Luminescent properties of GaN:Eu,O annealed at high temperature under photoexcitation and current injection

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Eu,O-codoped GaN (GaN:Eu,O) is an efficient red light-emitting material based on the GaN platform. We have demonstrated red light-emitting diodes (LEDs) using GaN:Eu,O grown by organometallic vapor phase epitaxy (OMVPE) [1]. Eu^{3+} ions doped in GaN form several luminescent sites with different local atomic structures around the Eu^{3+} ions. In particular, OMVPE7,8, which are believed to have an oxygen atom in the vicinity of the Eu^{3+} ion, are known to be excited with much higher efficiency as opposed to other sites [2]. Recently, we have shown that post-growth thermal annealing at a high temperature (>1000 °C) reconstructs luminescent sites and converts inefficient sites into OMVPE7,8 [3]. Furthermore, it was found that another efficient site with a peak at ~2.004 eV is also preferentially formed by annealing (labeled as OMVPE X here). However, OMVPE X has not been studied in detail so far. In order to fabricate further bright GaN:Eu,O-based LEDs, it is highly important to investigate the detailed fundamental characteristics of OMVPE X under photoexcitation and current injection.

In this regard, we first conducted temperature-dependent photoluminescence spectroscopy for GaN:Eu,O annealed at 1100°C, which has been published in Ref.[3]. OMVPE X shows a dominant emission at room temperature, while the emission is relatively weak at low temperatures, suggesting that its optical activity is thermally activated, just as reported for OMVPE8 [4]. We then fabricated an LED with an annealed GaN:Eu,O active layer, and a conventional LED (w/o anneal) as a reference using the OMVPE method. The sample is constructed by ud-GaN (1.2 μm), n-GaN (1.8 μm), GaN:Eu,O (190 nm), p-GaN (50 nm), and p^+-GaN (25 nm) layer. Annealing was performed at 1100°C for 20 min in N_2 ambient after the GaN:Eu,O layer growth. Figure 2 shows electroluminescence spectra for these LEDs. For the LED with an annealed active layer, OMVPE X is seen to be the predominant emission, clarifying this site is highly efficient under current injection. From these results, we conclude that OMVPE X, which is preferentially formed by high-temperature annealing, is a promising luminescent site for the realization of bright GaN:Eu,O-based LEDs.

【Reference】[1] A. Nishikawa, Y. Fujiwara *et al.*, *Appl. Phys. Express* **2**, 071004 (2009). [2] D. Timmerman, Y. Fujiwara *et al.*, *Phys. Rev. Appl.* **13**, 014044 (2020). [3] T. Iwaya, Y. Fujiwara *et al.*, *Appl. Phys. Lett.* (In press). [4] R. Wakamatsu, Y. Fujiwara *et al.*, *J. Appl. Phys.* **116**, 043515 (2014).

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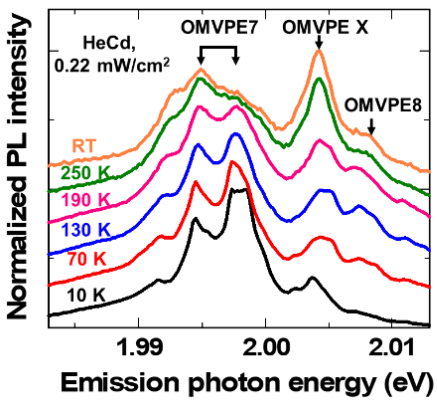

Fig. 1 PL spectra for GaN:Eu,O annealed at 1100°C for temperatures between 10 K to RT.

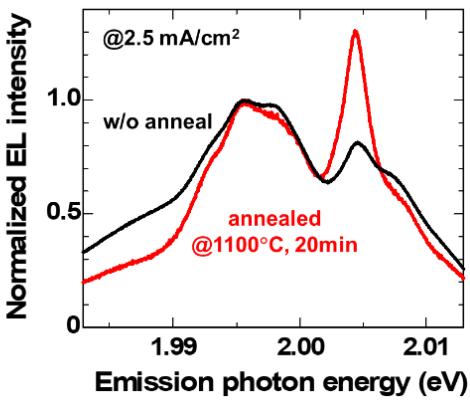

Fig. 2 EL spectra for a conventional LED (w/o anneal) and a LED with an annealed active layer.