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Characterization of GaN Surfaces by X-ray Crystal Truncation Rods Scattering

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We studied the gallium nitride (GaN) (001) surface structures using reflection high-energy electron diffraction in an ultra-high vacuum condition and found that GaN demonstrated a 1×1 structure. In this study, we investigated the GaN (001) surface structures normal to the surface using X-ray crystal truncation rod scattering. We discussed the comparison of the GaN grown by metal organic chemical vapor deposition (MOCVD) and hydride vapor phase epitaxy (HVPE) and compared the calculated values and experimental results by using the two-domain model and roughness parameter β.

1 Introduction

For the further development of the energy saving society, GaN has been attracting increasing attention. GaN has many advantages, such as higher efficiency, smaller size, and faster switching-speed, owing to its wide energy band gap of 3.39 eV.

In this study, we investigated the GaN (001) surface structures using RHEED and those perpendicular to the surface using X-ray crystal truncation rod (CTR) scattering to characterize the GaN surfaces.

2 Experiment

Two types of GaN (001) samples were investigated in this study. One was grown by MOCVD on sapphire and the other was grown by HVPE on GaN. Regardless of the growth method, as-received, GaN demonstrated clear (1×1) RHEED patterns and Kikuchi lines in UHV at an electron beam energy of 15 keV. The GaN grown by HVPE was polished by a standard mechano-chemical method; however, the GaN grown by MOCVD was not polished.

The CTR experiment was performed using the synchrotron radiation at the beamline 4C of the Photon Factory. The X-ray energy was 10.2 keV.

3 Results and Discussion

Figure 1 illustrates the experimental data, i.e., GaN (001) grown by MOCVD on sapphire and HVPE on GaN. As shown in Fig. 1, MOCVD-GaN and HVPE-GaN revealed different shapes.

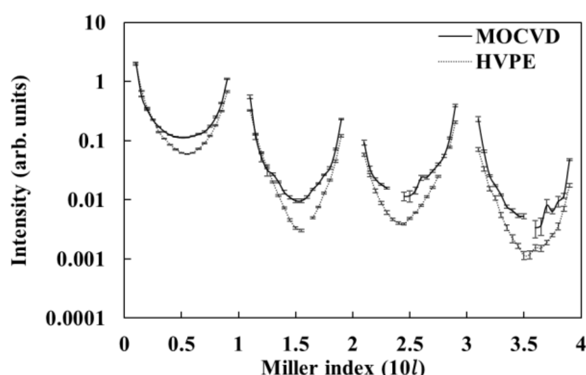

Fig. 1. CTR scattering intenstity of GaN grown by MOCVD and HVPE.

To satisfy the structure model, we considered a two-domain model. The GaN surface consists of two domains, A and B reported by Romanyuk et al. [1].

I. K. Robinson reported that the shape of the scattering intensity curve is influenced by the roughness parameter β ($0 < \beta < 1$) [2].

Based on this, we discuss our experimental data. We found that the GaN grown by MOCVD agreed with the 0.6:0.4 domain-ratio model with $\beta = 0$ as shown in Fig. 2, and the HVPE-GaN agreed with the 0.6:0.4 model with $\beta = 0.5$ as shown in Fig. 3.

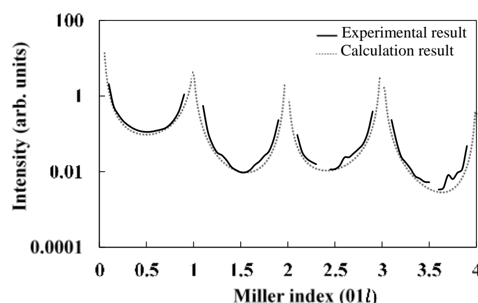

Fig. 2. Experimental and calculation results of GaN grown by MOCVD. GaN grown by MOCVD best agreed with the 0.6:0.4 model with a roughness parameter of $\beta = 0$.

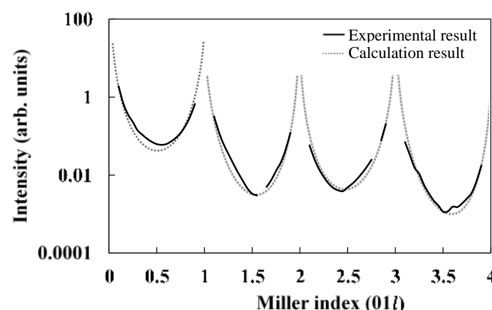

Fig. 3. Experimental and re-calculation results of GaN grown by HVPE. GaN grown by HVPE agreed with the 0.6:0.4 model with a roughness parameter of $\beta = 0.5$.

References

[1] O. Romanyuk, P. Jiricek, T. Paskova, *Surf. Sci.* **606**, 740 (2012).
[2] I. K. Robinson, *Phys. Rev. B* **33**, 3830 (1986).

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