論 文 の 内 容 の 要 旨

論文題目　Reduction of Dislocations in Gallium Nitride Grown by Metal Organic Vapor Phase Epitaxy using novel Seed layers and Controlled Nucleation

（新規シード層と核発生制御による有機金属気相成長GaNの転位低減）

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Group III-nitrides based semiconductor optoelectronic devices had been paid much attention during the last two decades. Due to absence of bulk GaN substrate, GaN was generally deposited on hetero substrates such as sapphire SiC and Si. The lattice mismatch and thermal mismatch between GaN and these substrates were so large that the dislocation density of GaN epilayer on hetero substrates was much higher than that of III-V semiconductor and Si epitaxial films, that resulted in the efficiency and lifetime reduction of GaN based devices.

For GaN epitaxy on hetero substrates, the seed layer was necessary to enhance the wetting force between the HT GaN and the substrate. For HT GaN on sapphire, the most successful approach, named as two steps growth, was depositing a thin in situ low temperature GaN (LT GaN) or low temperature AlN directly on sapphire as seed layer. High quality HT GaN epilayer could be achieved on these seed layer on sapphire substrate. However, even the dislocation density of GaN film achieved by two steps growth on sapphire substrate could reach to mid 10^8 cm^{-2}, that was not good enough for the next generation optoelectronic devices, such as high efficiency light emitting diodes. New technology was expected to improve the quality of HT GaN epilayer.

In this work, in order to substitute conventional in situ LT GaN or LT AlN seed layer that deposited in MOVPE, a novel ex situ thin AlN film that deposited in physical vapor deposition(PVD) chamber was used as seed layer to aim at high quality epitaxial GaN film in

MOVPE. Moreover, in order to reduce dislocations in HT GaN, the relationship of initial growth and dislocation density of HT GaN was investigated. It was found that the edge dislocation density of HT GaN decreased as the HT GaN initial islands density reduced. And beside the initial growth, extending 3D growth time of HT GaN initial islands before coalescence resulted in low edge dislocation density of thick HT GaN films. Based on the optimization of PVD AlN deposition condition, high quality of HT GaN on PVD AlN seed layer on sapphire was achieved by reducing initial islands density and extending 3D growth time of HT GaN. The lowest dislocation density of HT GaN achieved by this strategy on PVD AlN on sapphire was 1.4×10^{8} cm^{-2} , while lowest dislocation density of HT GaN on LT GaN on sapphire substrate achieved by the same strategy was 2.5×10^{8} cm^{-2} in our MOVPE reactor.

Moreover, high quality HT GaN on Si substrate was achieved by employing the PVD AlN seed layer. By employing the same strategy as used on sapphire substrate, the lowest dislocation density of HT GaN on PVD AlN on Si could reach to as low as 3.1×10^{8} cm^{-2} , which was much better than GaN on Si achieved by dominate technologies without any patterned growth, normally larger than 1×10^{9} cm^{-2}.

Additionally, PVD AlN seed layer was used in HT GaN epitaxy on patterned sapphire substrate. It was found that effect of the initial growth and 3D growth time on the quality of HT GaN was not obvious on PVD AlN on patterned sapphire substrate. HT GaN with dislocation density of 1.5×10^{8} cm^{-2} was achieved by using PVD AlN seed layer on patterned sapphire substrate.

In conclusion, high quality of HT GaN epilayers were achieved on sapphire, si and patterned sapphire substrate by introduction of PVD AlN seed layer and initial growth optimization. It was found that low dislocations and smooth surface morphology in AlN seed layer were the keys to achieve high quality HT GaN epitaxial layer in MOVPE.