Growth of Self- Organized GaN Nanostructures on Al_2O_3 (0001) by RF MBE

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Fabrication of low -dimensional nanostructures with quantum wires/ disks/ dots is considered as one of the most promising approaches for improving the performance of optical devices based on AlGaInN system. At present, it is difficult to produce such nanostructures using selective area epitaxy. Many efforts have been devoted to development of self-organization processes as a suitable technology for fabricating the AlGaInN nanostructures without pre-growth (ELOG) and post-growth treatment [1].

In this paper we report on radio-frequency molecular-beam epitaxy (RF-MBE) growth of self-organized GaN nanocolumns on (0001) Al_2O_3 substrates and studies of their structural properties. GaN nanostructures with relatively uniform column density ~10^{10} cm^{-2} demonstrated different column diameters depending on the presence of low temperature GaN buffer layer: 20 –50 nm with buffer and 50 –100 nm without it. No post – growth processing such as etching or patterning was used. Additional control of column diameter can be provided by Ga flax intensity variation. The structures were grown at a constant RF power of 150 W and a substrate temperature >750^0C. The growth rate estimated from the height of the nanocolumns was 0.75 μm/h with buffer and 1 μm/h without buffer growth. The growth process was performed under the Ga-rich conditions and seems to be due to the vapor-liquid-solid (VLS) mechanism [2].

The triple -crystal X-ray diffraction measurements carried out in a θ -2θ mode show the main peak at an angle of 34.7 degrees, which shows that each column grows with the **c**-axis normal to the substrate surface. The XRD study reveals only the hexagonal GaN phase for all samples. The rocking curves have a Gaussian shape, which is typical for III-N's, and the best FWHM value was 33 arc sec, while the corresponding value for continuously grown layers, without columns, using the similar conditions (temperature, activated nitrogen flux) and lower Ga flux, were ~70 arc sec.

Transmission electron microscopy (TEM) analysis shows that the columns having a diameter less than 50 nm are free from dislocations. The effects of confinement of longitudinal optical phonons in nanocolumns were detected in the Raman spectra.

Thus, the controlled growth of high density equally oriented GaN nanocolumns has been reported, demonstrating on ability of VLS mechanism for nanostructure fabrication.

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