Influent of Ambient Hydrogen Gas on Crystalline Quality in GaN

A. Ubukata, H. Tokunaga, A. Yamaguchi, and T. Yamazaki

Compound Semiconductor Project, NIPPON SANSO Corporation
10 Ohkubo, Tsukuba, Ibaraki 300-2611, Japan
e-mail: Akinori_Ubukata@sanso.co.jp

The rapidly expanding market of optical devices has drastically increased the demand for GaN-based devices. This demand has driven the industry to increase the number of substrates or the diameter of a wafer. We have developed an atmospheric horizontal-type MOVPE (SR-6000) with a 6 inches diameter wafer platen [1,2]. This system is capable of handling 2 inches 6 wafers per growth. In this study, we have investigated growth conditions of GaN layers on sapphire substrates using this system. As precursors ammonia (NH_3), trimethylgallium (TMG), trimethylindium (TMI), and silane (SiH_4) were used with mixed H_2 and N_2 carrier gas. The GaN layers were grown 3 μm-thick on the GaN buffer layer. High sheet resistance of over 8000 ohm/sq. was obtained for nondoped GaN samples. The crystalline quality of GaN was measured by X-ray diffractometry rocking curve (XRC). Figure 1 shows the full-width at half maximum (FWHM) of XRC profile. With nitrogen rich carrier gas for the growth, the full-width at half maximum (FWHM) of the symmetrical (0002) XRC profile became narrower, while that of the asymmetrical (10-12) XRC profile was wider. On the other hand, FWHM of the asymmetrical (10-12) XRC profile improved dramatically with hydrogen rich carrier gas. These results suggest that the ratio of length of c axis to that of a axis is different between these two groups of samples [3,4]. The crystalline quality of GaN can be controlled by combination of two growth conditions. Figure 2 shows the result of XRC profile for GaN with combination of two growth conditions. Three points were measured at every 20 mm along diameter in a 2 inches wafer. Full width at half maximum of the symmetrical XRC profile and that of the asymmetrical XRC profile were 255-260 arcsec and 310-318 arcsec, respectively.

Also we investigated the effect of ambient H_2 gas on the emission intensity using $In_{0.17}Ga_{0.73}N$/GaN MQW structures [5]. In order to achieve a flat surface suitable for the growth of QW, 3 μm- thick of GaN layer was deposited. After that, MQW structure consisting of 3 nm-thick $In_{0.17}Ga_{0.83}N$ and 10 nm-thick GaN barrier layes, and 20nm-thick GaN capping layer were grown. All layers were undoped. The well and barrier thickness were estimated from simply from the growth rate of bulk and were confirmed using transmission electron microscopy (TEM). Figure 2 shows the room temperature photoluminescence (PL) spectra of the MQW structures excited with He-Cd laser. The PL peaks were observed at the wavelength of 475 nm, and FWHM were approximately 34-35 nm. For the barrier GaN grown with H_2 rich carrier gas, the PL intensity increased approximately three times as that for the QW grown with only N_2 carrier gas. The results indicate that In composition in the well was not changed between two samples by the PL emission peak wavelength. The effect of ambient H_2 in the barrier is also explained by the improvement of crystalline quality of GaN barrier layers in the MQW structures.

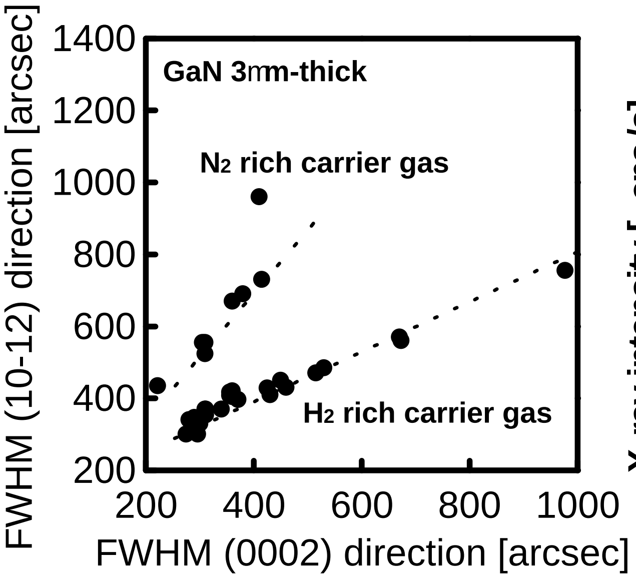

Figure 1 FWHM of XRC profile.

