Epitaxial Growths Of Gan On Linbo$_3$ Step Substrates

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$LiNbO_3$ has been widely used for various optical devices such as optical modulators and frequency converters. If we are able to grow GaN on this material, we can expect fabrication of highly integrated OEICs which utilize GaN light emitting devices and $LiNbO_3$ optical switches. However, It is known that epitaxial growth of high-quality GaN is quite difficult since $LiNbO_3$ is chemically vulnerable and its surface is easily damaged in a growth chamber. Recently we have found that the use of pulsed laser deposition (PLD) makes it possible to grow high-quality GaN films on various substrates with high chemical reactivity owing to the reduced growth temperature[1-3]. In this presentation, we report on the first successful epitaxial growth of high-quality GaN on atomically flat $LiNbO_3$ step substrates.

In order to obtain atomically flat surfaces, $LiNbO_3$ substrates were put in a box made of $LiNbO_3$ and annealed in air. GaN films were grown on the annealed $LiNbO_3$ using an RF-plasma assisted PLD apparatus with a background pressure of 1.0×10^{-10} Torr. We also tried the use of AlN buffer layers to suppress the interface reactions. The KrF excimer laser pulses (λ=248nm, τ=20ns) ablated a Ga metal (99.9999%) and ceramic AlN (99.9%) targets with an energy density of approximately 3 J/cm^2. The growth of the nitrides was *in-situ* monitored with reflection high-energy electron diffraction (RHEED) and the films were characterized with high resolution X-ray diffraction (HRXRD), glazing incidence X-ray reflectivity (GIXR).

Figure 1 shows surface morphology of the $LiNbO_3$ (0001) substrate annealed in a $LiNbO_3$ box at 1150 °C. One can see that the surface consists of atomically flat terraces separated by steps with a height of 0.24 nm which corresponds to the distance of the oxygen planes. We have found that GaN (0001) grows epitaxially on this atomically flat $LiNbO_3$ (0001) substrate with an in-plane alignment of GaN[11-20]//$LiNbO_3$[10-10]. We also tried to grow GaN on $LiNbO_3$ surfaces without the step-and-terrace structure but the crystalline quality of the films was quite poor. GIXR measurements have revealed that there exists an interfacial layer at the GaN/$LiNbO_3$ interface and its thickness is approximately 4.4 nm. We tried the insertion of the AlN buffer layer to suppress the interdiffusion of atoms and found that the thickness of the interlayer is reduced to 1.9 nm, as shown in Fig. 2. We have also found that the FWHM value of the GaN 11-24 diffraction spot is reduced from 0.59° to 0.23° by the use of the AlN buffer layer. These results indicate that the use of PLD, atomically flat $LiNbO_3$, and the AlN buffer layer makes it possible to grow high-quality GaN on $LiNbO_3$.

References:
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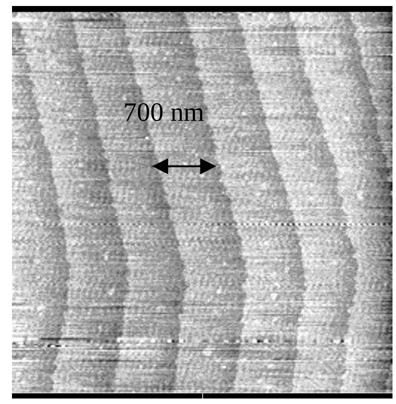

Figure 1. An AFM image of the surface for the $LiNbO_3$ (0001) substrate annealed in a $LiNbO_3$ box.

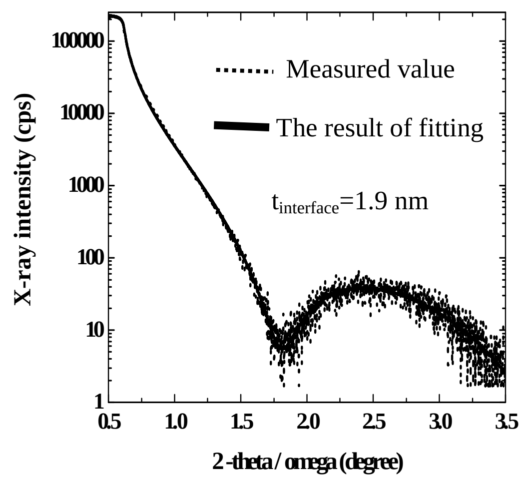

Figure 2. GIXR curve for the AlN / $LiNbO_3$ heterostructure.

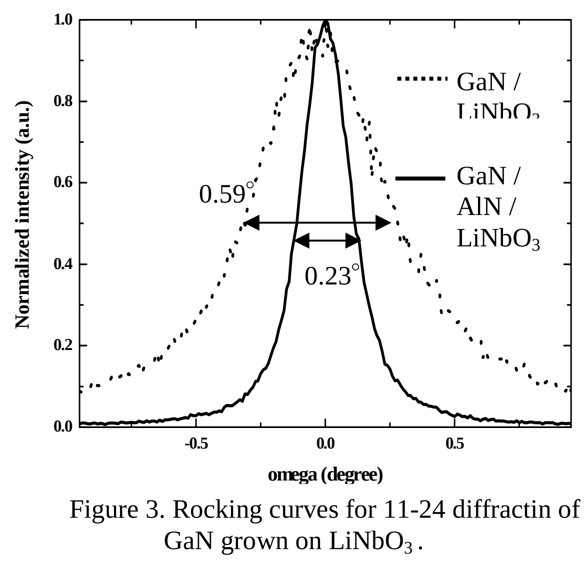

Figure 3. Rocking curves for 11-24 diffractin of GaN grown on $LiNbO_3$.