Effect of α-$(Al_xGa_{1-x})_2O_3$ Overgrowth on MSM-Type α-Ga_2O_3 Ultraviolet Photodetectors Grown by Mist CVD

Kenichiro Rikitake, Tomohiro Yamaguchi, Takeyoshi Onuma, and Tohru Honda

Dept. of Electrical Engineering and Electronics, Graduate School of Engineering, Kogakuin University, 2665-1 Nakano-machi, Hachioji, Tokyo 192-0015, Japan

e-mail: cm17055@ns.kogakuin.ac.jp

Ultraviolet (UV) photodetectors using high Al content AlGaN have been studying towards applications such as flame detection, sterilization and so on [1]. However, the growth of high-quality AlGaN with increased Al content required for UV photodetector has difficulty in epitaxy. Therefore, we have been focusing on corundum-structured gallium oxide (α-Ga_2O_3) as an alternative material. α-Ga_2O_3 has a wide bandgap of 5.3 eV, and the bandgap engineering is possible in whole composition range of $(Al, Ga, In)_2O_3$ alloys [2, 3]. Moreover, they can be heteroepitaxially grown on a variety of corundum-structured oxide materials, i.g., α-Cr_2O_3, α-Fe_2O_3, etc. A β-Ga_2O_3 based UV photodetector has been shown to have high responsivity [4], and Al_2O_3 deposition on β-Ga_2O_3 for surface passivation has been reported [5]. In contrast, α-Ga_2O_3 detector has so far not yet been reported.

In this study, a metal-semiconductor-metal (MSM)-type UV photodetector using α-$(Al_xGa_{1-x})_2O_3$ on α-Ga_2O_3 is fabricated by mist CVD.

1-µm-thick unintentionally doped α-Ga_2O_3 film was grown on *c-plane* sapphire substrate by mist CVD. Ga acetylacetonate was used as a source material for this mist CVD growth, and it was solved in deionized water with a small amount of hydrochloric acid. The concentration of Ga was 0.05 mol/L. It was followed by 20-50-nm-thick $(Al_xGa_{1-x})_2O_3$ growth using Al and Ga acetylacetonate as source materials. Then, α-Ga_2O_3-based MSM-type photodetector was fabricated by employing Ni (50 nm)/Au (100 nm) pads as Schottky electrodes.

Figure 1 shows XRD 2θ-ω scan profile. (0006)α-Al_2O_3 and (0006)α-Ga_2O_3 diffraction peaks were observed. 2θ-ω and ϕ scan profiles indicate growth of single crystalline epitaxial film. As shown in Fig. 2, the full-width at half maximum of the X-ray rocking curve for (0006)α-Ga_2O_3 diffraction peak is 39.8 arcsec. The absorption coefficient α was determined by optical transmittance measurements. Then, $(\alpha h\nu)^2$-$h\nu$ plots give bandgap energy of 5.3 eV. Figure 3 shows photo-responsivity of the MSM-type photodetector. Increase in responsivity above the bandgap energy of 5.3 eV was successfully observed. Maximum photo-responsivity was estimated to be 1.0 A/W. However, the photo-responsivity decreased in the energy range between 5.6 and 5.8 eV due to surface effect of the α-Ga_2O_3 film. Surface effect on MSM-type UV photodetectors using α-$(Al_xGa_{1-x})_2O_3$ on α-Ga_2O_3 structure will be shown at the cofference.

The authors would like thank Prof. Fujita and Dr. Kaneko of Kyoto University for their help with the experiments. This work was supported in part by Grant-in-Aid for Scientific Research on Innovative Areas (No. 16H06417) from the Japan Society for the Promotion of Science and the Cooperative Research Program of "Network Joint Research Center for Materials and Devices".

[1] A. Yoshikawa *et al.*, Jpn. J. Appl. Phys. **55**, 05FJ04 (2016).
[2] N. Suzuki *et al.*, J. Cryst. Growth **401**, 670 (2014).
[3] S. Fujita and K. Kaneko, J. Cryst. Growth **401**, 588 (2014).
[4] T. Oshima, T. Okuno and S. Fujita, Jpn. J. Appl. Phys. **46**, 7217 (2007).
[5] S. Pratiyush *et al.*, Appl. Phys. Lett. **110**, 221107 (2017).

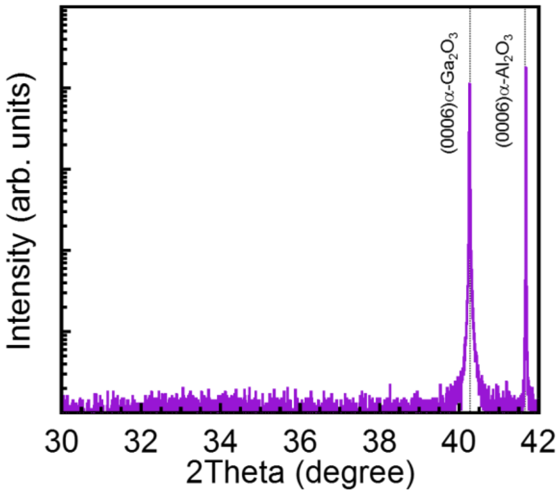

Fig. 1: XRD 2θ-ω scan profile of Ga_2O_3 film.

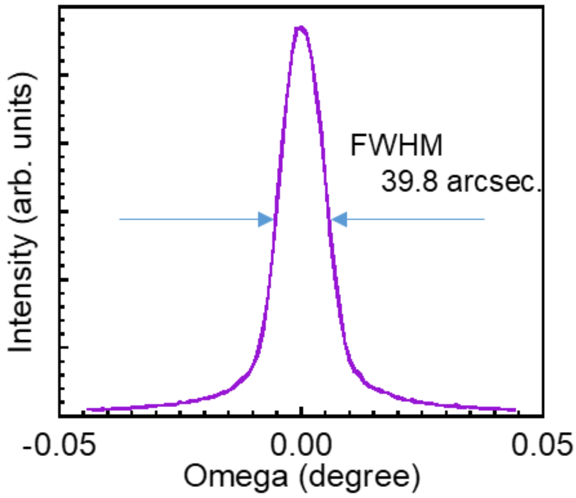

Fig. 2: XRD ω scan profile of Ga_2O_3 film.

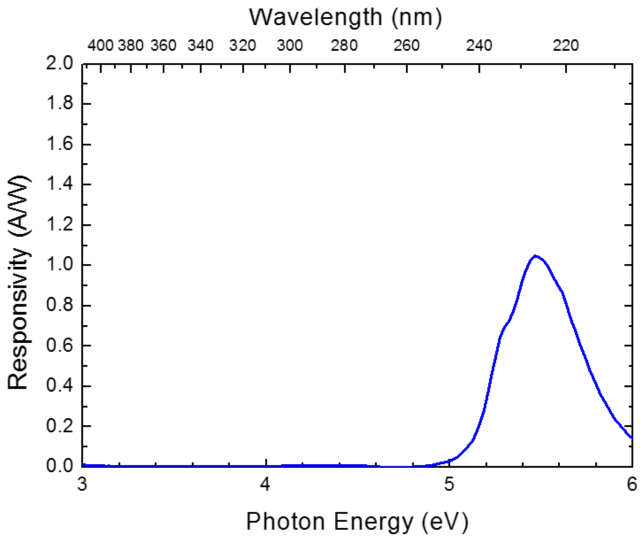

Fig. 3: Photoresponsivity spectrum at room temperature
in MSM-type photodetector fabricated using α-Ga_2O_3 film.