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A Chemically-driven Top-down Approach for the Formation of High Quality GaN Nanostructure with a Sharp Tip

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We have developed a chemically-driven top-down approach using vapor phase HCl to form various GaN nanostructures and successfully demonstrated dislocation-free and strain-relaxed GaN nanostructures without etching damage formed by a selective dissociation method. Our approach overcomes many limitations encountered in previous approaches. There is no need to make a pattern, complicated process, and expensive equipment, but it produces a high-quality nanostructure over a large area at low cost. As far as we know, this is the first time that various types of high-quality GaN nanostructures, such as dot, cone, and rod, could be formed by a chemical method without the use of a mask or pattern, especially on the Ga-polar GaN. It is well known that the Ga-polar GaN is difficult to etch by the common chemical wet etching method because of the chemical stability of GaN. Our chemically driven GaN nanostructures show excellent structure and optical properties. The formed nanostructure had various facets depending on the etching conditions and showed a high crystal quality due to the removal of defects, such as dislocations. These structure properties derived excellent optical performance of the GaN nanostructure. The GaN nanostructure had increased internal and external quantum efficiency due to increased light extraction, reduced strain, and improved crystal quality. The chemically driven GaN nanostructure shows promise in applications such as efficient light-emitting diodes, field emitters, and sensors.

Keywords: GaN, wide band gap semiconductor, optical property, nanostructure, chemical etching