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Growth conditions and optical properties of self-assembled GaN nanorod grown on (111) Si substrate without buffer layer

C. M. Park, Y. S. Park, T. W. Kang, S. H. Lee*, and J. E. Oh*
Quantum Functional Semiconductor Research center, Dongguk University
*School of Electrical and Computer Engineering, Hanyang University

We have investigated the growth conditions and optical properties of GaN nanorod grown on (111) Si substrate by molecular beam epitaxy. The hexagonal shape nanorods with lateral dimension from 10 to 350 nm was fully relaxed from lattice strain, having a very good crystal quality characterized by extremely strong and narrow photoluminescence excitonic lines near 3.47 eV. The nano-rod starts to protrude after the formation of approximately 0.4 um thick columnar film base, and its density and physical dimension, diameter and height, are strongly dependent on V/III ratio and growth time. We have found that the hexagonal nano-rod can be formed on Si substrate, not only in N-rich condition but also even in a Ga-rich condition, when it is formed without buffer layer at high growth temperatures. Three distinct features are observed. First, free exciton transition is observed at a high energy of 3.477 eV with decreasing diameter of GaN nano-rods. Secondly, the photoluminescence spectra show an abnormal behavior with increasing temperature. The third feature is the size effect in that the PL peak energies are blue-shifted with decreasing diameter of the GaN nano-rod. The activation energy of the free exciton for the GaN nano-rod with different diameters was evaluated.