SELF-ORDERING OF GaN NANOSTRUCTURES ON VICINAL SiC SURFACES

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Fabrication of quantum structures in nanometer scale is of great importance for the next generation device applications. It is advantageous to use self-ordering phenomena on selected material surfaces as a template of such small scale structures [1]. Vicinal surfaces of SiC after high temperature hydrogen etching show ordered nanofaceting structures [2]. Here we demonstrate GaN nanostructures heteroepitaxially grown on such ordered SiC nanofactes.

Initially, we investigated adsorption and desorption kinetics of Ga on vicinal 6H-SiC surfaces (4 degree off toward [11-20]) by the use of in-situ RHEED specular beam intensity as a function of surface temperature and Ga flux in the MBE system [3]. The surface showed ordered nanofacets consisting of the pairs of (0001) and (11-2n) with the ~21nm periodicity. The asymmetric diffraction conditions were used to specifically monitor surface events on each nanofacet, (0001) or (11-2n). On both facets Ga atoms adsorb in a 2D mode followed by 3D mode as seen by the RHEED oscillation at the initial stage (Fig. 1). The desorption process after the termination of the Ga flux showed reversed behavior of adsorption. However, the intensity variation on each facet at the desorption stage was different (slow on (0001) facets), suggesting selective Ga desorption on (11-2n) facets. By the immediate nitridation of such surfaces with Ga adatoms we achieved to fabricate GaN nanostructures (quantum wires and dots).

Figures 2 and 3 show AFM images of GaN nanostructures grown on SiC under different desorption time of Ga (see (a) and (b) in Fig. 1 for each condition). Aligned quantum dots were observed on both facets in Fig. 2 due to the presence of a Ga monolayer on both facets. The dots can be formed via strain accumulation during nitridation. As the Ga desorption proceeds (b) (11-2n) facets loose Ga adatoms faster than (0001) facets. After the complete (or almost) loss of Ga from (11-2n) facets submonolayer Ga adatoms may still remain on (0001) facets as seen by the incomplete recovery of the RHEED specular intensity. This turns out the quantum wire-like structure on (0001) facets after nitridation as shown in Fig. 3. Note some gap between wires due to (11-2n) facets where no Ga was present.

In summary, we achieved in fabricating of GaN quantum structures on vicinal SiC surfaces, consisting of periodical nanofacets. Different Ga desorption kinetics was recognized on each nanofacet surface by the RHEED specular beam intensity variation under asymmetric diffraction conditions. After the immediate nitridation of "slectively" Ga desorbed SiC surfaces various GaN quantum structures were generated.

[1] A. Shuchukin et al., Rev. Mod. Phys., 4, 71 (1999).
[2] H. Nakagawa et al., Phy. Rev. Lett. 91, 226107-1 (2003).
[3] L. X. Zheng et al., Phys. Rev. B. 61, 4890 (2000).

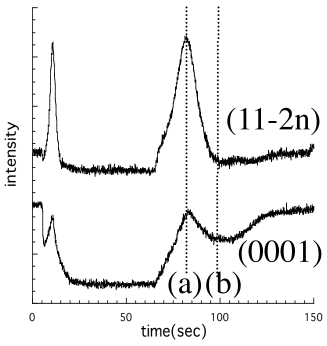

Fig. 1. Variations of the RHEED specular beam intensity during Ga adsorption and desorption on SiC (0001) and (11-2n) nanofacets. Ga is supplied at t = 5 sec and terminated at t = 65 sec.

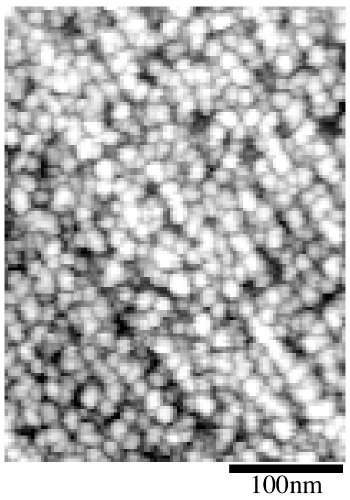

Fig. 2. AFM image of GaN growth on SiC by the nitridation of Ga at the time (a) in Fig. 1. GaN quantum dots are aligned along [1-100].

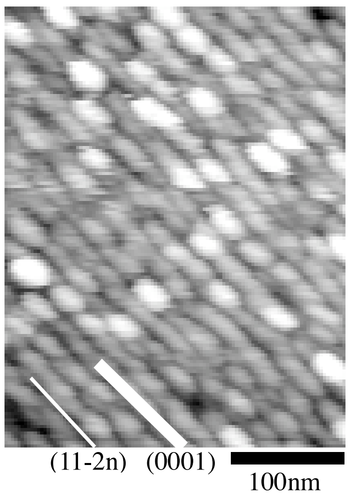

Fig. 3. AFM image of GaN growth on SiC by the nitridation of Ga at the time (b) in Fig. 1. GaN quantum wires are aligned along [1-100].