Investigation of high-temperature annealing process of sputtered AlN films

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AlN substrate is desirable for various optoelectronic and electronic applications due to its excellent physical properties. Our group recently reported the realization of high-quality sputtered AlN films by high temperature "face-to-face" annealing [1]. However, the mechanism of AlN quality improvement by annealing is still unclear. In order to figure this out, the microstructure of sputtered AlN films annealed under different condition was investigated by scanning transmission electron microscopy (STEM) observation in this work.

250 nm AlN films were grown on c-plane sapphire substrates by sputtering. Subsequently the sputtered AlN films were thermally annealed in N_2 at 1500 ºC and 1700 ºC for 1h "face-to-face" as described in Ref. 1. The full width half maximum (FWHM)s of X-ray rocking curves for (10-12) diffraction decrease from 7012 arcsec to 932 arcsec and 274 arcsec after 1500 ºC and 1700 ºC annealing respectively, while the FWHMs for (0002) reduce from 279 arcsec to almost the same value about 50 arcsec.

Fig. 1 shows cross-sectional STEM images of sputtered AlN on sapphire substrate (a) without, (b) with 1500 ºC and (c) with 1700 ºC annealing taken along the [11-20] AlN zone axis. Columnar structures are observed in grown layer with annealing in Fig. 1 (a). The inset shows illustration of area indicated by white rectangle and the EDS result demonstrates higher O concentration around gaps between each columnar structure (denoted by ellipses). After 1500 ºC annealing the column structures disappear and irregular grains corresponding to different contrasts appear as shown in Fig. 1 (b). Meanwhile no columnar structure and grain is observed after 1700 ºC annealing according to Fig. 1 (c). Hexagonal shaped voids form after annealing as pointed by arrows in Fig. 1 (c). We assume that the twist and combination of column structures due to high temperature annealing probably is the reason for the qualitative improvement of sputtered AlN films.

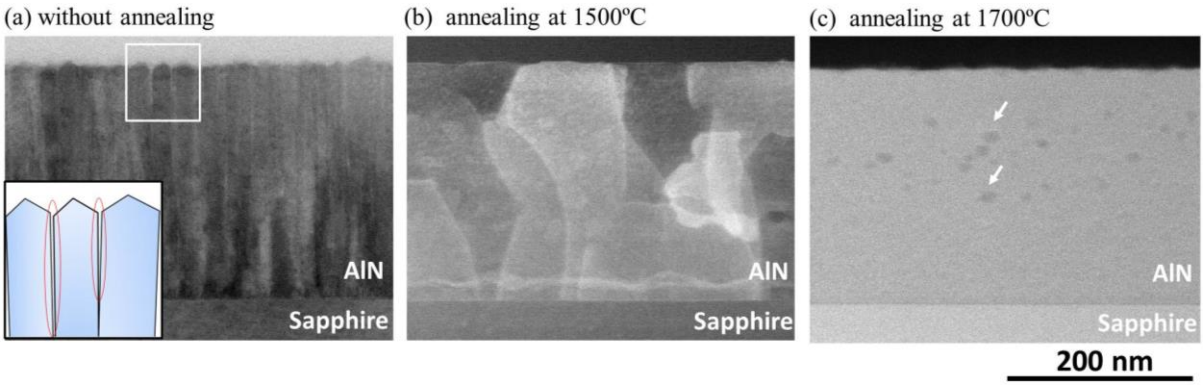

Fig. 1 Cross-sectional STEM images of sputtered AlN on sapphire substrate (a) without, (b) with 1500 ºC and (c) with 1700 ºC annealing taken along the [11-20] AlN zone axis.

Reference

[1] H. Miyake *et al.*, J. Cryst. Growth **456**, 155-159 (2016).

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