GROWTH OF N-TYPE $Al_xGa_{1-x}N$ (x>0.5) WITH LOW ELECTRIC RESISTIVITY AT HIGH V/III RATIO

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Improving the productivity of deep ultraviolet light-emitting diodes (LEDs) requires growth of 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 [1]. Additional findings included that the impurity carbon concentration in n-type AlGaN should be reduced to obtain a low electric resistivity. In this study, we investigated the doping characteristics of Si-doped $Al_{0.5}Ga_{0.5}N$ layers on an AlN/sapphire template as a function of SiH_4/Group-III ratio with relatively low carbon concentration.

We used a low-pressure MOCVD reactor (SR4000HT, Taiyo Nippon Sanso). A 1.0-µm-thick Si-doped $Al_{0.5}Ga_{0.5}N$ layer was grown on a 2-in. AlN/sapphire template at a V/III ratio of 1488, growth temperature of 1110 °C, and growth pressure of 20 kPa. The SiH_4/Group-III ratio was varied from 8.6×10^{-5} to 3.0×10^{-4}. The electrical characteristics were evaluated using Hall measurements. The carbon concentration in $Al_{0.5}Ga_{0.5}N$ grown at 3.5 µm/h was less than 4×10^{17} cm^{-3}.

The carrier concentration of n-type $Al_{0.5}Ga_{0.5}N$ increased linearly up to 1.2×10^{19} cm^{-3} as a function of increasing SiH_4 supply ratio (Fig. 1). There was no degradation in surface morphology of the wafers. The mobility remained unchanged at approximately 50 cm^2/Vs. In the most highly Si-doped AlGaN, the sheet resistance was 97 ohm/cm^2 and the electric resistivity was 9.8×10^{-3} ohm-cm. These results achieved similar level as the n-type GaN underlying layer of conventional blue LEDs. The electrical properties of higher Si-doped $Al_{0.5}Ga_{0.5}N$ and higher-Al-content Si-doped AlGaN will be presented at the conference.

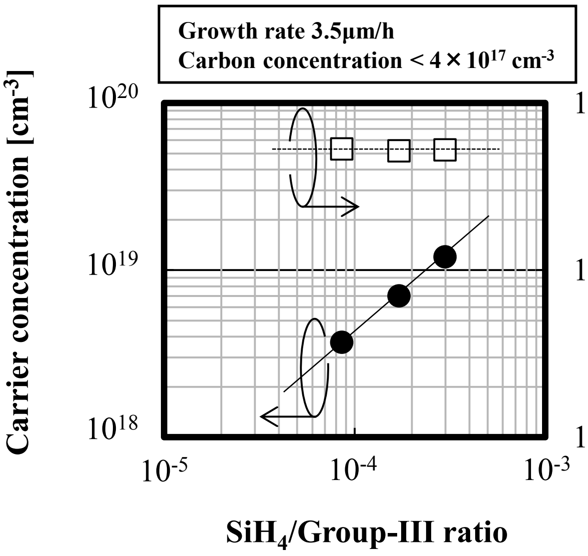

Fig. 1 Carrier concentration and mobility of n-type $Al_{0.5}Ga_{0.5}N$ as a function of SiH_4/Group-III ratio.

REFERENCES:

[1] K. Ikenaga, “Growth of silicon-doped $Al_{0.6}Ga_{0.4}N$ with low carbon concentration at high growth rate using high-flow-rate metal organic vapor phase epitaxy reactor”, Jpn. J. Appl. Phys., Vol. 55, pp 05FE04, 2016.