HVPE/MOMBE Hybrid Growth of High Quality Hexagonal GaN on SiO_2 Substrates with an AlN Buffer Layer

T. Nakayama, M. Namerikawa, O. Takahashi, T. Suemasu and F. Hasegawa
Institute of Applied physics, University of Tsukuba, Tsukuba, Ibaraki, 305-8573, Japan
e-mail : nakayama@ims.tsukuba.ac.jp

Introduction

Since there is no lattice matching substrate to GaN, it is generally grown on sapphire substrates with a GaN or AlN buffer layer. Hexagonal GaN has unique properties such as that it has tendency to grow in c-axis perpendicular to the substrate, and that the surface tends to become flat when the growth temperature is more than about 1000°C, especially when it is grown by Halide VPE [1,2]. On the other hand, there is a report that strong photoluminescence (PL) was observed in poly-crystal GaN grown on a quartz (SiO_2) substrate by GSMBE [3]. If high quality GaN can be growth on a quartz substrate, application of GaN will expand to many purposes such as a large size display.

Purpose of this work is to investigate possibility of high quality GaN growth on a quartz substrate at about 1000°C by Halide VPE, combining with MOMBE which makes possible to grow an AlN buffer layer.

Experimental

First of all, about 200 nm thick GaN was grown on a quartz substrate with and without about 50nm thick AlN layer by a conventional MBE system, using metal Ga as a Ga source and Di-methyl-aluminum-hydride (DMAH) as a Al source. Di-methyl-hydrazine (DMHy) was used as the nitrogen source for both growths. The growth temperature was 700°C for both layers. Then, a thick (about 20 micron meters) GaN layer was grown at 1000°C by Halide VPE using metal Ga and NH_3 as Ga and nitrogen sources, respectively. Crystal orientation of the grown layer was characterized by XRD and the grown surface was observed by a SEM. Crystal quality of the grown layers were also estimated by the photoluminescence.

Results and Discussion

XRD patterns of HVPE/MOMBE hybrid grown GaN without and with an AlN buffer layer are shown in Fig. 1 (a) and (b), respectively. MOMBE GaN grown without an AlN buffer layer shows many peaks indicating that it is poly-crystal, and even HVPE GaN on the MOMBE GaN shows (10-13) peak though c-axis orientation is much more enhanced. On the contrary, both HVPE and MOMBE GaN grown with an AlN buffer layer show perfect c-axis orientation to the substrate. This is probably due to the fact that AlN is more stable in hexagonal phase than GaN and grow easily in c-axis orientation.

Surface morphology of the MOMBE GaN is shown in Fig.2. The surface of GaN grown without an AlN buffer layer is very rough (Fig. 2-a), but that with an AlN buffer layer is much more smooth (Fig. 2-b), though there are many cracks. This is probably due to the fact that AlN adheres well to the quartz substrate.

Figure 3 shows cross sectional SEM photographs of HVPE GaN grown on MOMBE GaN shown in Fig.2. Many hexagonal pillars with different heights and tilted directions are seen for GaN grown without an AlN buffer layer (Fig. 3-a). On the contrary, the GaN layer grown with an AlN buffer layer is continuous and has a relatively flat surface (Fig. 3-b).

PL spectra of HVPE GaN/MOMBE GaN measured at 77k is shown in Fig. 4. GaN grown without an AlN buffer layer shows only a broad peak at 375nm (3.3eV), similarly to the one reported by Iwata et al [3]. On the other hand, GaN grown with an AlN buffer layer shows clearly the exitonic band edge emission at 358nm (3.46eV), and the eA emission at 379nm (3.27eV) and its LO phonon replicas. These results indicate that a high quality GaN can be grown on a quartz substrate by adopting an AlN buffer layer and HVPE growth at high temperatures.

It is expected that quality of GaN can be improved furthermore by applying the ELO growth for HVPE in near future, and that GaN grown on a quartz substrate can be applied to practical uses in future.

[1] Akira Usui et al, Jpn. J. Appl. Phys. Vol. **36** (1997) pp. L899-L902
[2] F.Hasegawa et al, Jpn. J. Appl. Phys. Vol. **38** (1999) pp. L700-L702
[3] Kakuya Iwata et al, Jpn. J. Appl. Phys. Vol. **36** (1997) pp. L661-L664

