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Variable-color Light-emitting Diodes Using GaN Microdonut Arrays

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We report the fabrication and electroluminescent characteristics of GaN/InxGa1-xN microdonut-shaped light- emitting diode (LED) microarrays as variable-color emitters. The diameter, width, height, and period of the GaN microdonuts were controlled by their growth parameters and the geometrical factors of the growth mask patterns. For the fabrication of microdonut LEDs, p-GaN/p-AlxGa1-xN/u-GaN/u-InxGa1-xN heteroepitaxial layers were coated on the entire surface of n-GaN microdonuts. The microdonut LED arrays showed strong light emission, which could be seen with the unaided eye under normal room illumination. Additionally, magnified optical images of microdonut LED arrays exhibited microdonut-shaped light emissions having spatially resolved blue and green colors. Their electroluminescence spectra had two dominant peaks at 460 and 560 nm. With increasing applied voltage, the intensity of the blue emission peak increased much faster than that of the green emission peak, indicating that the color of the LEDs is tunable. We also demonstrated that EL spectra of the devices could be controlled by changing the size of microdonut LEDs. What we want to emphasize here with the microdonut LEDs is that they have additional inner sidewall facets which did not exist for other typical three-dimensional structures including nanopyramids and nanorods, and that InxGa1-xN single quantum well formed on the inner sidewall facets had unique thickness and chemical composition, which generated additional EL color. The origin of the electroluminescence peaks was investigated by structural characterizations and chemical analyses.

Keywords: light-emitting diodes; nanostructure; multicolor; quantum well; indium gallium nitride

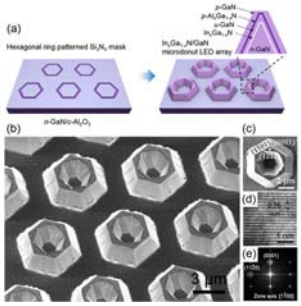

Fig. 1.

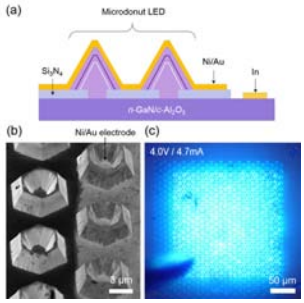

Fig. 2.

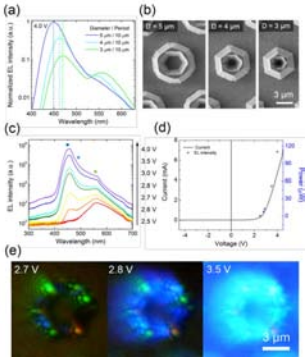

Fig. 3.

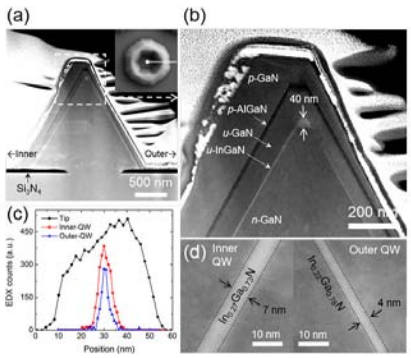

Fig. 4.