Effect of Oxygen on Polarity and Crystalline Quality of AlN Films Deposited by Pulsed DC Reactive Sputtering

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AlN is a good candidate material as a substrate for AlGaN-based UV LED. The sputtering technique is a beneficial one due to its simplicity, low cost, and high reproducibility. Pulsed DC reactive sputtering technique leads to make dense and higher growth rate of AlN films among the other sputtering methods [1]. The polarity of III-N semiconductors materials is important as it determines its properties. N-polar (-C) III-N has higher charge carriers concentration than III-polar (+C) III-N [2]. However, III-polar III-N has lower Ohmic contact resistivity [3], higher Schottky Barrier Height (SBH) [3, 4], smoother surface, and higher growth rate [5]. Therefore, Al-polar AlN is required for further fabrication of AlGaN/AlN UV LED. The purpose of this study is to investigate the oxygen effect on polarity inversion and crystalline quality of the AlN films deposited by pulsed DC reactive sputtering.

All of the AlN films were deposited at 823 K with DC power of 600 W. The pulsed DC power source was used with a frequency of 100 kHz and duty ratio of 60%. N-polar nitrided a-plane sapphire [6] was used as the substrate. The polarity inversion technique of these AlN thin films is needed. Oxygen addition is simple and effective technique to inverse the polarity of AlN film from N-polar to Al-polar AlN [7]. Therefore, the oxygen partial pressure (P_{O2}) was varied at 5.0×10^{-10}, 5.5×10^{-3}, and 5.0×10^{3} Pa in the initial Ar-50 vol% N_2 mixture gases (at P_{total} of 10^5 Pa). The total pressure (P_{total}) was also varied at 0.3, 0.4, and 0.6 Pa. The wet etching was done using 0.8 mol/L KOH as an etchant at 313 K in 30 s to determine the polarity of AlN films. The surface morphology was observed through laser optic measurement. The XRC-FWHM measurements were also done to obtain the crystal quality of AlN films.

Figure 1 shows the XRC-FWHM values of sputtered AlN films at P_{total} of 0.6 Pa. The oxygen addition leads to the lower XRC-FWHM value of sputtered AlN film (better crystal quality of AlN film). Figure 2 shows the surface morphology of sputtered AlN films at P_{total} of 0.6 Pa with different P_{O2} before and after etching with KOH. The addition of oxygen with P_{O2} of 5.0×10^{3} Pa leads to change the polarity from N-polar to Al-polar AlN. The best crystal quality of AlN film was achieved at P_{total} of 0.6 Pa and P_{O2} of 5.0×10^{3} Pa with 486 arcsec of AlN (0002) and 1055 arcsec of AlN (10-12) with Al polarity.

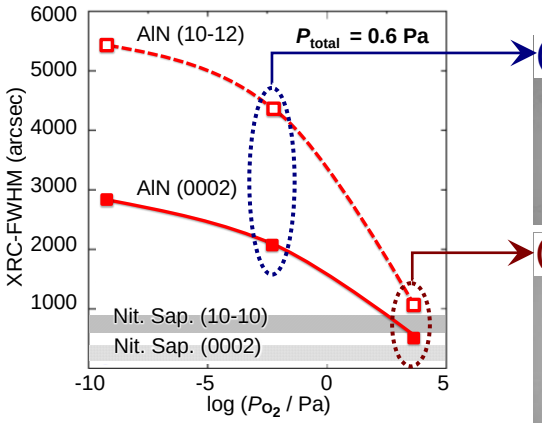

Fig. 1 Effect of P_{O2} on XRC-FWHM values of AlN films sputtered at P_{total} of 0.6 Pa.

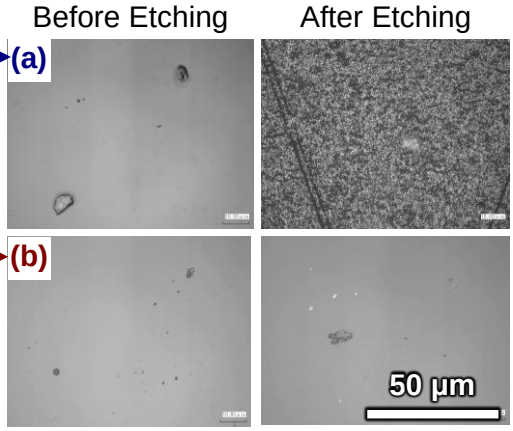

Fig. 2 Surface morphology of sputtered AlN films at P_{total} of 0.6 Pa with different P_{O2} before and after etching.

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