CONTROL ID: 2492614

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TITLE: Characterization of AlN and Mg-doped $Al_xGa_{1-x}N$(x>0.2) Grown by Using Horizontal High-flow-rate MOVPE System

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PRESENTATION TYPE: Poster Presentation Preferred

CURRENT SYMPOSIUM: B: Wide-Bandgap Group-III Nitride Materials and Devices (AlN, GaN, InN, BN, etc.)

KEYWORDS: Synthesis & Processing/Deposition/Vapor Phase Epitaxy (VPE), Composition & Microstructure/Material Type/alloy, Composition & Microstructure/Material Type/nitride.

Abstract:

Abstract Body: In a nitride-based deep-ultraviolet light emitting diode (DUV-LED), low luminous efficiency resulting from the low efficiency of hole injection is one of the most important issues. For Mg-doped p-type GaN, the electrical characteristics can be improved by using a high growth pressure. [1] However, For Mg-doped p-type AlGaN, it is difficult to grow high-quality AlGaN at higher growth pressure because of a hazardous gas phase pre-reaction between trimethylaluminum and ammonia. [2] We realized high-rate growth of n-type AlGaN at high growth temperature using a high-flow-rate metal organic vapor phase epitaxy (MOVPE) tool. [3] In this study, we optimized the growth conditions and obtained high-quality AlN on sapphire. In addition, Mg-doped $Al_xGa_{1-x}N$ (x>0.2) was grown on a high-quality AlN template at growth pressure as high as 70kPa. We investigated the effect of the growth temperature on the characteristics of p-type AlGaN.

We grew AlN and Mg-doped AlGaN using a high-flow-rate MOVPE reactor (SR4000HT, Taiyo Nippon Sanso). A structure of 3-μm-thick AlN/100-nm-thick AlN buffer layer was grown on a c-plane sapphire substrate. The growth temperature of the 3-μm-thick AlN was 1300°C and that of the AlN buffer layer was changed from 890°C to 980°C for each sample. To investigate the p-type AlGaN characteristics, we grew a 10-nm-thick p^+-GaN/0.3-μm-thick Mg-doped AlGaN/0.6-μm-thick AlGaN buffer layer on the AlN template at a growth pressure of 70 kPa and at growth temperatures ranging from 1025°C to 1150°C.

The full width at half maximum of the (10-12)-plane X-ray rocking curve for AlN was improved from 603 arcsec to 442 arcsec by reducing the growth temperature of AlN buffer layer from 980°C to 890°C. However, the surface of the AlN became rough compared with the other samples. The optimal growth temperature of the AlN buffer layer was 920°C in this investigation. For the Mg-doped AlGaN, p-type activation was confirmed in all the samples. We obtained an electric resistivity of 16 ohm-cm in Mg-doped $Al_{0.29}Ga_{0.71}N$ grown at the highest growth temperature of 1150°C, however, Mg diffusion at the interface was confirmed by secondary ion mass spectrometry analysis. Further optimization of the growth conditions is necessary to achieve both low electric resistivity and low Mg diffusion.

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