[I~3] [초청]

Optimization of GaN epitaxial growth by low-pressure MOCVD

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GaN is usually grown heteroepitaxially on sapphire(0001) substrates, which have a lattice mismatch of 13.8 %. When GaN is grown directly on the sapphire substrate, this results in three-dimensional growth and a film quality which is not suitable for device application. Recent experiments[1,2] have demonstrated that high quality GaN could be grown on sapphire substrates when a thin, low-temperature, AlN or GaN buffer layer are used to initiate the growth process. It was shown that the low-temperature buffer layer exhibits significant recrystallization during the thermal annealing and this nucleation layer promotes lateral growth and coalescence of discrete nucleation islands. In this paper, a systematic investigation on the influence of GaN buffer layer on the growth and properties of the overgrown GaN film was undertaken.

GaN films were grown by low-pressure metalorganic chemical vapor deposition on sapphire (0001) substrates with H_2 carrier gas. The reactor pressure was maintained at between 76 to 700 torr. The susceptor rotation speed was kept constant at 300 rpm. Trimethylgallium(TMG) and ammonia gas were used as sources for Ga and N, respectively. After nitidation of 5 min at 1000°C, the growth itself is done by a two step process. In the first step a GaN buffer layer is grown at a low temperature between 450 to 600°C using a TMG flow of 29 μmol/min, a NH_3 flow of 3.3 slm, and a H_2 flow of 15 slm. These as-grown films, with thickness ranging from 200 Å to 5500 Å, were heated to 1010°C under NH_3 flow to explore the influence of annealing effects. For the main GaN epilayer, the growth temperature was between 950 and 1050 °C.

Significant differences in the morphology and crystallinity of overgrown GaN epitaxy with changes in buffer layer were observed as reported recently by S.D. Hersee et al.[3] Figure 1(a) and (b) show AFM images of the 510°C and 600°C buffer layer, respectively. The 600°C buffer is found to be rough with a RMS surface roughness of 113 Å, and consists of large discrete grains. In comparison, the 510°C buffer shows much smoother morphology with a RMS surface roughness of 16 Å, and relatively smaller grains. The reactor pressure also influences the surface. The 200 torr buffer exhibits smaller sized grain with a smoother than the 700 torr buffer. Therefore, decreasing of the growth temperature and the reactor pressure leads to a flattening and a small size of the grains. The annealed GaN buffer layers shows columnar features which are lager in demension than those prior to annealing as shown in Fig. 1 (c) and (d). The coherence of the smaller and the smoother polycrystalline grains of the buffer layer are found to accelerate the coalescence process and this appear to be a prerequisite for a transparent and colorless film, with a featureless surface. The crystalline perfection of GaN film continues to improve after few microns and correlates with an improvement in Hall mobility as shown in Fig. 2. The maximum mobility in a 4.5μm GaN epilayer is 493 cm^2/V-s. Typical background carrier concentration is about 1×10^{17}cm^{-3}. 10K photoluminescence measurements show strong and sharp bound exciton and free exciton peaks at 3.48 eV and 3.51eV, respectively, confirming the growth of high quality GaN films.

References

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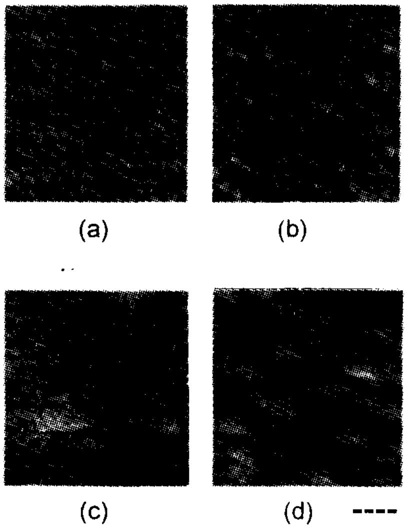

Fig. 1. AFM images of GaN buffer grown at (a) 510 °C(as-grown) (b) 600 °C(as-grown) (c) 510 °C(annealed) (d) 600 °C(annealed). The maker represents 0.25 μm.

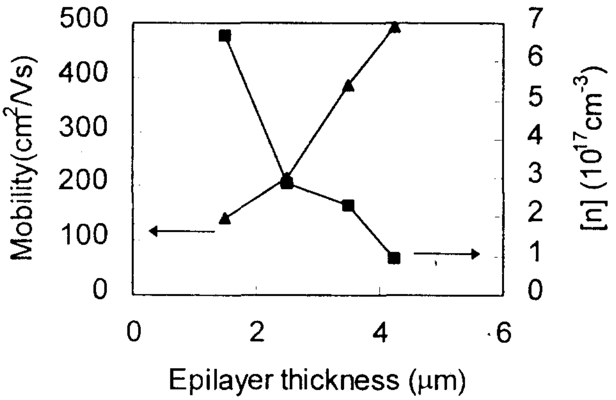

Fig. 2. Carrier concentration and Hall mobility as a function of film thickness grown at 1010 °C.