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Si (111)基板上 GaN 成長の in-situ 観察による GaN 膜厚最適化

GaN thickness optimization by in-situ observation of GaN growth on Si (111)

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1 Introduction

GaN-on-Si has been investigated intensively in last decade. However, the physics behind it is not yet well clarified, e.g. detailed growth behavior of nitrides on Si. Here we report the in-situ observation of GaN growth on Si (111) with low temperature (LT) AlN interlayers (ILs).

2 Experiment results and discussion

GaN samples were grown on 2-inch Si (111) wafers by MOCVD. Laser beams at three wavelengths were applied to observe the growths. Reflectance at 405.9 nm is used to detect the surface. Reflectance at 632.5 and 951.3 nm both could be used to monitor the growth rate. The latter is also used to sense true temperature. Three laser beam spots were used to detect the wafer curvature and asphericity. GaN was grown on high temperature (HT) AlN buffer layer with five LT-AlN ILs. In this series of samples, the thickness of AlN buffer and ILs were fixed to be 100 nm and 15 nm respectively, and only the thickness of GaN layers were varied to clarify the GaN growth behavior in terms of curvature transition, as shown in Tab. 1 and Fig. 1.

Tab. 1 Thickness of GaN layers (nm)

No.	1st	2nd	3rd	4th	5th	6th	Total	$Crvt._{min}$
A	860	250	250	250	250	1750	3610	-324
B	430	250	390	390	390	1750	3600	-479

From the growth of sample A, the basic growth behavior of GaN can be known. For the 1st GaN, the curvature value decreased slightly during nucleation stage; after islands completely coalesced, it increased linearly to 220 km^{-1}. For GaN ILs, the curvature value decreased linearly before GaN relaxation, since they were grown on LT-AlN ILs which can introduce compressive stress due to its smaller lateral lattice constant than HT-AlN. Therefore there are two ways to introduce more compressive stress, by reducing the 1st GaN thickness or increasing GaN IL thickness, as shown in sample B. The thickness of 1st GaN is minimized according to curvature value and the reflectance of 405.9 nm and 951.3 nm. The 1st GaN growth should be terminated after the coalescence of initial GaN islands. Curvature value is the direct indication of island coalescence. Before complete coalescence, it cannot be captured and was shown as a straight line. However, the recovery of reflectance also shows the information of island coalescence and thickness. For instance, the reflectance of 405.9 nm dropped from 0.2 to 0.09 as 1st GaN thickness decreased from 860 nm to 430 nm, which has coalesced completely. By optimizing the thickness of GaN layers, higher compressive stress can be achieved with even smaller total thickness.

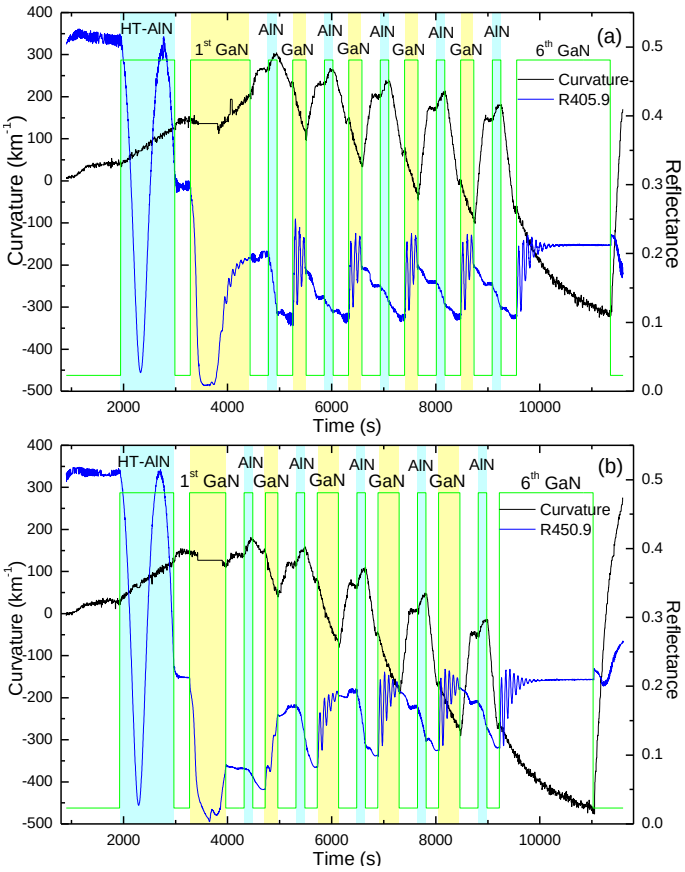

Fig. 1 Growth curves (a) sample A, (b) sample B

3 Summary

In respect of compressive stress introduction, the thicknesses of GaN layers were roughly optimized by in-situ observation of curvature transition and reflectance monitoring.