Influence of Growth Temperature on the Crystalline Quality of Hexagonal GaN Layer on GaAs (111)A by Metalorganic Hydrogen Chloride Vapor Phase Epitaxy

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GaN-based compound semiconductors have been one of the most attractive wide band-gap materials for short-wavelength light emitting devices and for high-temperature electronic devices. However, due to the lack of GaN substrate, these devices are commonly grown on foreign substrates such as sapphire substrate by metalorganic vapor phase epitaxy (MOVPE). Therefore, it is difficult to avoid defect generation, cracking and bending of the grown layer.

One solution to overcome the difficulties is preparation of thick GaN epitaxial layers using hydride VPE (HPVE), where the growth of GaN can be possible with high growth rate. Recently, large free-standing GaN substrates have been obtained by separating thick HVPE GaN layers from sapphire substrates.[1,2)] However, it is very difficult to separate the GaN layer from a sapphire substrate because the sapphire is very hard and is not etched by any etchant. Then, growth of thick GaN layer on GaAs substrate is worth investigating because GaAs is easy to remove by lapping or etching. However, investigation of HVPE growth of thick GaN layer on GaAs substrates at temperatures as high as 1000ºC is rather small number[3)] in contrast to that on sapphire substrate. This is due to the unstable nature of the GaAs at high temperature. In this paper, we describe the investigation of the substrate orientation dependence for the growth of GaN on GaAs (111)A and (111)B surfaces by metalorganic hydrogen chloride vapor phase epitaxy (MOHVPE). Temperature dependence of GaN growth by MOHVPE above 900ºC is also shown in this paper.

GaN growth was performed on both sides polished GaAs (111) substrate under atmospheric pressure using H_2 as the carrier gas. Trimethylgallium (TMG) and ammonia (NH_3) were used as gallium (Ga) and nitrogen (N) sources, respectively. TMG was mixed with hydrogen chloride (HCl) at the mixing zone of the reactor maintained at 750ºC to form gaseous GaCl. GaN was grown on both GaAs (111)A and (111)B surfaces simultaneously in the downstream region, where the GaCl and NH_3 were mixed.

First, surface features of GaAs (111)A and (111)B surfaces covered with a 50-nm-thick GaN buffer layer grown at 550ºC and heated in NH_3 ambient up to 1000ºC were observed (**Fig. 1**). It was found that the GaAs (111)A surface covered with 50-nm-thick GaN buffer layer did not deteriorate even after subsequent heating in NH_3 ambient up to 1000ºC, whereas serious deterioration occurred on the GaAs (111)B surface. These results suggests that the growth of high-quality GaN can be possible on the GaAs (111)A surface.

Then, the surface morphologies of 25-μm-thick GaN layers grown at various temperatures on the 50-nm-thick GaN buffer layer on the GaAs (111)A was investigated (**Fig. 2**). Although the grown thickness is same in these samples, surface morphology of the grown layer is drastically improved with increase of the growth temperature.

The surface of GaN layer grown at 920ºC did not show mirror-like part, whereas that grown at 1000ºC showed mirror like surface without hexagonal pit. These results indicate that the growth temperature at 1000ºC or above is essential for growth of a GaN layer with mirror-like surface.

Influence of the growth temperature on optical property and crystalline quality of the GaN layer were also investigated, which showed that the growth of thick GaN layer on GaAs (111)A surface at 1000ºC or above is one of a promising method for the preparation of free-standing GaN substrate. More detail results will be reported at the conference.

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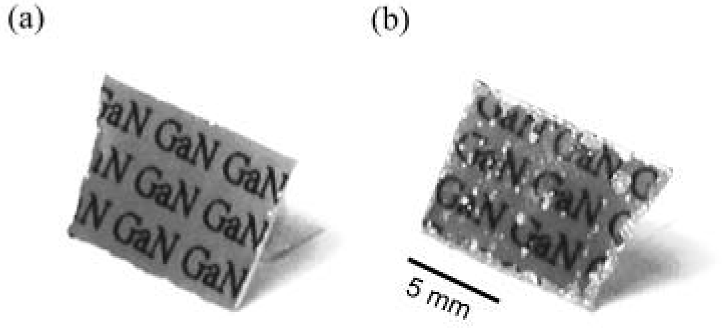

Fig. 1. Photographs of the GaAs substrate covered with a 50-nm-thick GaN buffer layer grown at 550ºC and heated to 1000ºC in NH_3 ambient. (a) on GaAs (111)A surface, and (b) on GaAs (111)B surface.

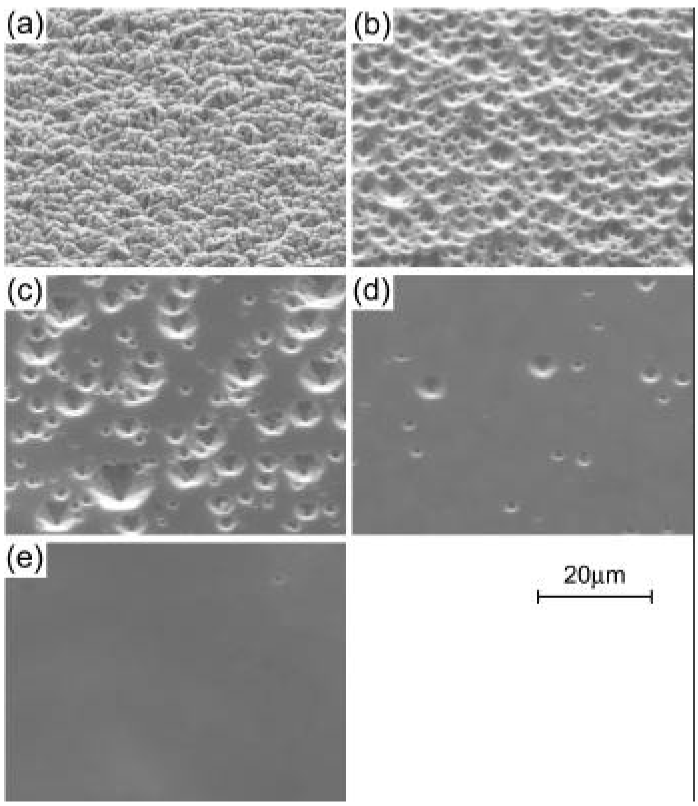

Fig. 2. Surface morphologies of the 25-µm-thick GaN layers grown on 50-nm-thick GaN buffer layer/GaAs (111)A surface at various temperatures observed by SEM: (a) 920ºC, (b) 940ºC, (c) 960ºC, (d) 980ºC and (e) 1000ºC.