Improvement of planarity of InGaN using face to face annealing with NH_3

N. Okada*, A. Nakata, A. Sasaki, S. Kurai, and Y. Yamada
*lead presenter: nokada@yamaguchi-u.ac.jp
Yamaguchi university, Japan

Group III nitride semiconductors have a wider band gap energy than Si, which are very useful for photoelectric conversion devices. The wireless power supply using laser and solar cell based on group III nitride is one candidate to realize high conversion ratio. In particular, focusing on solar cells, InGaN is used as the absorption layer, and defects caused by lattice mismatch between the GaN base layer and the InGaN active layer are a problem that reduces power conversion efficiency. Therefore, it is thought that the efficiency can be improved by using relaxed InGaN as underlayer, suppressing the generation of defects thanks to reducing the lattice mismatch difference. However, *c*-plane InGaN, which is mainly used in photoelectric conversion devices, has a problem of surface roughness with V-pit formation when the critical film thickness is exceeded. In order to solve the problems, this study reports on the improvement of surface flatness using an annealing technique based on face-to-face annealing (FFA), which is effective for improving the quality of AlN layer[1].

InGaN films with 200 nm, 400 nm, and 700 nm thickness were grown on *c*-plane sapphire substrates by metal organic vapor phase epitaxy. Next, FFA was performed on each sample at annealing temperature of 950-1150 °C and annealing time of 10-30 min with NH_3 flow. Fig. 1 shows the schematic structure of FFA for the InGaN layers. Fig. 2 shows the surface SEM images of the upper InGaN of each sample before and after FFA for different annealing time with annealing temperature of 1150 °C. The V-pit densities of the samples grown for10, 20, and 30 min without FFA were 3.3×10^8 cm^{-2}, 2.5×10^8 cm^{-2}, and 2.2×10^8 cm^{-2}, respectively. After the FFA, the almost V-pits in samples were disappeared, and the surface conditions of the lower InGaN surfaces after FFA was worse than those of the upper ones. This is thought to be because annealing caused the lower InGaN material desorbed and embed the V-pits in upper samples, resulting in very smooth surface. In addition, cathodoluminescence (CL) showed that dislocations moved laterally, and we believe that the migration of dislocations may have contributed to the V-pit reduction. To confirm the upmost surface composition, Auger electron spectroscopy was carried out. Under certain FFA conditions, the energy peaks related to all elements of In, Ga, and N were observed, confirming that the crystal surface is composed of InGaN.

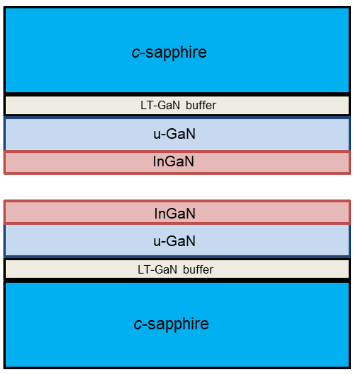

Fig. 1 Schematic structure of FFA for InGaN layers

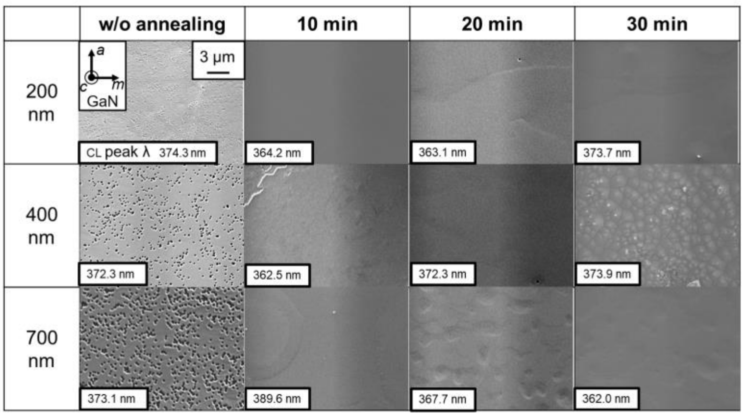

Fig. 2 Surface SEM images of upper InGaN before and after FFA for different annealing time

References

[1] H. Miyake et al., J. Cryst. Growth **456** (2016) 155.