The influence of the low-temperature buffer-layer on substrate-induced biaxial compressive stress in a GaN film on a sapphire substrate

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Since the high interfacial energy associated with GaN thin films on sapphire substrate leads to three-dimensional island growth of GaN, a two-step metalorganic chemical vapor deposition (MOCVD) growth has been used to promote two-dimensional GaN growth on sapphire substrate. This process includes a thin, low-temperature polycrystalline AlN or GaN buffer layer, which introduces a high density of dislocations in the consequent GaN layer grown at high temperature. Previous studies have demonstrated that low-temperature buffer growth conditions strongly affect the electrical and optical properties of consequent GaN film. However, many of the physical properties of GaN and its growth mechanism based on the low-temperature buffer layer are still not well known. In this work, the influence of the low-temperature buffer-layer thickness on substrate-induced stress was investigated.

A novel design three-flow reactor MOCVD system was used to grow GaN film on (0001) sapphire substrate at atmospheric pressure using hydrogen as the carrier gas and nitrogen as the sub-flow. The trimethylgallium (TMGa) and ammonia (NH_3) were used as precursors. The substrate was initial annealed at 1150℃ in H_2 ambient for 10 min. Then , the temperature was decreased to about 525℃ to grow the GaN buffer layer, followed by a 2μm undoped GaN layer grown at 1050℃. In order to investigate the influence of thickness of the low temperature GaN buffer on substrate-induced stress and electrical properties in a GaN film, five samples were grown using the different buffer-layer thickness, which could be adjusted by growth time. The thickness of the low-temperature buffer layer for these samples are 0, 6, 12, 18, and 25 nm, respectively.

Figure 1 shows PL spectra of Sample A, B, C, D, and E measured at room temperature. In each case, the excitation power is 50 mW. In the case of Sample A, the GaN film was grown without any low-temperature GaN buffer-layer , whose surface morphology exhibits in the form of three-dimension isolated islands. In this case, PL emission spectrum is wider, whose peak is observed at about 3.336 eV, which could be attributed to the band-edge emission of GaN. By increasing the thickness of low-temperature buffer-layer of GaN from 6 nm to 25 nm, the surface morphology was changed from separate two-dimension islands to mirror-like surface. In this case there are two peaks in the PL spectra. In order to investigate these two peak in detail, the PL spectra were fitted. Figure 2 shows that two peaks address blue-shift with increasing the buffer-layer thickness. Figure 3 shows the intensity of the main peak is increasing and that of the second is decreasing. This means the buffer layer are not only supposed to act as nucleation layers, but also to change the state of residual strain.[1]

Other investigation results will be discussed in the presentation.

