GROWTH AND CHARACTERISATION OF HIGH QUALITY GAN FILM BY EXPITAXIAL LATERAL OVERGROWTH

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Epitaxial lateral overgrowth (ELO) is an attractive way to produce high quality GaN films with a low density of extended defects, which is beneficial both to studies of the fundamental properties of the GaInAlN materials system and to GaN-based device technology. Developments in ELO growth have led to increased lifetimes for GaN based blue lasers. In this study, high quality GaN continuous films have been obtained by ELO using a low pressure MOCVD system. A 2-μm-thick GaN seed layer was grown on a c-plane sapphire substrate. A 100 nm SiN mask was grown by PECVD and patterned into stripes, oriented in the $\langle 1\bar{1}00 \rangle$ direction of GaN, defining 3 μm growth window with a periodicity of 13 μm. After about 4 μm of ELO GaN growth on the patterned substrate, the GaN stripes coalesced, forming a flat surface. Samples were characterised by scanning electron microscopy (SEM), X-ray diffraction (XRD), photoluminescence (PL) and transmission electron microscopy (TEM).

The whole ELO growth process have been monitored by in situ reflectivity measurements. Fig.1 shows a typical reflectivity curve with growth time, which can be divided into four stages. At the first stage, the reflectivity increases with time while the substrate is heated to the growth temperature. A high frequency oscillation observed after the GaN initiating on the growth window indicates the vertical growth rate is very high at the beginning of the growth. The third stage begins when the film thickness is higher than the mask. At this stage the lateral growth starts and the vertical growth rate decreases with time. After coalescence, the growth rate becomes constant, which is 1.3mm/hour in this case.

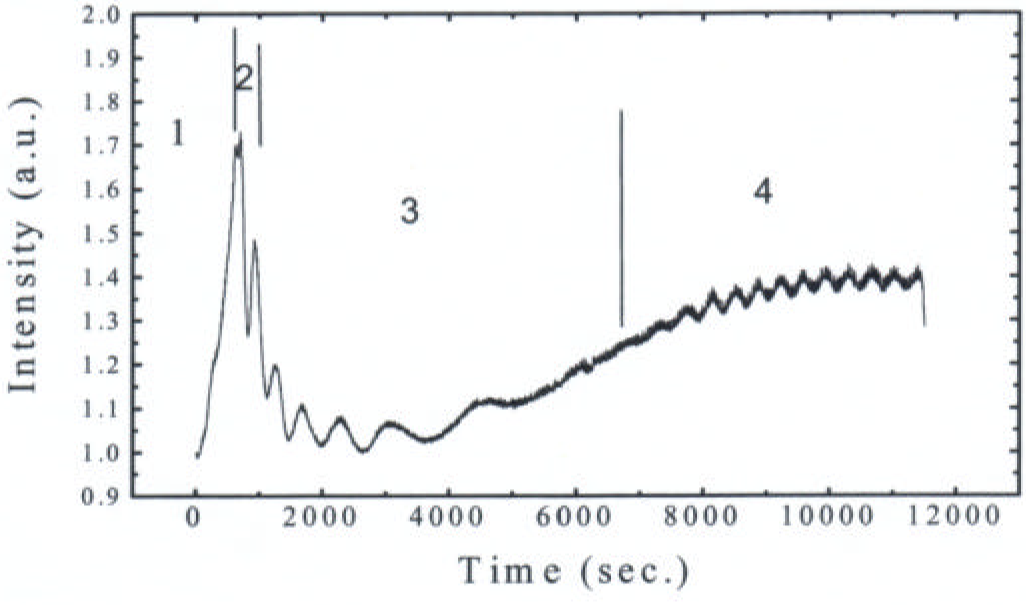

Fig.1. Typical reflectivity curve of an ELO growth

The tilt angle of 0.15° between lateral part and window part was obtained by XRD measurement, which is the lowest value reported so far. However, the tilt between lateral part and window part is no longer evident when the ELO-GaN film becomes thicker. From XRD measurement, we also found that the compressive stress in lateral part is higher than that in the window part. Yellow luminescence was not observed in the ELO GaN by PL. TEM studies show that the dislocation density is much lower in lateral part. Threading dislocation density in window part is about $8x10^8$ cm^{-2}. Very few threading dislocations have been found in lateral part. That means the dislocation density in the lateral parts is lower than $1x10^5$ cm^{-2}. We have found that coalesced boundary is formed by dislocations along stripe $(\bar{1}100)$ direction with a Burgers vector of $(11\bar{2}0)$. Such dislocations have also been found at the edges of the growth window. The TEM pictures for a whole period of ELO GaN are shown in Fig.2 and Fig.3 by a cross section view and a plan view, respectively. From these cross section and plan view TEM pictures, one can find that in the lateral part there are some dislocations along $(11\bar{2}0)$ direction, but they do not thread into the surface.

