Fully coalesced thin GaN growth on AlN substrates for AlN-based HEMTs by hot-wall MOCVD

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The pursuit of next-generation ultra-wide bandgap semiconductor electronic devices for high power and frequency continues. AlN-based HEMTs are emerging as a compelling choice due to their superior critical electric field (11.7 MV/cm) and excellent thermal conductivity (300 W/mK). However, achieving high-quality AlGaN/GaN/AlN double-heterostructure HEMTs (DH-HEMTs) poses challenges. The growth of GaN on AlN induces compressive strain in the channel layer, leading to a columnar growth mode of GaN, increased dislocation density, and suboptimal surface roughness, making it difficult to achieve a thin and smooth GaN film.

In this study, we address these challenges by modifying growth parameters, such as TMGa flow rate and growth pressure, to obtain fully coalesced GaN channel layers on AlN substrates via hot-wall metal-organic chemical vapor deposition (MOCVD). In order to minimize carbon concentration in the GaN channel later, a two-step growth was implemented, based on the SIMS analysis of the back-ground impurity concentrations as a function of growth conditions. AlGaN/GaN HEMT structures on AlN substrates with state-of-the-art 2DEG properties are achieved with sheet resistance of 364 ohm/sq, a 2DEG mobility of 1804 cm2/V.s, and a sheet density of 9.56×10^12 cm-2 for the HEMT structure on AlN substrates.

By optimizing growth conditions in hot-wall MOCVD of GaN channels on AlN substrates, these findings have the potential to significantly enhance the efficiency and effectiveness of AlN-based HEMTs for high-power and high-frequency applications.