Suppression of Inclusions in GaN Crystals Formed During Na-Flux Growth Through the Flux-Film-Coated Technique

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Gallium nitride (GaN) substrates are generally regarded as ideal for high-performance optoelectronic and electronic power devices. For the widespread use of GaN devices to come about, large-diameter and thick GaN crystals with low threading dislocation density (TDD) are desired. To create these ideal crystals, it has been proposed that the combination of two growth methods, hydride vapor phase epitaxial (HVPE) growth on a seed grown by an ammonothermal method would make good use of their advantages: rapid growth and low TDD, respectively [1]. We have similarly conducted HVPE growth and oxide vapor phase epitaxial (OVPE) growth on a seed grown by the Na-flux method [2]. In the combination method, the suppression of Ga-Na inclusions in a Na-flux-grown seed is necessary, because such inclusions vaporize, expand, and explode during VPE growth due to their growth temperature (>1000°C), which is much higher than that of Na-flux growth (about 900°C). Inclusions formed during Na-flux growth due to the development of giant steps with hundreds-μm-order height, as illustrated in Figure 1(a). This induces an overhang, which incorporates a part of Ga-Na melt in a crystal as inclusions. Thus, cancelling giant steps is effective to suppress inclusions.

In this study, we propose a way to selectively promote lateral growth to cancel giant steps by extracting a crystal from the melt in a crucible. Throughout the operation, residual Ga-Na melt is selectively left around pyramidal planes in front of giant steps and not left at other flat *c* planes without giant steps, as illustrated in Fig. 1(b). This results in the promotion of lateral growth only and the dissolution of giant steps. The technique is carried out during the growth of pyramidal GaN crystals from multiple seeds to promote coalescence, in which residual Ga-Na melt formed among pyramidal crystals [3]. This is called as the flux-film-coated (FFC) technique. Photographs of GaN crystals and surface SEM images with conventional growth and growth with the FFC technique are shown in Figs. 1(c) and (d), respectively. The crystal with the FFC technique had a much smoother surface and significantly fewer inclusions.

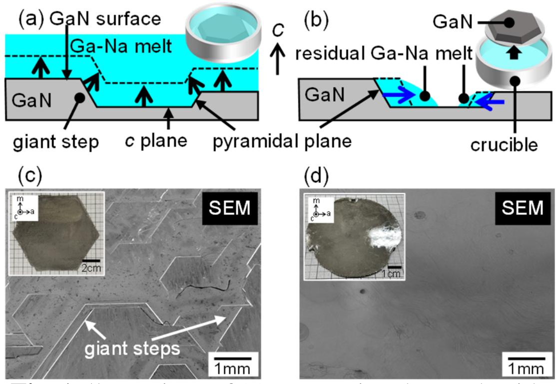

Fig. 1 Illustrations of (a) conventional growth with the FFC technique; SEM images with inset photograph of crystals with (c) conventional growth and (d) growth with the FFC technique.

References
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