# Structure analysis of AlN films grown on SiC substrate by RF-MBE

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(0001) 6H-SiC has been a attractive substrate on which high frequency and high power electronics devices using III-V nitride materials are fabricated, because of its higher thermal conductivity and the closer lattice match with GaN (3.5%) than those of sapphire. For the growth of GaN on SiC substrate, it is necessary to grow an AlN buffer layer with the smooth surface for the subsequent epitaxial growth and electrically isolation from SiC substrate. In this study, the effect of growth temperature on the surface morphology and structure of AlN layers are reported.

The AlN layers studied here were grown by RF-MBE on (0001) 6H-SiC substrates. Before the growth, the SiC substrates were cleaned by $H_2$ (5 SCCM)-$N_2$ (0.5 SCCM) mixed plasma for 20 min at 900°C with the RF power of 300 W. The beam equivalent pressure of Al, nitrogen flow rare and RF power were $1.2 \times 10^{-7}$ Torr, 2 SCCM and 215 W, respectively. The thickness of AlN layers were about 200 nm. The structure and morphological characteristics of the AlN layers were investigated using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). TEM specimens for cross-sectional observation were prepared by mechanical thinning and Ar-ion milling. The samples were observed with a JEM-2010 electron microscope operated at 200 keV. The lattice constant of the AlN layers along the *c*-axis was measured by X-ray diffraction (XRD).

Figure 1 shows SEM images comparing surface morphology of the AlN layers grown at different temperature. With increasing growth temperature, the surface morphology were changed from the three dimensional rough surface to the relatively flat surface. The growth rate was found to be almost constant in this growth temperature range, indicating that the V/III ratio was also constant during a series of the growth. Therefore, the improvement of surface morphology of AlN layers result from the enhancement of surface migration with increasing growth temperature. Cross sectional TEM images of the AlN layers grown at 850°C and 900°C are shown in Fig. 2. It is evident that the growth with columnar structure resulting in the three dimensional rough surface is well suppressed in the growth at 850°C. Some pits with a size of ~100 nm are observed at the surface as shown by the arrow in Fig. 2(b), corresponding to the large pits in Fig. 1(c). It is likely seemed that these pits are formed by the insufficient surface migration causing less coalescence of islands. Dependence of growth temperature on the lattice constant of the AlN layers along the *c*-axis measured by XRD are shown in Fig. 3. The decrease of the lattice constant at lower growth temperature is considered to relate to three dimensional columnar growth behavior, in which strain could be easily relaxed at the surface and/or grain boundary.

In summary, we have investigated structure and surface morphology of AlN layers grown on (00019 6H-SiC substrates by RF-MBE. As increased the growth temperature up to 850°C, growth mode of AlN layers changed from three-dimensional columnar growth to two-dimensional growth, resulting in the relatively flat surface. The change in lattice parameter of AlN depending on the growth temperature was also observed

**Acknowledgement**

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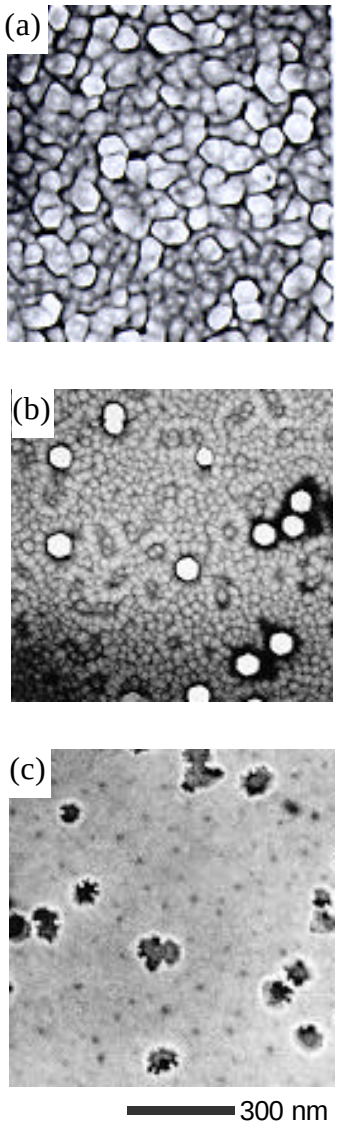


Fig. 1 SEM images of surface morphology of the AlN layers grown at (a) 750°C, (b) 800°C and (c) 850°C.

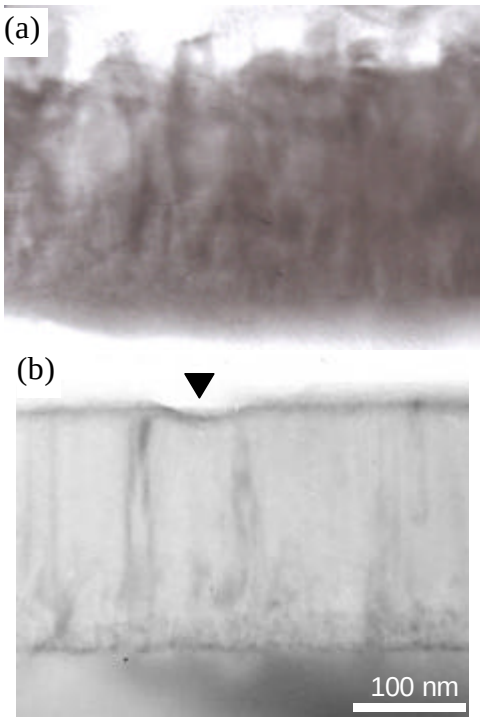


Fig. 2 Cross sectional TEM images of the AlN layers grown at (a) 800°C and (b) 850°C.

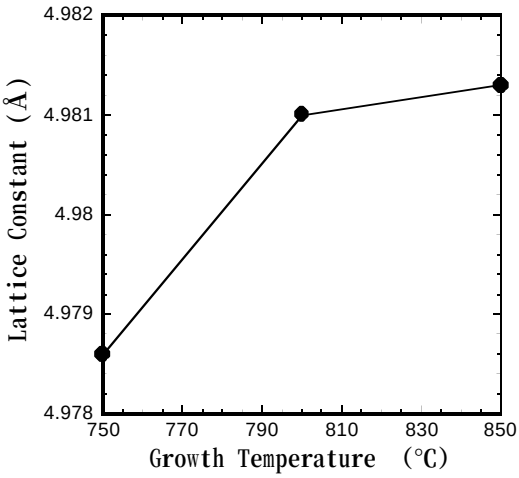


Fig. 3 Dependence of growth temperature on the lattice constant of the AlN layers along the *c*-axis measured by XRD