Effect of low growth rate high temperature GaN buffer layer on the growth of thick GaN by hydride vapor phase epitaxy

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As a promising wide band gap semiconductor, GaN has numerous applications in electronics and optoelectronics [1-2]. However, the lack of a suitable lattice-matched substrate makes the growth of high quality devices in this materials system difficult. Renewed interest in hydride vapor phase epitaxy (HVPE) as a technique for growth of epitaxy-ready (quasi-bulk) GaN substrates is therefore motivated by demonstration of thick GaN layers on sapphire substrates with high growth rate (up to 60 μm/h) as well as greatly improved structural and electrical quality [3].

For HVPE growth, it is reported that low-temperature (500-800 ^{o}C) buffer layer results in polycrystalline GaN material [3] or poor materials quality [4] instead of improving GaN film quality as found by other growth techniques.

We have concentrated on in-situ low growth rate (LGR) high-temperature (HT) deposited GaN buffer layer for thick epitaxy-ready GaN layers grown by HVPE. The substrates used are *c*-Al_2O_3 (0001). The goal of this work is to show the improvement of GaN quality with the introduction of the in-situ LGR HT GaN buffer layer. The characterization is completed by means of optical differential interference contrast microscopy (ODIMC), X-ray diffraction (XRD), photoluminescence (PL) and scanning electron microscopy (SEM).

The main results of our work are as follows:

1) ODIMC observations show that the surface morphology of the layers does not exhibit vivid hillock-type surfaces though there are cracks at the surfaces. The number of cracks in GaN deposited on the HT GaN buffer layer (10^2 cm^{-2}), compared to those in GaN deposited directly on *c*-Al_2O_3 (0001), decrease considerably with the introduction of a HT GaN buffer layer.

2) In order to investigate the crystalline quality of the layers, we determined the value of full width at half maximum (FWHM) of the donor-bound exciton line in the PL spectra as well as the (0002) reflection in the XRD pattern using both rocking curve (ϖ -scan) and ϖ-2θ scan measurements at room temperature. It is shown that: comparing GaN directly deposited on *c*-Al_2O_3 (0001) (sample *b*) with that on the LGR HT buffer layer (sample *a*), the FWHM of ϖ -sacn varies from 1099 arcsec to 787.68 arcsec and ϖ-2θ FWHM value varies from 99 arcsec to 64. The exciton PL peak width varies from 14 meV to 7 meV at 4.2 K.

The measurements of surface morphology, structural and optical properties clearly show that the in-situ LGR HT buffer layers have greatly improved the crystal quality. Using SEM a defective columnar layer of about 1 μm and a well-structured layer of about 3 μm above which were observed. According to the SEM observations, we attribute the improvement of GaN crystal quality to

a) minimization of the defective columnar region to be very thin with the low growth rate of the buffer layer and
b) induced formation of a well-structured layer above the defective columnar region thus the suppression of columnar structure prior to main growth of a thick layer.

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