Challenge and Opportunity of high-flow rate MOCVD tool for UV-LED Application.

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Deep ultraviolet light-emitting diodes (DUV-LEDs) requires an n-type $Al_xGa_{1-x}N$ ($x > 0.5$) with low electric resistivity as a cladding layer at a high rate. Recently, we reported that n-type $Al_{0.6}Ga_{0.4}N$ can be grown at a high rate using a high-flow-rate MOCVD reactor (SR4000HT, Taiyo Nippon Sanso) [1]. In the report, we indicated that the impurity carbon concentration in n-type AlGaN should be reduced to obtain a low electric resistivity and demonstrated growth of Si-doped $Al_{0.5}Ga_{0.5}N$ layers at 3.5μm/h on an AlN/sapphire template with a low carbon concentration. The sheet resistance and the electric resistivity even in a 1μm-thick Si-doped AlGaN were 97 ohm/cm^2 and t was 9.8×10^{-3} ohm-cm, respectively.

Furthermore, excellent crystal quality AlN and AlGaN as underlying layers are required for high luminous efficiency in on-top photo emission layers. It was reported that the crystal quality of the AlN buffer layer was improved through high-temperature annealing under N_2 gas ambient [2]. Here, we investigated the characteristics of AlN layers regrown on buffer layers of AlN/sapphire that were annealed in pure N_2 gas. A 150-nm-thick AlN layer was grown by MOCVD and then followed annealed by using an annealing furnace (STA1800, Taiyo Nippon Sanso). By annealing at 1700 °C, the X-ray rocking curve-full width at half-maximum (XRC-FWHM) of the (0002) was decreased from 66 arcsec to 62 arcsec, and that of the (10-12) was drastically decreased from > 2000 arcsec to 609 arcsec. Over the regrown AlN on the AlN template, the XRC-FWHMs of the (0002) and (10-12) planes were 50 arcsec and 414 arcsec, respectively.

These results indicate that a high-flow-rate MOVPE reactor and a high temperature annealing furnace are useful for low-cost production for high performance of DUV-LEDs.

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