The study of initial growth processes on the growth of InN by RF- molecular beam epitaxy

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This doctoral thesis, which is summarized below, focuses on the crystal growth technique of III-nitride semiconductors and their physical properties. III-Nitrides require hetero-epitaxial growth because they are very difficult to obtain as bulk crystals. However, there are no suitable substrate materials with good thermal expansion coefficients and lattice constants for use with nitrides, and thus the crystal growth of III-nitrides has been very difficult. Initial growth processes play very important roles in obtaining high-quality III-nitrides. In this thesis, the effects of initial growth processes on realizing high-quality InN film, which is the most difficult material to grow among III-nitrides, are presented.

At first, the issues in the direct growth of InN on a sapphire substrate, which is commonly used, are studied. When InN is grown directly on a sapphire substrate, InN has highly *c* -axis orientation. For *a* -axis orientation within *c* -plane, however, InN easily forms multi-domain structure. This is due to the similarity of lattice mismatch values between InN and a sapphire substrate for these two cases with and without in-plane rotation. Although the formation of multi-domain structure can be controlled by optimizing growth conditions, it is very sensitive to the growth conditions.

Secondly, the role of initial growth processes to resolve these issues in the direct growth is revealed, which leads to growth of high-quality InN on a sapphire substrate. Especially, substrate nitridation is presented to be a useful way to suppress the metastable rotation domains.

Thirdly, growth of single crystalline InN is realized directly on a Si substrate for the first time by controlling initial growth processes based on the above results. The InN growth on a Si substrate has several advantages over sapphire. For example, a Si substrate is easily obtained at large area and low cost. In the case of the growth on Si, however, the formation of an amorphous SiNx layer on Si has prevented to obtain single crystalline InN. The formation of this layer is successfully suppressed by using appropriate initial growth processes, which leads to growth of single crystalline InN on a Si substrate.

Fourthly, the growth of InN on silica-glass is studied. By using appropriate initial growth processes growth of c-axis oriented InN even on amorphous silica-glass is realized.

Finally, the optical properties of InN grown on various substrates are investigated. These results support that the fundamental band-gap energy of InN should be 0.7eV. The difference in band gaps of InN between the previously reported value of 1.9 eV and the recently reported value of 0.7 eV is also discussed.

Thus, this doctoral thesis is written up to have summarized about the effects of initial growth processes to realize high-quality InN growth on various substrates.