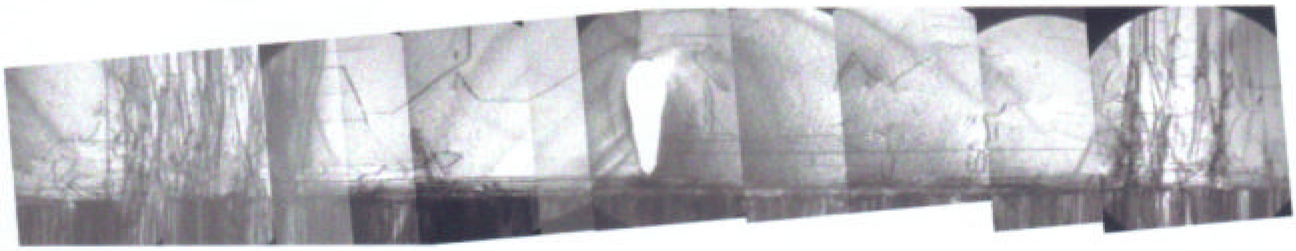

Fig. 2. Cross section TEM picture of ELO GaN

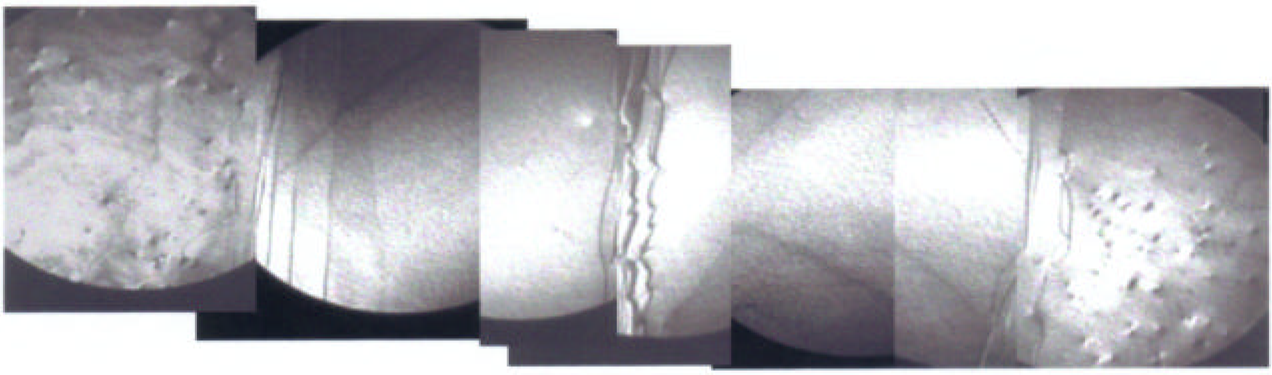

Fig. 3. Plan view TEM picture of ELO GaN

The InGaN/GaN multiple quantum wells (MQW) grown on the ELO GaN show very high quality. Fig. 4 shows a cross-section TEM picture of an InGaN/GaN MQW. The In content in the well layers is estimated to be at least 30%. The micro-PL spectrum measured from the window part and the wing part are shown in Fig.5. PL intensity of the wing part is two times higher than that of the window part. Two peaks were observed in the PL spectra of the window part. The peak with longer wavelength might result from In segregation around dislocation. It has been proved that the In content around dislocation is high in the InGaN/GaN QW grown on sapphire.[1)]

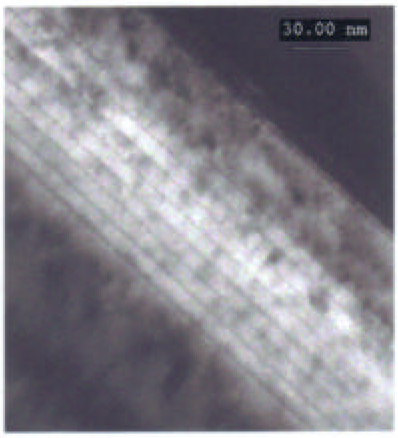

Fig.4. Cross-section TEM picture of a InGaN/GaN MQW

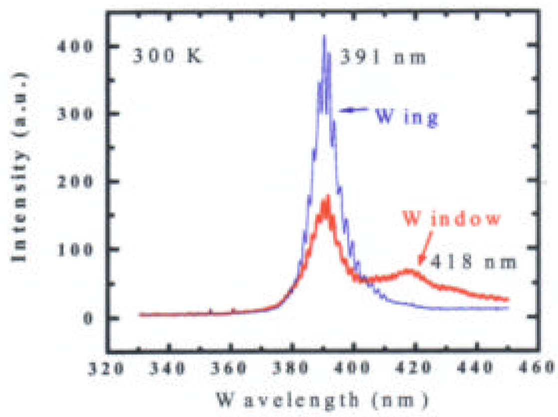

Fig.5. Micro-PL spectrum of a InGaN/GaN MQW

References

1) T. Sugahara, M. Hao, T. Wang, D. Nakagawa, Y. Naoi, K. Nishino, and S. Sakai, Jpn. J. Appl. Phys, 37, (1998) L1195.