Thermal Imprinting Process using ZnO Nanoparticles-Dispersed Resin for the Improvement of Light Extraction Efficiency of GaN-based LEDs

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Recently, GaN-based LEDs have attracted great interest for their wide applications, such as traffic signals, backlighting in liquid crystal displays, vehicle lamps and general illuminations. However, their external quantum efficiency should be further improved in order to realize solid-state lighting. The external quantum efficiency of conventional GaN-based LEDs is mainly limited by total internal reflection at the interface between the device and the air.

To enhance the light extraction efficiency of LEDs, texturing methods such as photonic crystal (PhC) structures[1] and surface roughening[2] have been intensively researched. However, plasma etching process is required in most of these patterning processes and it degrades the electrical property of LED devices by generating plasma damages in the GaN epitaxial layer. Moreover, it is difficult to fabricate sub-wavelength-scaled patterns due to the use of high cost patterning technique such as photolithography and e-beam lithography.

In this study, a high refractive resin containing ZnO nanoparticles was fabricated and used in a thermal nanoimprint process on GaN-based LEDs in order to directly modulate the light without plasma etching. Through this process, PhC and pseudo-moth-eye (PME) patterns, composed of ZnO nanoparticles-dispersed resin, were formed on the ITO electrode of the LED device as shown in figure 1. As a result, the optical output power of the PhC patterned and the PME patterned LED devices was enhanced by up to 12 % and 7 % compared to the unpatterned LED device at 20 mA drive current, respectively. And electrical properties of all patterned LED devices were not degraded.

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[1] S.-M. Pan, R.-C. Tu, Y.-M. Fan, R.-C. Yeh, J.-T. Hsu, IEEE Photonics Technol. Lett. 15, 649 (2003).

[2] T. N. Oder, K. H. Kim, J. Y. Lin and H. X. Jiang, Appl. Phys. Lett. 84, 466 (2004).

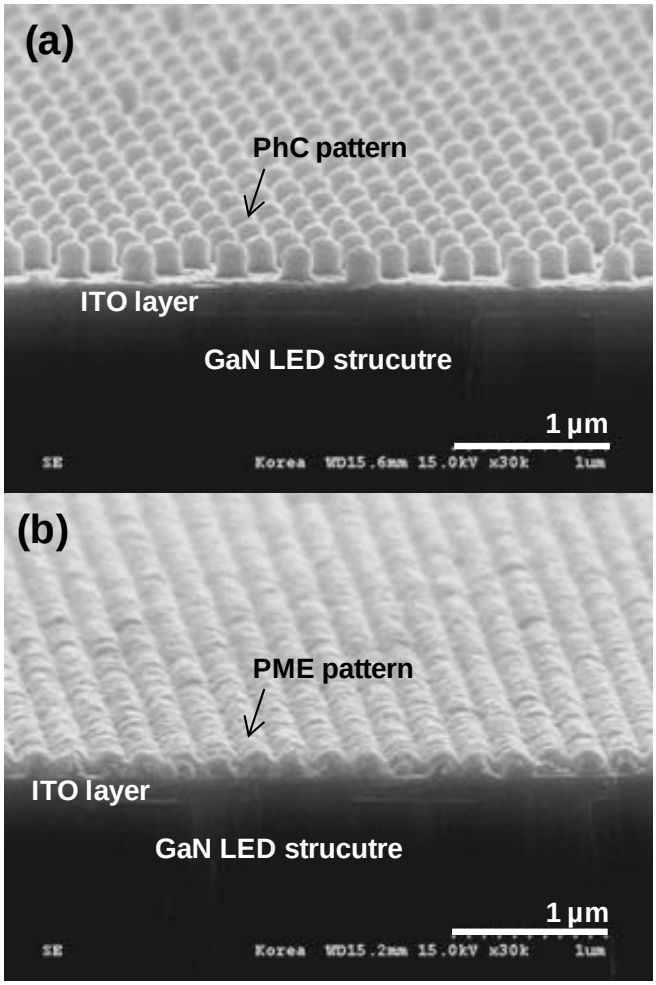

Figure 1: SEM micrographs of (a) PhC and (b) PME patterns composed of ZnO-nanoparticles-dispersed resin