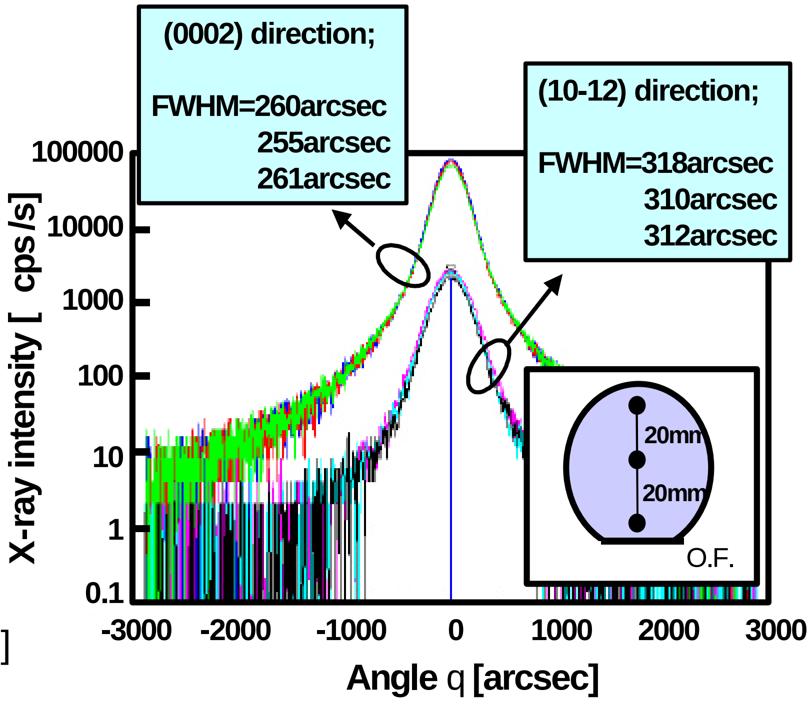

Figure 2 XRC profile for GaN bulk layer.

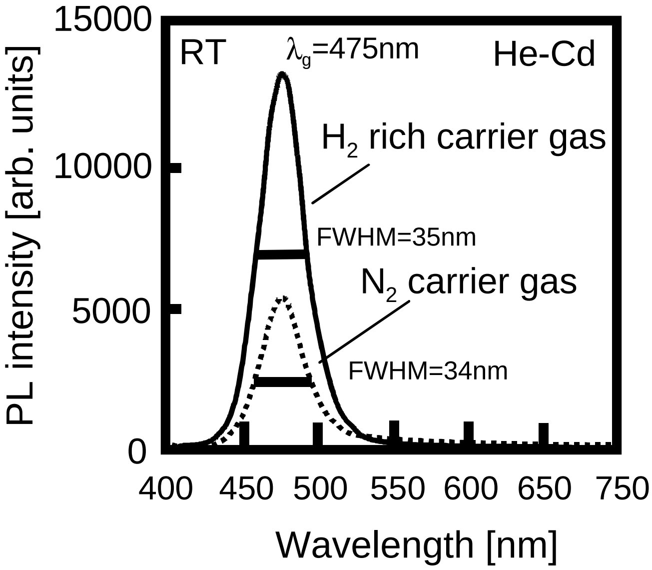

Figure 3 PL spectra for $In_{0.17}Ga_{0.83}N$/GaN MQW structures.

Conclusion

We investigated growth conditions of GaN layer using atmospheric horizontal-type MOVPE (SR-6000) with a 6 inches diameter wafer platen. As a carrier gas, ambient H_2 and N_2 gas were compared on the crystalline quality of GaN. It was found that the GaN barrier layer grown with ambient H_2 rich gas was effective for the InGaN/GaN QW structures on emission intensity.

References

[1] H. Tokunaga et al.: J. Cryst. Growth **221** (2000) 616.
[2] H. Tokunaga et al.: J. Cryst. Growth **189** (1998) 519.
[3] S. Yamaguchi et al.: J. Appl. Phys. **89** (2001) 7820.
[4] M. Kariya et al.: Jpn. J. Appl. Phys. **39** (2000) L143.
[5] S. J. Leem et al.: Jpn. J. Appl. Phys. **40** (2001) L371.