Facet Growth Induced Dislocation Reduction by Pre-Roughening of GaN Surface in the Na-flux Method

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GaN substrates with low threading dislocation density (TDD) are essential for highly efficient GaN-based vertical devices. We have produced GaN substrates with low TDD by using the multi-point seed (MPS) technique in the Na-flux method, in which small GaN crystals are arranged on a sapphire substrate [1]. However, in the MPS technique, GaN substrates still have regions with TDD on the order of 10^5 cm^{-2}[2], so we explore for a novel method to further reduce TDD. Recently, it has been reported that TDDs have been reduced by encouraging facet development such as $\{10\bar{1}1\}$ planes in the halide vapor phase epitaxy method (HVPE) [3,4]. We have found that similar facet growth can be achieved in the Na-flux method by using GaN substrates with a rough surface which was caused by decomposition of GaN. In this study, we investigated whether TDDs are reduced by facet growth on a rough surface.

In the Na-flux method, the seed substrate is held in the gas phase to dissolve nitrogen into the Ga-Na melt before immersing it into the melt for growth. In this study, the temperature during holding was changed from the conventional 870°C to 900°C to decompose and pre-roughen the surface of the HVPE seed substrate. Then, the temperature was lowered to 880°C and the seed substrate was immersed in the melt to grow GaN crystals. As a comparison, crystals were also grown with constant holding and growing temperatures of 870°C.

As shown in panchromatic cross-sectional CL images of the grown crystal in Fig. 1(a), with pre-roughening, an uneven interface was observed between the seed substrate and the growth layer because of decomposition on the seed substrate surface. In addition, the growth layers had different luminescence intensities on facet grown and *c*-plane grown layers. On the other hand, in Fig. 1(b) under conventional condition, the interface was flat and the luminescence intensity of the growth layer was uniform. Next, we evaluated TDDs of the crystal grown under decomposed conditions by multiphoton excitation photoluminescence observation. TDDs of the growth layer and seed substrate were 1.5×10^5 cm^{-2} and 7.8×10^5 cm^{-2}, respectively. Since TDD was not reduced at the interface under conventional condition, this indicated that the facet growth decreased TDD. The TDD reduction process and the results of applying the pre-roughening on a Na-flux GaN substrate will be detailed at the conference.

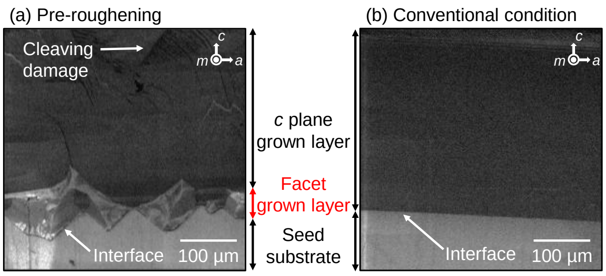

Fig. 1. Panchromatic cross-sectional CL images of crystal grown (a) with and (b) without pre-roughening of crystal surface (Emission wavelength: 190 nm – 650 nm).

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References

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