Fabrication of InGaN/GaN Quantum Nanodisks for LED by Combination of Bio-template and Neutral Beam Etching

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Introduction

Since quantum dots (QDs) are proposed, various growth techniques have been developed and realized QDs lasers, amplifiers, and solar cells applications. QDs are fabricated by the Straski-Krastanow (S-K) epitaxial growth, however, it is very difficult to preciously control the size and thickness independently. We have already proposed combination of bio-template [1] nano-patterning process and ultra-low damage neutral beam etching (NBE) [2,3,4] for realizing QDs by III-V compound materials of GaAs, InGaAs. In this study, we have developed a top-down fabrication process and made InGaN/GaN nano-pillars structure. This method can also be further improved to control the ferritin density by changing the concentration of ammonium acetate (AA) solutions.

Results and discussions

The InGaN/GaN single quantum well (SQW) wafer was grown on a 2-inch c-plane sapphire substrate by metal organic vapor phase epitaxy (MOVPE) using NH3, TEGa and TMIn as the recursors. The structure consisted of a 2-μm thich GaN buffer layer, 2-nm thick $In_{0.2}GaN$ well and 10-nm-thick GaN capping layer. After chemical cleaning on the surface, polyethylene glycol decorated ferritin was spin coated by various AA concentrations as shown in Figure 1. We can control the density from 1.4 x 10^{11} to 2.4 x $10^{11}cm^{-2}$. And then, we removed protein shells by oxygen anneal in vacuum, hydrogen radical treatment to remove surface oxide. Finally, we realized the sub-10nm in diameter and 22-nm high InGaN/GaN nanopillars by NBE as shown in Figure 2. After measured by transparent electron microscopy, we have not measured defects on the sidewalls, therefore, no critical damages on the sidewall of nanopillars were realized. This fabrication technique have a promising method for obtaining III-N quantum dots.

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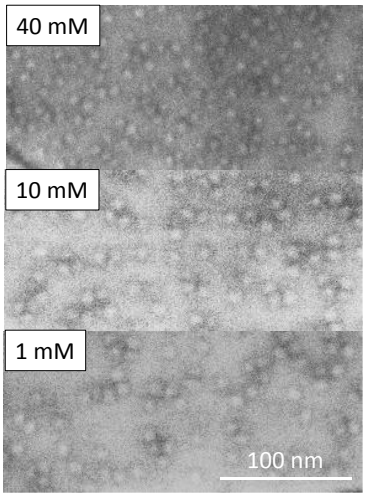

Figure 1. Top SEM images and density of ferritin arrangement with various concentration

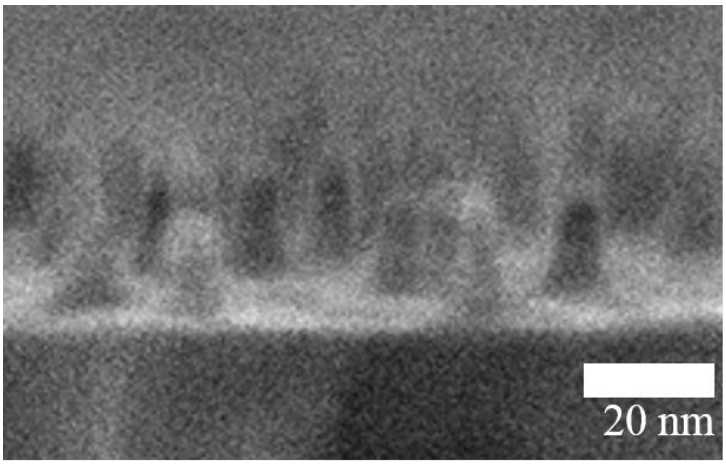

Figure 2. Cross section SEM image of InGaN/GaN nanopillars