# InGaN Film Growth on Polarity Controlled GaN Buffer Layer by Ammonia-MBE

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## *1. Introduction*

Epitaxial wurtzite Ⅲ-nitrides, which is a promisinig material for optoelectronic, high-temperature and high-power device applications, has a polar structure whose c axis is parallel to the growth direction on sapphire(0001) substrate. In the wurtzite Ⅲ-nitrides films, lattice polarity is one of the key issues which affect the optical and electrical properties of grown films[1-3]. In metalorganic chemical vapor deposition (MOCVD), polarity control is possible by choosing the initial growth procedures and there are some reports about the polarity dependence of the qualities of the films such as morphological properties or the amount of impurities in the films[4]. As for the molecular beam epitaxy (MBE), only the films with N-face is assumed to be obtained, though the growth parameters which determine the polarities of the films are not so clear. So, there are few reports about the polarity dependence of the qualities of the films grown by MBE. Recently, we have succeeded in realizing the GaN films with Ga-face by In irradiation during growth by rf-plasma assisted MBE[5] or initial nitridation of sapphire(0001) substrate with $NH_3$[6]. In this paper, we report about the polarity dependence of the In incorporation in the grown InGaN films on polarity controlled GaN buffer layers by ammonia-MBE.

## *2. Experimental*

InGaN films were grown by ammonia-MBE on polarity cotrolled GaN buffer layers. The polarity controlled GaN buffer layers were prepared as follows: Ga-face and N-face GaN films were grown on low-temperature (LT) GaN buffer layer with and without initial nitridation of sapphire(0001) substrate using $NH_3$, respectively. After the cleaning by heating at 910 C for 30 min, the temperature of the sapphire(0001) substrate for N-face GaN buffer layer was decreased to 500 C and the LT GaN buffer layer of 200Å thickness was deposited, followed by the growth of GaN film of 1000Å thickness at 820 C. The substrate for Ga-face GaN buffer layer was nitrided at 910 C by supplying $NH_3$ for 30 min before the deposition of the LT GaN buffer layer of 200Å thickness. The film growth was carried out by supplying Ga from an effusion cell with flux intensity of $2.8\times10^{13}/cm^2\cdot s$ and $NH_3$ through a mass flow controller into the system at the flow

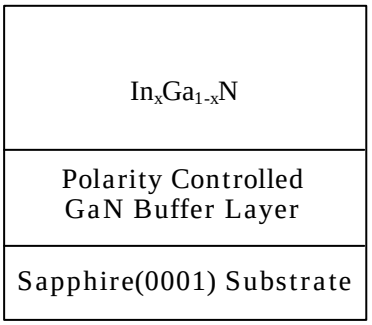


Fig. 1. Cross sectional view of Sample

rate of 5 sccm without cracking. On these GaN buffer layers, InGaN films were grown at the growth temperatures of 615 C and 580 C and various Ga/In flux rasio(Table I). The In contents (x) in the grown $In_xGa_{1-x}N$ films were determined from sifts of band edge emission of the films in cathode luminescence at room temperature. Emission from the deep level is not observed in all the samples.

| Growth Condition of $In_xGa_{1-x}N$ | | | Polarity of | In content |
|---|---|---|---|---|
| Ts ( C) | Ga flux (/cm· s) | In flux (/cm· s) | GaN Buffer Layer | x |
| 615 | $2.8\times10^{13}$ | $1.1\times10^{13}$ | Ga-face | 0.8 |
| | | | N-face | 1.2 |
| 580 | $2.8\times10^{13}$ | $1.4\times10^{12}$ | Ga-face | 2.8 |
| | | | N-face | 5.8 |
| 580 | $9.0\times10^{12}$ | $5.5\times10^{12}$ | Ga-face | 13.3 |
| | | | N-face | 18.1 |
| 580 | $9.0\times10^{12}$ | $2.7\times10^{12}$ | Ga-face | 11.4 |
| | | | N-face | 15.0 |

Table I. Growth conditions and In contents in the growth $In_xGa_{1-x}N$ films

### *3. Results and Discussions*

Table I summarizes the growth conditions and In contents in the grown $In_xGa_{1-x}N$ films. Regardless of the Ga/In flux ratio and/or **III-V** ratio, the In contents in the grown InxGa1-xN films with N-face are higher than that of $In_xGa_{1-x}N$ films with Ga-face at each growth temperature. These facts mean that the In incorpotration is dependent on the growth mode. However, the detailed In incorporation mechanism into the films is unclear at present.

### *4. Conclusions*

The polarity dependence of In incorporation in the growth of $In_xGa_{1-x}N$ films on polarity controlled GaN buffer layers by ammonia-MBE have been investigated. The In contents in the grown $In_xGa_{1-x}N$ films on GaN buffer layers with N-face are higher than that of $In_xGa_{1-x}N$ films on GaN buffer layers with Ga-face at each growth temperature. These findings suggest that the In incorpotration is dependent on the growth mode.

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