The difference in growth mechanisms of GaN thin films on metal-foil and quartz glass substrates

Yuichi Sato, Toshihumi Hishinuma and Susumu Sato
Dept. of Electrical and Electronic Engineering,
Faculty of Technology and Resource Science,
Akita University
1-1 Tegata-gakuen-cho, Akita 010-8502, Japan
Email: yusato@quartet.ipc.akita-u.ac.jp

UV-rays emitted from GaN-based LEDs are quite intense, and a lot of applications of such LEDs could be considered. A possibility for realizing a full-color fluorescent flat-panel-display has been investigated until now[1~3]. RGB phosphor films are minutely arranged and excited by UV-rays emitted from a micro UV-LED array based on GaN in the display device. Large area substrates have to be used for the fabrication of the micro UV-LED arrays. However, the typical substrates for GaN film growth are single-crystal wafers[4,5], and their areas are not large enough. Metal-foils are candidates for the purpose since they could be supplied as large substrates. Moreover, flexible flat-panel displays could be realized by using the flexible metal-foil substrates. In this work, growth of GaN thin films on various metal-foils is attempted, and their growth mechanisms are compared with the case in which GaN films are grown on quartz glass substrates.

Several metal foils (Ti, Mo, Ta, W, SUS) of 50 μm thickness were selected as substrates for the growth. GaN films were grown by the reactive evaporation method[6]. Gallium beams supplied from a Knudsen cell and N_2 RF plasma existing in the whole chamber space were reacted. Growth rate of the GaN films was about 0.2 μm/h and their growth temperature was varied up to 750℃.

GaN thin films were grown on quartz glass substrates as a comparison. X-ray diffraction patterns of the films are shown in Fig. 1. Diffraction peaks concerning the c-face of the hexagonal GaN and other GaN peaks were observed when the growth temperature was low. On the other hand, highly c-axis oriented GaN films were obtained with increasing of the growth temperature. X-ray diffraction patterns of the films grown on Ti foils are shown in Fig. 2. GaN films were directly grown on the foils in this case. Several diffraction peaks of GaN were similarly observed with the peak of the GaN c-face when their growth temperature was low. However, the several diffraction peaks were still observed even though their growth temperatures increased while the films on quartz glass substrates showed high c-axis orientation.

The surfaces of the metal-foils were relatively rough, and it was considered as a cause of the difference in the crystallinity of the GaN films. Then, Ti thin films were sputter-deposited on the quartz glass substrates by the RF magnetron sputtering method, and GaN thin films were grown on the Ti thin films having quite flat surfaces to confirm it. However, X-ray diffraction peaks other than the c-face peak were still observed though the peak of the c-face became intense as shown in Fig. 3.

Highly c-axis oriented GaN films were not obtained on both the metal-foils and the Ti thin films, surface roughness of the substrates was not a primary cause of the difference. On the other hand, the metal-foils and the Ti thin films were polycrystalline substrates as shown in Fig. 4 while the quartz glass was an amorphous substrate. The difference in crystallinity of the GaN films was probably caused from the difference in crystallinity of the substrates used.

References
1) Y. Sato, N. Takahashi and S. Sato, Jpn.J.Appl.Phys., 35, L838 (1996).
2) Y. Sato, N. Takahashi and S. Sato, Jpn.J.Appl.Phys., 37, L129 (1998).
3) Y. Sato and S. Sato, Jpn.J.Appl.Phys., in press.
4) H. Amano, I. Akasaki, K. Hiramatsu and N. Koide, Thin Solid Films, 163, 425 (1988).
5) S. Nakamura, Y. Harada and M. Seno, Appl.Phys.Lett., 58, 2021 (1991).
6) Y. Sato and S. Sato, J.Crystal Growth, 145, 262 (1995).

