Impacts of growth temperature on electrical properties of Mg-doped AlGaN films grown by RF-MBE under nitrogen-rich conditions

Kiri Shida[1], Ruka Nakamura[1], Koki Mizumura[1], Mahiro Hayasaki[1], Yuzo Itoh[1], Tomohiro Yamaguti[1], Toru Honda[1], Takeyoshi Onuma[1]
[1] Kogakuin University

Deep ultraviolet (DUV) light is widely used in the medical and sterilization fields. Especially, emission wavelengths shorter than 220 nm is recently recognized as human-friendly sterilization light [1,2]. AlGaN alloys are promising material for the DUV emitters. But, one of the drawbacks is monotonic increase in an activation energy of Mg acceptor [3,4]. In this study, Mg-doped AlxGa1-xN films were grown by the RF-MBE under nitrogen-rich conditions.

407-848-nm-thick Mg-doped AlxGa1-xN films were grown on 425-nm-thick c-plane AlN on Al2O3 templates [5] for 1 hour. The beam equivalent pressures (BEP) of Al and Ga were respectively set as 3.0 10-8 and 2.7 10-7 Torr, with a nitrogen flow rate of 1.0 ccm and RF Power of 150 W. Mg was supplied from effusion cell with temperature of 360°C. Thermocouple substrate temperature (Tsub) was varied from 675 to 750°C. Mg-doped GaN films were also grown at the same Tsub range for comparison. The films were evaluated using spectroscopic ellipsometry (SE), atomic force microscopy (AFM), X-ray diffraction (XRD), infrared reflectance, Hall effect, and Seebeck effect measurements.

Values obtained by the Hall effect and Seebeck effect measurements at room temperature (RT) are summarized. It indicates that the Mg-doped AlGaN film grown at 725°C revealed a hole density of 9.5×1018 cm-3.

The results indicate suitable Tsub range depends on x for the growth of Mg-doped AlGaN under the nitrogen-rich condition.

[1] H. Kitagawa et al., American Journal of Infection Control 49, 299 (2021).

[2] N. Yamato et al., Photochemistry and Photobiology 96, 853 (2020).

[3] Y. Taniyasu et al., Nature. 441, 18 (2006).

[4] A. Chakraborty et al., J. Appl. Phys. 101, 053717 (2007).

[5] H. Fujikura et al., Appl. Phys. Express 13, 025506 (2020).