Growth of bulk GaN Crystal by Na Flux Method

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Na flux method developed by Yamane can grow GaN crystals in a Ga-Na mixed solution at relatively low pressure of nitrogen atmosphere (<5MPa) and at temperature range of 750~900 deg.C. At the beginning, we have utilized the seed crystal fabricated by the vapor phase growth method in order to make a large diameter GaN crystal. In spite of the poor quality seed substrate with high dislocation density over $10^9/cm^2$, high quality GaN crystal with the dislocation density around $10^{4\sim5}/cm^2$ could be obtained. It is possible to grow a 4-inch GaN crystal on a HVPE-GaN substrate. However, there should be the limitation of the quality and size of GaN crystal grown on the HVPE substrate containing the residual stress.

Recently, we have developed two new techniques to grow large dislocation-free GaN by Na flux method. First one is Point Seed (PS) technique[1]. This technique can be realized by putting a sapphire plate with a small hole (0.5 – 1.5 mm in diameter) on a GaN plate seed. Centimeter-sized bulk GaN single crystals with large dislocation-free areas could be fabricated by this technique. Cathodoluminescence measurement at the interface between the seed and the grown crystal has revealed that almost all dislocations propagated from the GaN seed were bent and terminated at the initial growth stage.

Second one is coalescence growth of multi-GaN crystals in order to fabricate a large diameter single GaN crystal within a short period2). As a first step, we grew two GaN point seeds and coalesced them. Two GaN point seeds were established by mounting a sapphire plate with two small holes. The coalescence direction was a-direction. Other experimental conditions were same as above. We have found the two GaN crystals grown from two separate seed area coalesced without generating dislocations at a coalescence boundary. X-ray rocking curve measurements revealed that miss-orientation of c-axis of two crystals around a coalescence boundary gradually diminished during the growth. The grown GaN crystal can remove from substrate easily during the growth. This phenomenon is effective to reduce the stress in the grown GaN crystal. The size of the GaN crystal can be increased as increasing the number of seed crystals. Up to now, we succeeded to fabricate 2.5-inch GaN crystals by the coalescence technique. Some of the crystals have very large curvature radius (~100 m), which exceed the detection limit of a Rigaku SmartLab X-ray diffractometer. Additionally, the point contact Schottky diode at the coalescence boundary of the crystal could work normally. These results indicate the high potential of the new two techniques to realize dislocation-free GaN crystals with large diameter and low strain.

Reference

1) M. Imade *et al.*, Crystal Growth & Design, **12** (2012) 3799

2) M. Imanishi et al., Applied Physics Express **5** (2012) 095501