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Growth, Fabrication, and Characterization of GaN-based Columnar LEDs

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GaN micro- (or nano-) column structures have been studied in an attempt to enhance the LED performance by improving the light extraction and reducing the strain due to the large lattice mismatch between GaN and InGaN. Nowadays columnar LEDs are drawing attention as a candidate for a multicolor emission source as illustrated in Fig. 1. Though numerous studies have focused on selective area growth, the top-down approach has often been the subject of study since it can realize a columnar structure more easily than when using the bottom-up method. However, predominant issue in the top-down approach is dry-etch damage resulting from the inductively coupled plasma (ICP) and reactive ion etching (RIE) systems. According to the previous reports the damage usually results in the increase in the sheet-resistance of GaN, along with the decrease in the reverse breakdown voltage and the reductions in the Schottky barrier height in the diodes formed on GaN. The roughened sidewall after etching also exhibited higher series resistance in the device and deteriorates the electrical characteristics. KOH treatment has been found to improve the electrical characteristics through the removal of the damaged region and providing the vertical profile in the sidewall with a smooth surface. Moreover, the size control of GaN micro- (or nano-) columns also becomes possible by adopting the KOH treatment.

The objective of this research is to improve the LED performance by utilizing the micro-column arrays having sidewall contacts fabricated through the top-down approach. We also report the size-controlled InGaN/GaN nano-columns by combining the top-down method with KOH treatment as shown in Fig. 2, and then present the results of the spatial strain distribution analysis on the InGaN/GaN nano-columns via a high resolution optical characterization.

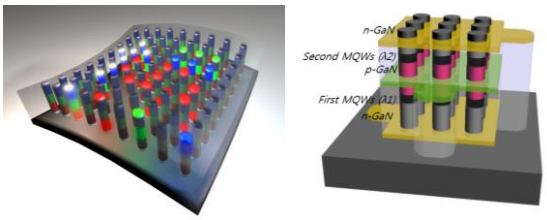
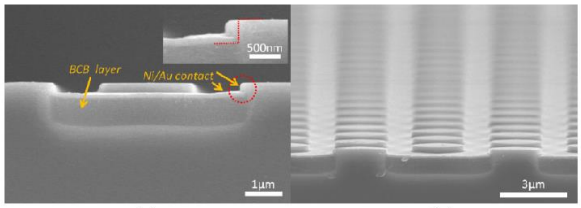


Figure 1.

The conception illustrate of the multi-junction LED using the sidewall electrical contact.



(a) (b)

Figure 2.

SEM images of sidewall contact InGaN/GaN LED.

(a) Cross-section view of the device

(b) A bird eye's view of the device