Performance Analysis of Light-Emitting Diodes by Optoelectronic Characterizations

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Nowadays, blue light-emitting diodes (LEDs) are being utilized in various applications ranging from the backlight units of liquid crystal displays to the general lighting. Blue LEDs, which forms the basis of high-efficiency white light sources, have various properties unique to the InGaN/GaN material system. While many technical difficulties in fabricating the efficient GaN LEDs have been overcome, there still remain issues in further improving the efficiency. The first step to improve the performance is the accurate characterization of the device. In this presentation, various optoelectronic characterization techniques will be discussed to highlight the characteristics of blue LEDs based on the InGaN/GaN material system.

Many characteristics of InGaN blue LEDs originate from defects in the crystal structure; reducing the nonradiative recombination current associated with defects is considered as one of the important issues in further increasing the efficiency of the device. While microscopic techniques such as transmission electron microscopy (TEM) have been utilized to characterize defects, testing the LEDs in the device level can also give useful information on the crystal quality. For example, the minimum ideality factor that can be obtained from the basic I-V characteristics of the device can give a quantitative measure of the crystal quality. Fig. 1 shows the basic idea behind the ideality factor obtained from the I-V characteristics.

Typically, various characterization methods can be combined to give a more complete picture of the device performance and its limiting mechanism. By combining such parameters as the internal quantum efficiency, device current, light output power, and carrier lifetime, information that could not be obtained from a single microscopic technique can be deduced. Examples of such measurements highlighting the characteristics of InGaN blue LEDs will be discussed during the presentation.

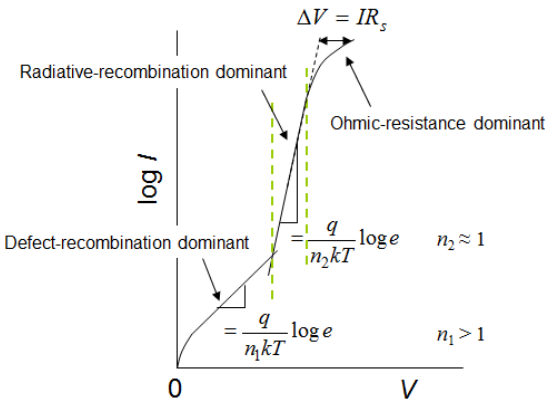

Fig. 1. Schematic I-V characteristics showing two current components: the defect-related nonradiative recombination current and the radiative recombination current.