Growth mechanism of step-free GaN surfaces

-Investigation of formation mechanism of atomically flat surfaces-

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Motivation

Nucleus and spiral growth modes are kinds of crystal growth modes. Crystal growth generally proceeds under a combination of nucleus and spiral growth. In this study, we tried to clarify the mechanism of crystal growth experimentally by achieving pure nucleus and spiral growth modes.

Originality

GaN films were selectively grown on GaN bulk substrates. We succeeded in obtaining step-free GaN surfaces and controlling nucleus and spiral growth modes. We also found that the dependence of nucleus and spiral growth rates on the surface supersaturation is well explained by a crystal growth theory.

Impact

This study will contribute to clarifying crystal growth mechanism and to realizing quantum wells with abrupt (step-free) hetero-interfaces. Abrupt hetero-interfaces are essential to achieve high-performance subband devices and LEDs with high monochromicity.

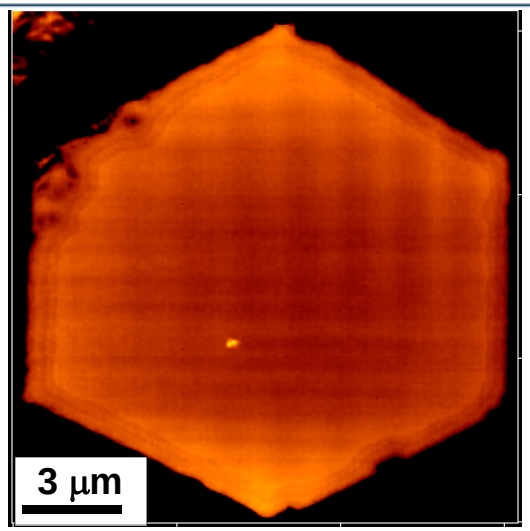

Fig. 1 Step-free GaN surface obtained by nucleus growth.

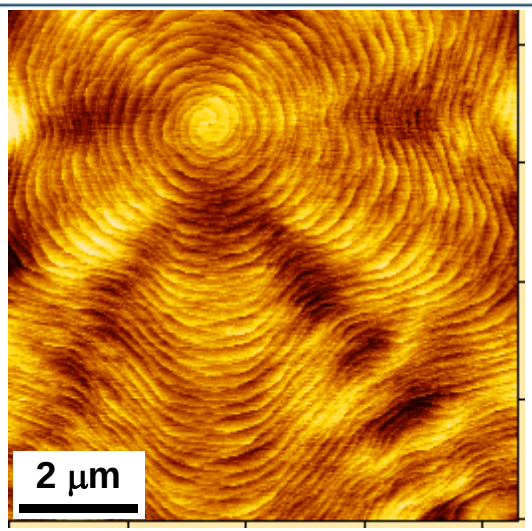

Fig. 2 Growth spiral formed by spiral growth.

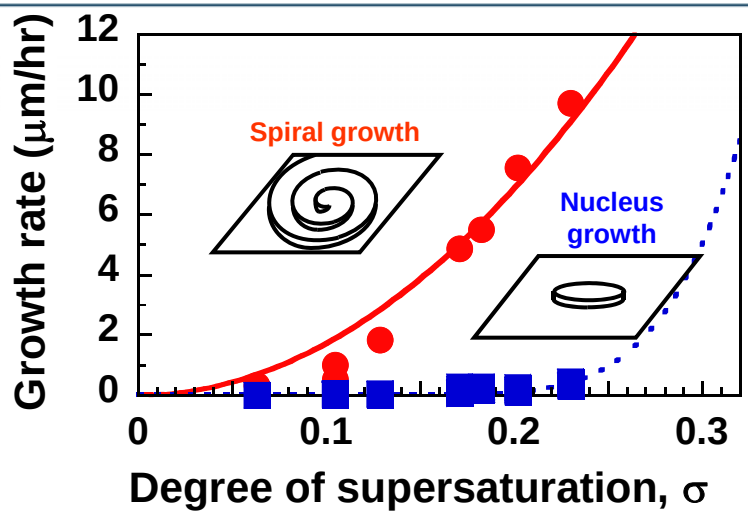

Fig. 3 Spiral and nucleus growth rates of GaN plotted as a function of the degree of supersaturation, σ.

GaN films were selectively grown on GaN bulk substrates with a low density of screw-type dislocations. Step-free GaN surfaces were formed by nucleus growth within selective-areas without screw-type dislocations (Fig. 1), while GaN surfaces exhibiting growth spirals were formed by spiral growth within selective-areas with screw-type dislocations (Fig. 2). In this study, both pure nucleus growth and pure spiral growth were obtained on a single substrate.

Surface supersaturation (driving force of crystal growth) was estimated from the interstep distances of growth spirals. Figure 3 shows the dependence of spiral and nucleus growth rates of GaN on the degree of supersaturation. The spiral growth rate increases parabolically, while the nucleus one has very low values. These results are consistent with a crystal growth theory.

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