Neutron detection characterization for BGaN neutron semiconductor imaging sensors

T. Nakano[A], T. Sakurai[A], K. Ando[A], M. Hino[B]

[A]*Sizuoka Univ.*, [B]*Kyoto Univ.*

Recently, neutron detection has been applied in various fields, and the development of neutron detectors that are suitable for widespread neutron detection is expected. BGaN has been proposed and developed as a novel neutron semiconductor detection material. BGaN is a ternary nitride alloy that includes B atoms, and is capable of capturing neutrons and detecting signals in a sensitive layer. Such BGaN detectors have been developed as neutron-detecting semiconductors capable of pseudo-direct detection. BGaN has been developed as a UV LED semiconductor material, but is not currently being developed due to the difficulty of BGaN epitaxial growth. We have developed BGaN epitaxial growth using metal-organic vapor phase epitaxy (MOVPE) for BGaN to function as a neutron-detecting semiconductor, and have achieved the establishment of thick film epitaxial growth technique[1]. Furthermore, the fabrication of a pin diode structure and neutron detection was achieved, indicating the possibility of a BGaN neutron detector[2]. However, sufficient neutron detection characteristics have not been obtained, and understanding the detailed neutron detection behavior in BGaN detectors is important for future development. However, the neutron detection characteristics are not enough, and the understanding of the neutron detection mechanism in BGaN detectors is important for future development. Therefore, BGaN neutron detection characteristics are evaluated by the results of irradiation experiments using monochromatic neutrons and calculation resluts using PHITS code to obtain a direction toward a neutron imaging sensor.

We fabricated pin-BGaN diodes by using metal organic chemical vapor deposition (MOCVD). Growth conditions in MOCVD are described in the following. Ga, B and N source gases are TMGa, TMB and NH_3, respectively. The Mg and Si dopants were used Cp_2Mg and MMSi. 10-μm-BGaN layers were grown under nitrogen atmosphere at a growth temperature of 1000 °C and a growth pressure of 10 kPa. Structure characteristics for BGaN films are evaluated by X-ray diffraction (XRD) and scanning electron (SEM) measurement. Radiation detection characteristics for BGaN detectors are evaluated by energy spectra measurement for each radiation source. ^{241}Am was used in the α-particles irradiation experiment. Neutron irradiation experiments were conducted at MINE-1 in Japan Research Reactor 3 (JRR-3).

Figure 1 shows the energy spectra of 10 μm-BGaN devices under irradiation of neutron and α-particles. As a result, the neutron detection peak was confirmed. The neutron capture peak was obtained for the first time in neutron detection using a BGaN detector, confirming that the BGaN detector is detecting neutrons. The peak profile (peak position and FWHM value) was slightly changed compared to the 2.3 MeV a particle energy spectrum. We are considering the effect of charged particles escaping outside the sensitive layer as the reason of this different. However, further studies are needed to elucidate the details.

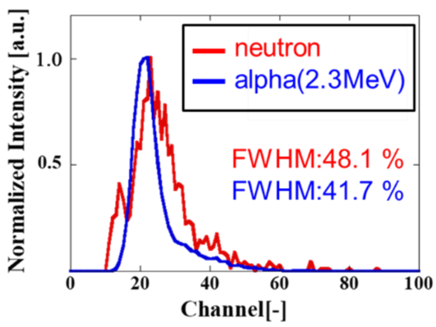

Fig 1. energy spectra of BGaN devices under irradiation of neutron and α particles

[1] K. Ebara *et al.*, Jpn. J. Appl. Phys. **58,** SC1042 (2019)

[2] T. Nakano *et al.*, J. Appl. Phys. **130,** 124501 (2021)