# Multi-wafer Atmospheric Pressure MOVPE Reactor for Nitride Semiconductors and ex-situ Dry Cleaning of Reactor Components by Chlorine Gas for Stable Operation

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Atmospheric pressure growth is important to obtain high bright LED and Laser diode based on nitride semiconductors. P-type GaN with a hole concentration of more than $1\times10^{18}cm^{-3}$ can be grown with growth rate of 3 μm/h at a growth pressure higher than 500Torr. Hole concentration of GaN:Mg is decreased as the growth pressure is decreased[1]. Smaller thermal budget on MQW during the succeeding growth of P-type contact and cladding layer is important to reduce degradation of the MQW. GaN with dislocation density on the order of low $10^8cm^{-2}$ can also be grown on sapphire substrate by atmospheric pressure MOVPE, provided that parasitic reaction is well suppressed. It is also important to grow heterostructure of Al containing alloys continuously for device applications with keeping proper growth condition for the other layer such as GaN:Mg.

However, until recently reactor size of atmospheric pressure MOVPE has been limited to a relatively small scale of 2inch by 3 or 6 because of a difficulty of designing a large size reactor with a sufficient gas flow velocity at atmospheric pressure. In this paper, we will describe an atmospheric pressure MOVPE reactor with a capacity of 2 inch by 10 or 3 inch by 8. In this reactor, parasitic reaction of particulate generation is suppressed by using a high flow speed design. By using this reactor, we have grown $Al_{0.1}Ga_{0.9}N$ with a growth rate of 1 μm/h at atmospheric pressure. In Fig.1, thickness and composition uniformity of $Al_{0.087}Ga_{0.913}N$ is shown. As a result of suppression of parasitic reaction, we have also grown GaN with a growth rate of more than 28 μm/h. Fig.2 shows a growth rate of GaN as a function of normalized TMG supply rate to a carrier gas flow.

In production environment, it is also very essential to operate a reactor under a stable condition. To this end, we have adopted an ex-situ dry cleaning of all the reactor components with deposit on them for every growth run. Dry cleaning was conducted by chemical etching of the deposit by chlorine gas in a hot tube reactor at about 800℃[2].

[1]H. Tokunaga, A. Ubukata, Y. Yano, A. Yamaguchi, N. Akutsu, T. Yamasaki and K. Matsumoto, J. Crystal Growth 272(2004)348-352.

[2]Y. Fukuda, T. Orita, N. Akutsu, K. Ikenaga, S. Koseki, K. Matsumoto and S. Hasaka, J. Crystal Growth 298 (2007) 433-436.

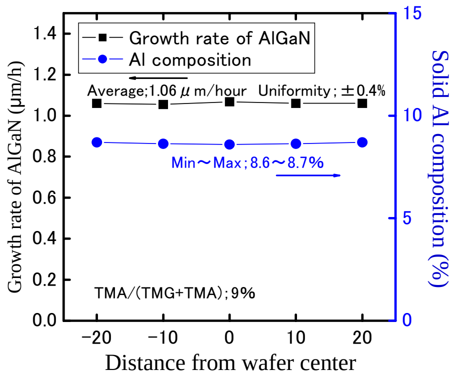


Fig.1 Al composition and thickness uniformity of AlGaN grown at atmospheric pressure.

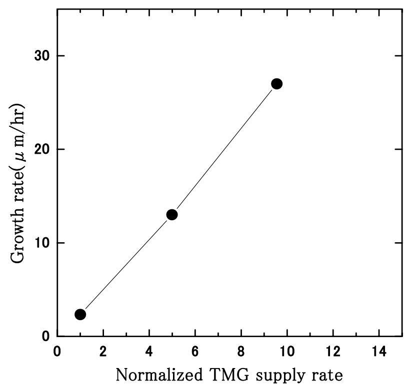


Fig.2 GaN growth rate vs. normalized TMG supply