References

1. Jacques I. Pankove, Theodore D. Moustakas, etc., Gallium Nitride (GaN) II pp. 249.

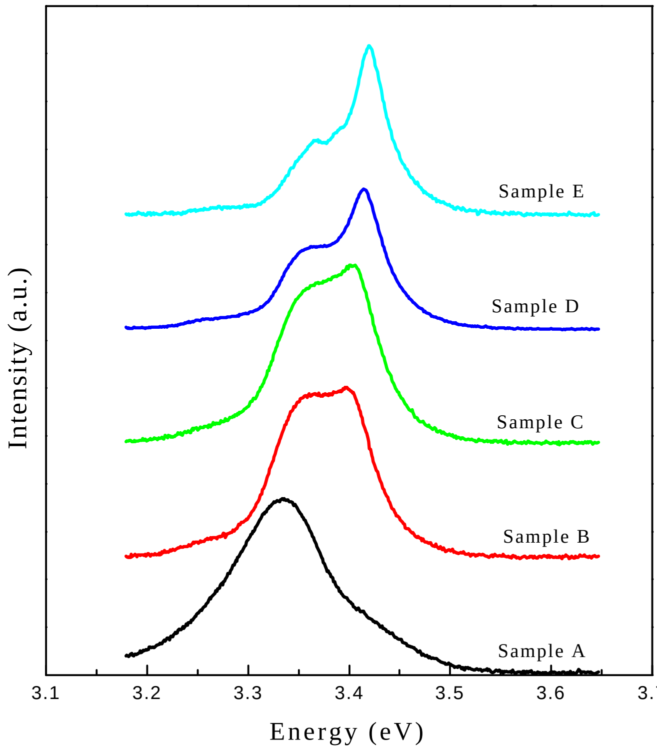

Fig. 1 PL spectra of samples with different thickness of LT GaN buffer layer

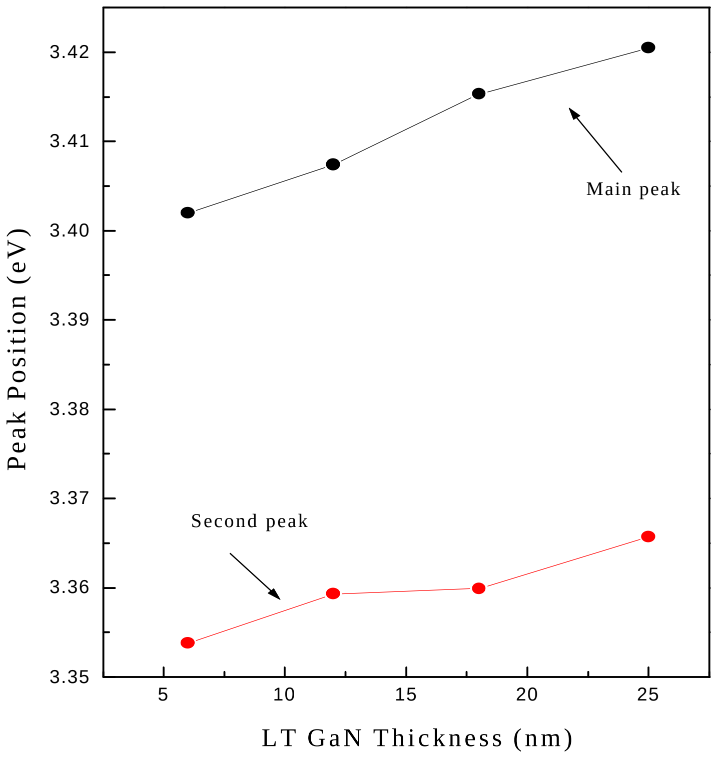

Fig. 2 the blue-shift with increasing the thickness of buffer-layer

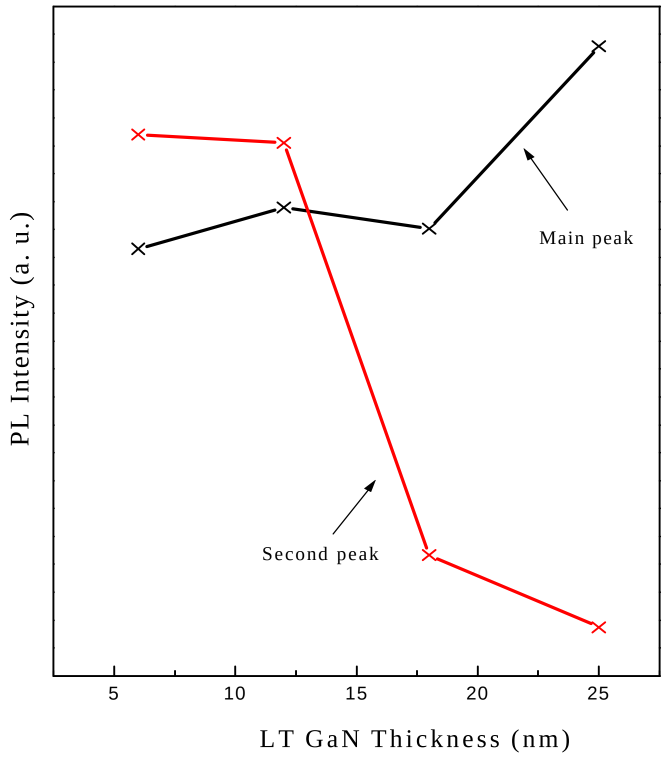

Fig. 3 PL intensity varies with different buffer-layer thickness