AlN Films Epitaxialy Formed by Direct Nitridation of Sapphire using Aluminum Oxynitride as a Buffer Layer

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The nitrides of Group III, such as GaN, InN and AlN are the most promising materials for optical devices in the region of blue to ultraviolet light. The electrical, optical and structural properties of epitaxial these nitrides are strongly influenced by the growth initiation. Therefore, a new substrate, which has the same crystal structure with the nitrides, the comparable lattice parameter and low dislocation density, is necessary for optimal initial growth of these nitride films. The present study aims to form high quality single-crystalline AlN films as a new substrate. The present study has been intended to epitaxialy form AlN films by direct nitridation of sapphire using aluminum oxynitride (alon) as a buffer layer, based on the chemical potential diagram of the Al-O-N-C system determined by the present authors[1, 2]. The alon layer is expected to relax the lattice mismatch between AlN and sapphire.

Figure 1 shows the typical X-ray images of Al and N of the cross-sectional view of the sapphire nitrided with CO-N_2 gas mixture, P_{CO} / P_{N2} = 0.1, for 12 h at 1973 K. From the gradient of oxygen concentration, it was observed that alon and AlN layers were serially formed on sapphire. Figure 2 shows the XRD pattern of AlN $\{10\bar{1}0\}$ peaks of the nitriding sapphire measured by pole figure. From the only hexagonal symmetric, it is confirmed that the formed AlN layer was single crystal. The alon buffer layer was also confirmed to be single crystal. From XRD profiles of θ - 2θ scan, the alon (100) and AlN $(10\bar{1}1)$ planes were parallel to α-Al_2O_3 $(11\bar{2}0)$ plane. The lattice mismatch factors of the α-Al_2O_3 $(11\bar{2}0)$ / alon (100) interface and the alon (100) / AlN $(10\bar{1}1)$ interface have been evaluated to be 9.80 % and 10.0 %, respectively, which is much smaller than that of the direct AlN $(10\bar{1}0)$ / α-Al_2O_3 $(11\bar{2}0)$ interface (20.8 %). Thus, the alon layer significantly relaxes the lattice mismatch between α-Al_2O_3 and AlN. Figure 3 shows the AFM image of the nitriding sapphire. The deference in height of the surface was as large as 400 nm, however, no grain boundaries were observed in the surface.

The following conclusions were derived from the results and discussion. The formed alon and AlN layers have been epitaxialy grown on the sapphire substrate and these layers have the following crystallographic relation,

$(11\bar{2}0)$ α-Al_2O_3 // (100) alon // $(10\bar{1}1)$ AlN.

The lattice mismatch of the interface between α-Al_2O_3 and AlN has been reduced almost half by using the alon buffer layer.

References

[1]W. Nakao, H. Fukuyama and K. Nagata, *J. Am. Ceram. Soc.*, in print
[2]will be presented by H. Fukuyama, W. Nakao and K. Nagata in this conference.

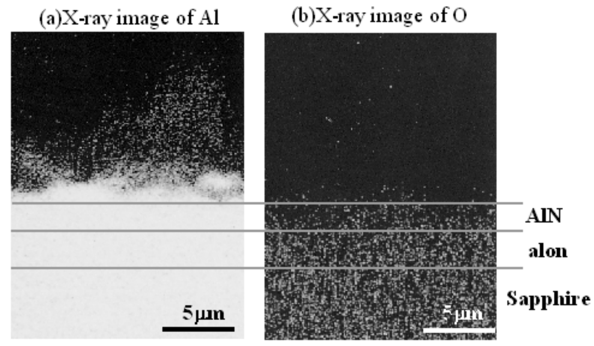

Fig. 1 X-ray images of (a) Al and (b) O of the cross-sectional view of the sapphire nitrided with CO-N_2 gas mixture, P_{CO} / P_{N2} = 0.1, for 12 h at 1973 K.

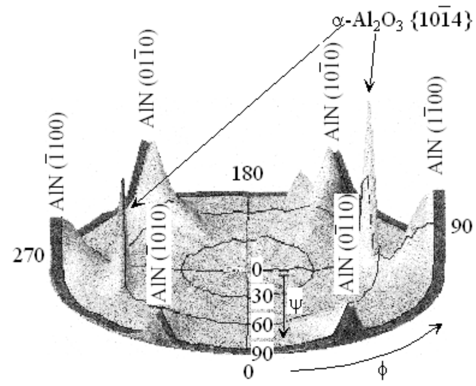

Fig. 2 XRD pattern of AlN $\{10\bar{1}0\}$ peaks of the sapphire nitrided with CO-N_2 gas mixture, P_{CO} / P_{N2} = 0.1, for 12 h at 1973 K

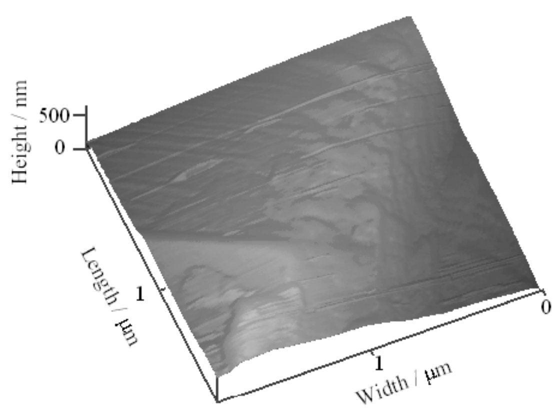

Fig. 3 AFM image of the sapphire nitrided with CO-N_2 gas mixture, P_{CO} / P_{N2} = 0.1, for 12 h at 1973 K