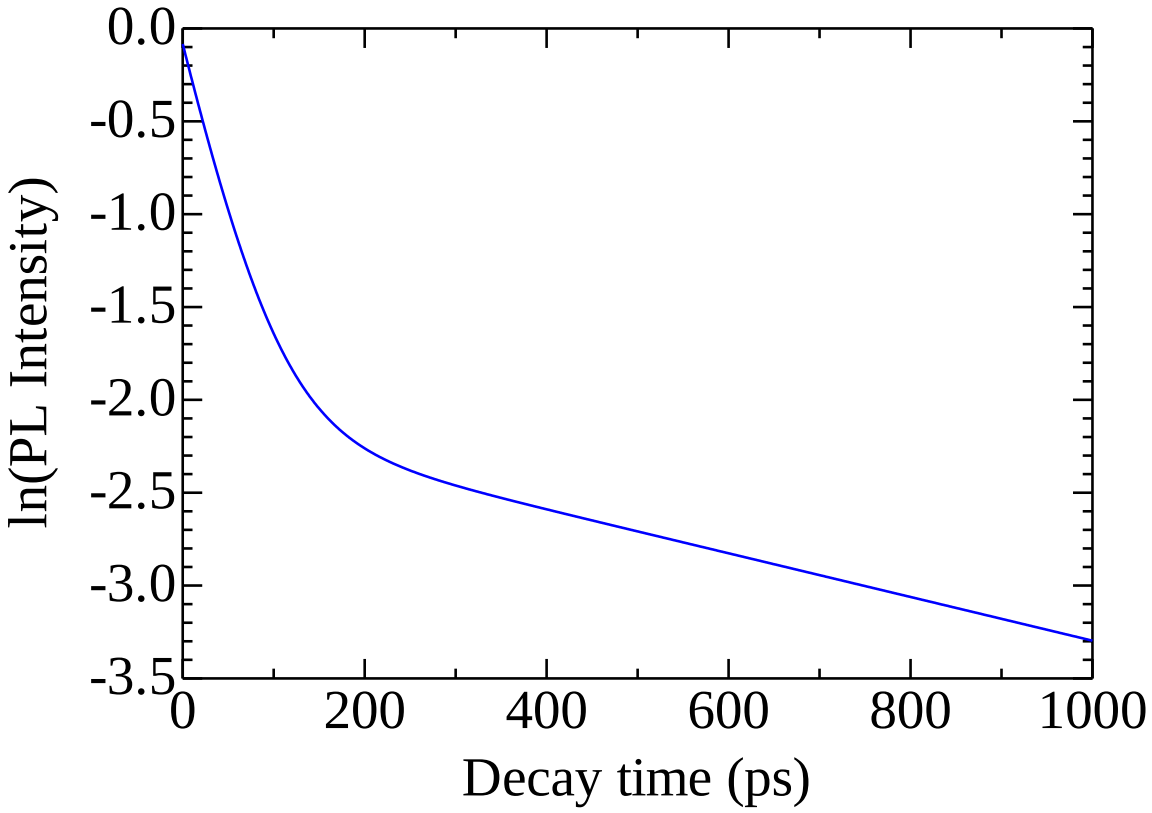

Fig. 1 Decay curve from n-type semiconductor.

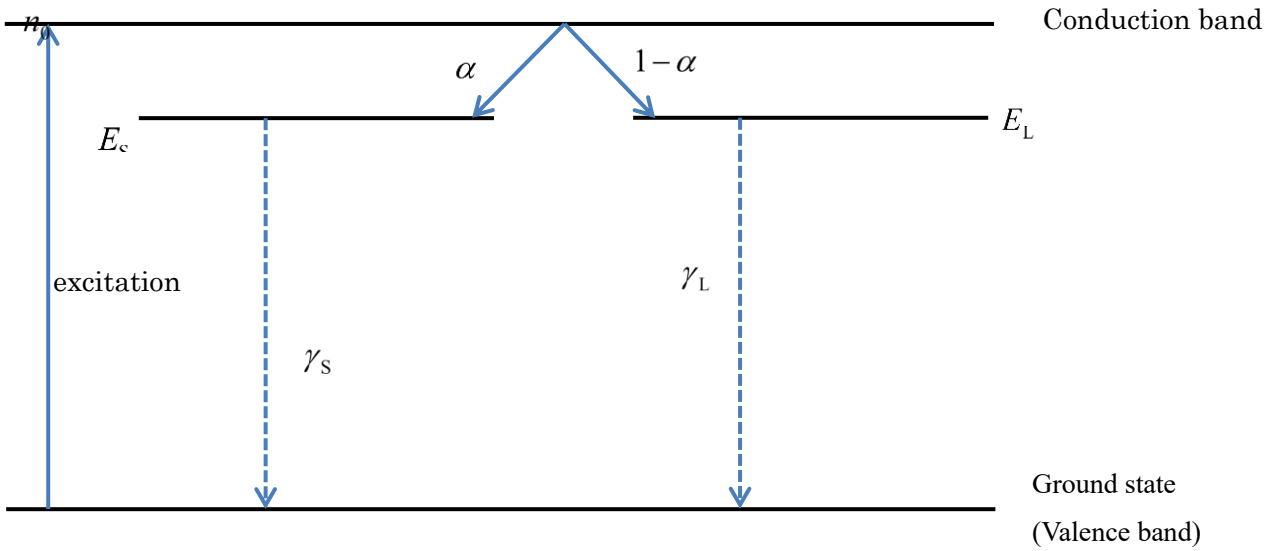

Fig. 2 transition model