19a-PA8-2

Extraction of Shockley-Read Hall and Auger Recombination Coefficients by Utilizing Theoretical Radiative Recombination Coefficient and Rate Equation in LEDs

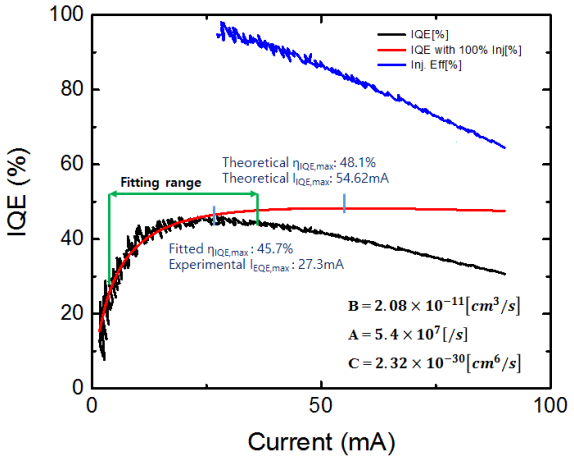
Hanyang Univ. [1], RIKEN [2],　°Joosun Yun[1,2], Jong-In Shim[1], and Hideki Hirayama[2]

E-mail: joosun.yun@riken.jp

Previous studies have shown that it is possible to extract Shockley-Read Hall (A), radiative (B) and Auger (C) coefficients in rate equation of LEDs when we know a parameter among the three (ABC) and IQE vs. current characteristic [1, 2]. Since radiative coefficient can be calculated theoretically [3], we will just need to estimate IQE vs. current curve to extract A and C parameters of LEDs as an essential prerequisite. IQE vs. current characteristics can be expressed as a cubic equation like below. , which is derived just by rate equation and definition of IQE with two assumptions. First assumption is that injection efficiency is 100% until the current of the peak IQE. Second assumption is that A, B and C parameters are constants.

$$(1)\quad I^2\eta_{IQE}^3+\left(2\eta_{IQE,max}I_{IQE,max}I-\frac{4\eta_{IQE,max}^3I_{IQE,max}I}{\left(\eta_{IQE,max}-1\right)^2}\right)\eta_{IQE}^2+\left(\frac{8\eta_{IQE,max}^3I_{IQE,max}I}{\left(\eta_{IQE,max}-1\right)^2}+\eta_{IQE,max}^2I_{IQE,max}^2\right)\eta_{IQE}-\frac{4\eta_{IQE,max}^3I_{IQE,max}I}{\left(\eta_{IQE,max}-1\right)^2}=0$$

In the equation (1), I, η_{IQE}, $\eta_{IQE,max}$, and $I_{IQE,max}$ mean current, IQE, peak IQE and current at peak IQE, respectively. This equation means that IQE vs. current curve is determined just by both $\eta_{IQE,max}$ and $I_{IQE,max}$. Therefore, IQE vs. current can be extracted if there are agreeable current range of 100% injection efficiency in the experimental EQE vs. current characteristics by fitting process. We adopted one more assumption that injection efficiency is nearly 100% until the current of peak EQE in experiment. In our study, $I_{IQE,max}$ is swept with the values from $0.5I_{EQE,max}$ to $2I_{EQE,max}$ at intervals of $0.015I_{EQE,max}$. Here $I_{EQE,max}$ means the current at peak EQE in experiment. In the case of $\eta_{IQE,max}$, it is swept from 0.1% to 99.9% at intervals of 0.1%. During the processes above, the fit curve between η_{IQE} vs. I and η_{EQE} vs. I until current at peak EQE is retrieved. This is the different approach with previous studies since we consider $I_{IQE,max}$ with 100% $\eta_{inj} \neq I_{EQE,max}$. Mismatching portion between them is attributed to the injection efficiency. After IQE curve is extracted, A, C and N (=carrier density) can be easily calculated with equations of references. Figure 1 shows that the extracted parameters of a 280nm AlGaN QW LED.



[1] H. Y. Ryu, G. H. Ryu, S. H. Lee, and H. J. Kim, J. Korean Phys. Soc. **63**, 180-184 (2013).

[2] H. Y. Ryu, H. S. Kim, and J. I. Shim, Appl. Phys. Lett. **95**, 081114 (2009).

[3] A. Dmitriev and A. Oruzheinikov, J. Appl. Phys. **86**, 3241-3246 (1999).