Control of Thickness and Composition Variation of AlGaN/GaN on 6” and 8” Substrates Using Multiwafer High-Growth-Rate MOCVD Tool

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There is considerable interest in the growth of GaN on Si substrates because of its potential for low cost, large size and good thermal conductivity. However, it is difficult to obtain uniform AlN and AlGaN over an entire 6 inch or 8 inch wafer in addition to a high growth rate because of the intense parasitic pre-reaction between the metal-organic source materials and NH_3. We used high-flow-speed MOCVD reactors with capacities of 7 x 6 inch (TAIYO NIPPON SANSO UR25K) and 6 x 8 inch or 10 x 6 inch (UR26K) for mass production. Precursors are injected into the reaction zone from a trilayer nozzle at the center of these reactors. Wafers are rotated in planetary motion. Each wafer holder disc is heated by resistance heaters, which are controlled separately in zone of the reactors.

GaN samples were grown under pressures of 40kPa and 100kPa on stationary 6 inch sapphire substrates without satellite rotation in the 10 x 6 inch reactor. Since the GaN growth rates along the gas flow direction of the two samples were almost the same in spite of the different growth pressures, it turned out that the gas-phase pre-reaction in the reactor was controlled well and the mass transport was dominant under both growth pressures. AlN samples were also grown at various growth rates on 6 inch and 8 inch Si wafers using these reactors. The AlN growth rates obtained at the same TMA supply concentration were the same. Since the growth rate did not saturate but increased linearly with the TMA supply to over 2μm/h, it is possible to conclude that the gas-phase pre-reaction is controlled in these reactors. We grew $Al_{0.22}GaN$/AlN/GaN/SLS/$Al_{0.6}GaN$/AlN on a 6 inch Si wafer using the 7 x 6 inch reactor. The average thickness and standard deviation (1σ) of the sample were 2.8μm and 0.14%, respectively. The thickness distribution Δ ((max. – min.) /average) of each layer in this sample was estimated as 2.8% or less by cross-sectional SEM measurement. In particular, the growth rate of SLS, which consisted of AlGaN and AlN, was 2.4μm/h after optimizing growth conditions, such as the carrier gas flow rate, V/III ratio and wafer temperature. From these results, it was demonstrated that these reactors and techniques are very useful for the mass production of power devices.

The wafer bowing and crystal quality of AlGaN/GaN on Si are affected by the wafer temperature uniformity in the growth process. It is possible to optimize the wafer temperature profile using the resistance heaters which are controlled separately in zone. We will report about the optimization at the workshop.

Supplementary information

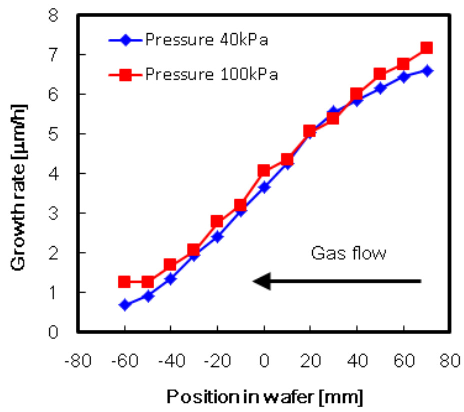


Figure 1 GaN growth rates under pressure of 40kPa and 100kPa along the flow direction on a stationary 6 inch sapphire substrate.

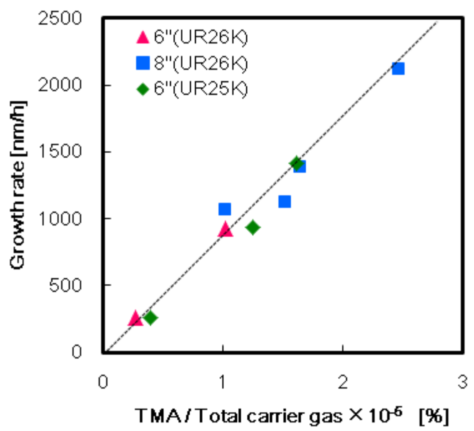
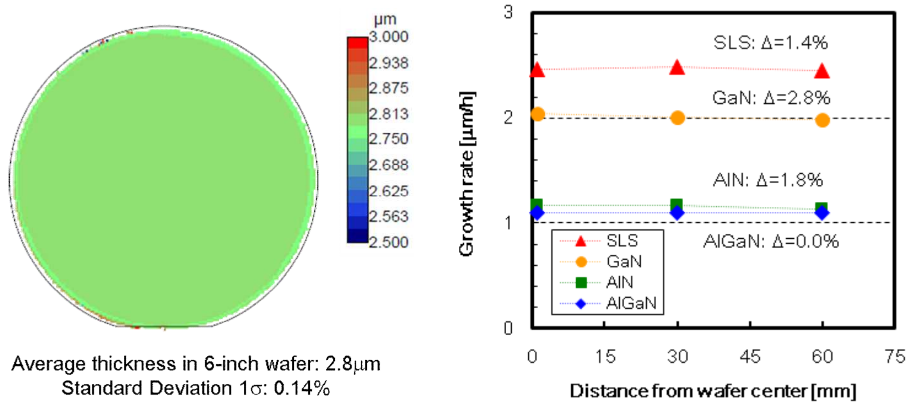


Figure 2 AlN growth rate as a function of TMA supply concentration using the MOCVD reactors (UR25K and UR26K).



(a) (b)

Figure 3 (a) Thickness mapping of the whole $Al_{0.22}GaN/AlN/GaN/SLS/Al_{0.6}GaN/AlN$ structure on 6 inch Si substrate.

(b) Thickness distribution of each composition layer estimated by cross-sectional SEM measurement. Δ is defined as (Max.-Min.)/Ave.