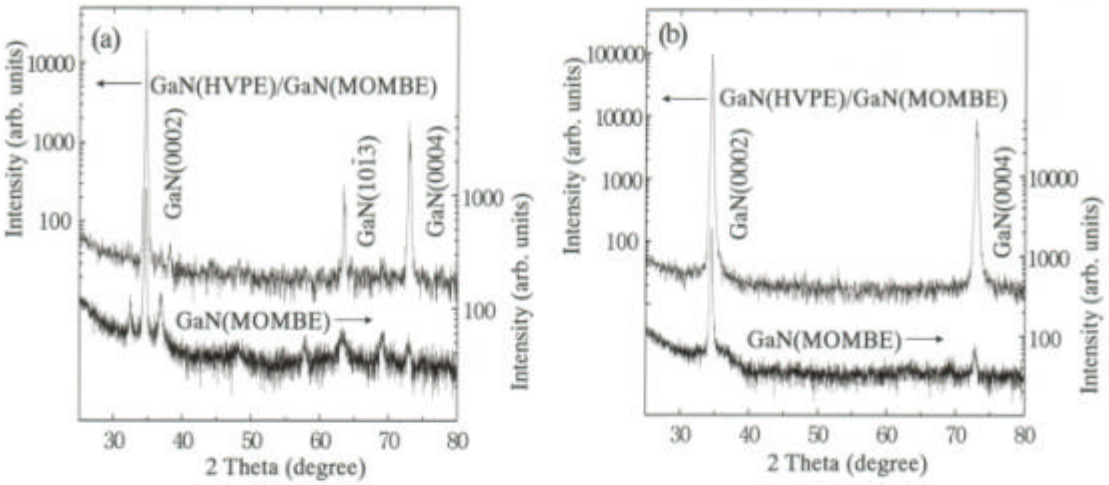

Fig. 1, XRD patterns of GaN grown (a)without an AlN buffer layer and (b)with an AlN buffer layer

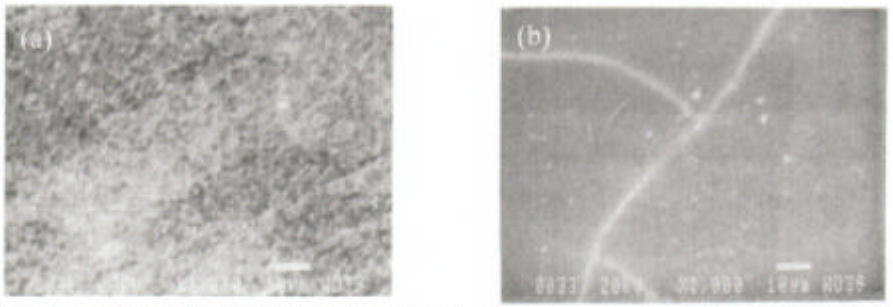

Fig. 2, Surface morphology of MOMBE GaN grown (a)without an AlN buffer layer and (b)with an AlN buffer layer

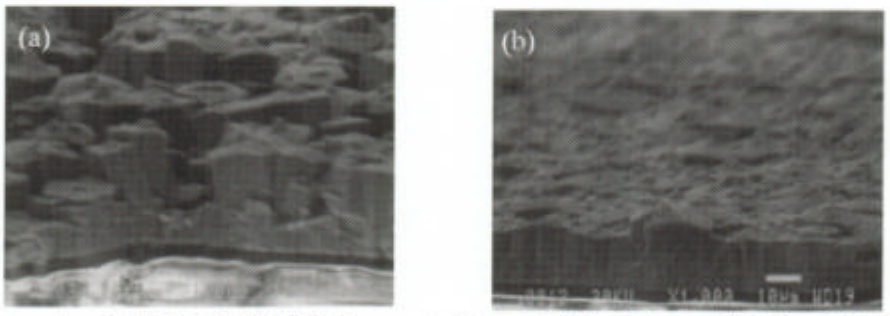

Fig. 3, SEM photographs of HVPE GaN/MOMBE GaN grown (a)without an AlN buffer layer and (b)with an AlN buffer layer

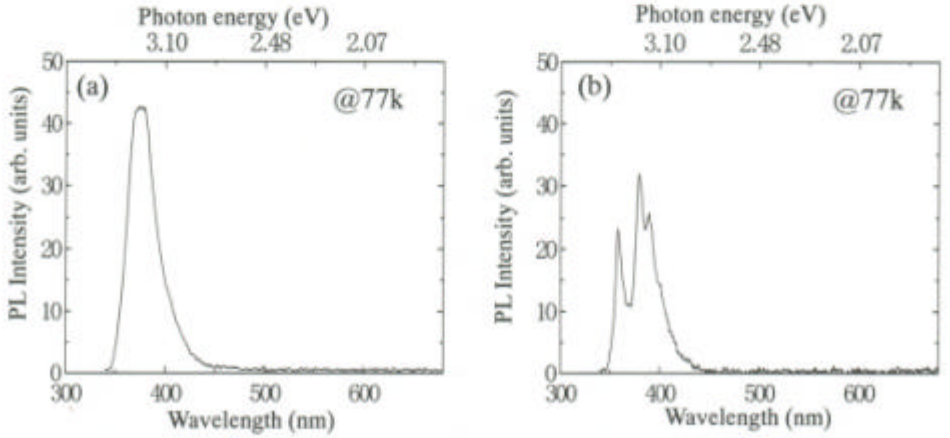

Fig. 4, PL spectra of HVPE GaN/MOMBE GaN grown (a)without an AlN buffer layer and (b)with an AlN buffer layer