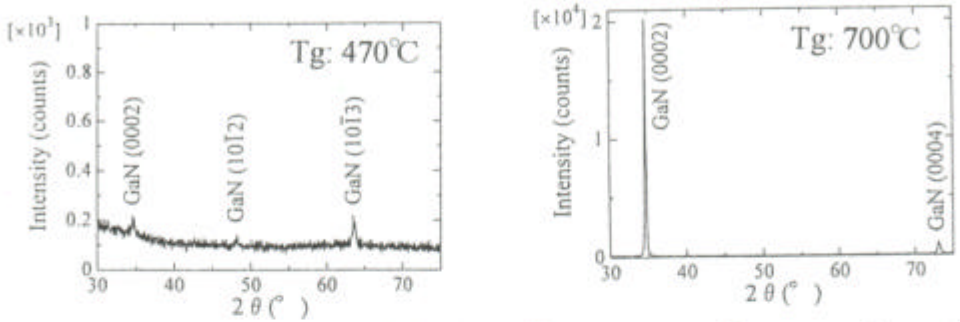

Fig. 1 X-ray diffraction patterns of the GaN films grown on the quartz glass substrates.

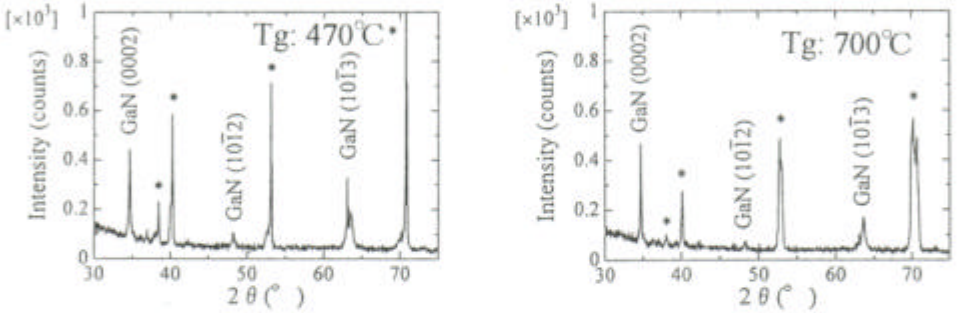

Fig. 2 X-ray diffraction patterns of the GaN films grown on the Ti foil substrates (* Ti).

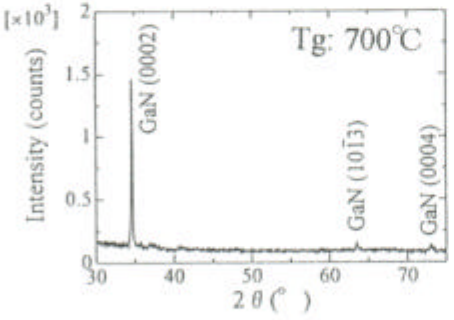

Fig. 3 X-ray diffraction pattern of the GaN film grown on the Ti thin film (on a quartz glass) substrate.

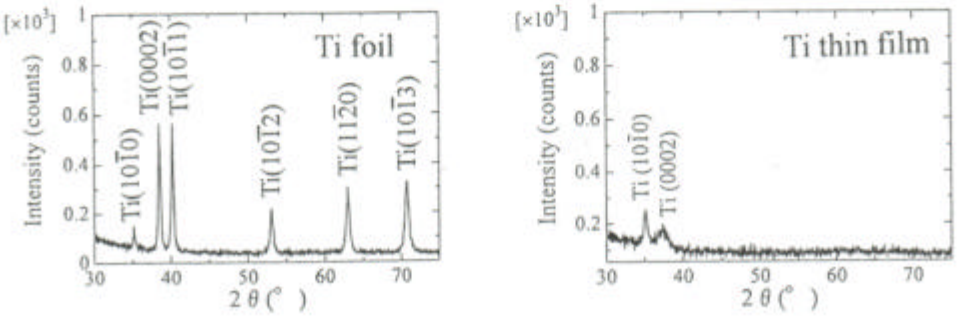

Fig. 4 X-ray diffraction patterns of the Ti foil and Ti thin film substrates.