High quality $Al_{0.6}Ga_{0.4}N$ and AlN growth on AlN template with a high temperature annealing in N_2 ambience

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Abstract

To improve the performance of deep ultraviolet LEDs (DUVLEDs), high-quality AlN and AlGaN are required for the underlying layers. Recently, an improvement of the crystal quality of the AlN buffer layer through high-temperature annealing under N_2-CO gas ambient was reported [1]. Here, we investigated the characteristics of AlN and $Al_{0.6}Ga_{0.4}N$ layers regrown on buffer layers of AlN/sapphire that were annealed in pure N_2 gas.

A 300-nm-thick AlN layer was grown by low-pressure metalorganic chemical vapor deposition (SR4000HT, Taiyo Nippon Sanso) and annealed at 1700 °C for 1 h in pure N_2 gas using an annealing furnace (STA1700, Taiyo Nippon Sanso). We grew a 3.0-μm-thick AlN layer at 1340 °C on this annealed template, as well as a 2.3-μm-thick $Al_{0.6}Ga_{0.4}N$ layer at 1150 °C. The growth rates for the AlN and $Al_{0.6}Ga_{0.4}N$ were 4.0 μm/h and 3.6 μm/h, respectively.

By annealing at 1700 °C, the X-ray rocking curve-full width at half-maximum (XRC-FWHM) of the (0002) plane was decreased from 70 to 38 arcsec, and that of the (10-12) plane was drastically decreased from 1278 to 442 arcsec. Over the regrown AlN on the AlN template, the XRC-FWHMs of the (0002) and (10-12) planes were 133 and 366 arcsec, respectively. The obtained surface morphology was smooth, with a root mean square roughness value of 0.31 nm. No cracks were generated by the regrowth of the 3.0-μm-thick AlN layer, while many cracks were observed in the AlN directly grown on sapphire. Cracks were also not observed in the regrown $Al_{0.6}Ga_{0.4}N$. These results indicate that the AlN template fabricated by N_2 annealing at high temperature can improve the quality and productivity of DUVLEDs.

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