Crystal plane dependence of interface states density in c- and m-plane GaN MOS capacitors

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Owing to its high breakdown electric field and high electron saturation velocity, Gallium Nitride (GaN) is ideal for devices requiring high-power and high-speed operation. In order to realize a normally-off vertical GaN Metal-Oxide-Semiconductor Field Effects Transistors (MOSFETs) for power conversion, the deposition of insulator films, which have high reliability and low interface state density (D_{it}), is required. However, crystal plane dependence of the D_{it} of GaN MOS capacitors has not been understood. Therefore, it is necessary to understand the crystal plane dependence of D_{it} in GaN MOS structure. In this study, we investigated the D_{it} correlations of the c-plane, just m-plane, and off-cut angles of 5° with the [0001] (known as "c+5 degree") m-plane GaN substrate.

The MOS capacitors were fabricated on n-type GaN epitaxial layers, which were grown on n-type c-plane, just m-plane, and c+5° m-plane GaN substrates. The thickness of each epitaxial layer 4 microns. Effective donor concentration of epitaxial layers was 2×10^{16} cm^{-3} from the Capacitance-Voltage (*C-V*) characteristics. For the gate insulator, aluminum oxide (Al_2O_3) was deposited using Atomic Layer Deposition (ALD) at 260°C. The thickness of Al_2O_3 was 50 nm due to the accumulation condition of the *C-V* characteristics. After the fabrication of the gate and back electrode, D_{it} was estimated using the Hi-Lo method at 300K.

From the resulting *C-V* characteristics of GaN MOS capacitors, it was observed that there was a decrease in the hysteresis, flat-band voltage shift, and frequency dispersion of the just m-plane and c+5° m-plane GaN MOS capacitors, when compared to those of the c-plane MOS capacitors. Figure 1 shows the crystal plane dependence of D_{it} using Hi-Lo method. The D_{it} of the m-plane GaN MOS capacitors was found to be in the range 10^{10}–10^{11} $cm^{-2}eV^{-1}$. These results indicate that the ALD-Al_2O_3/m-plane GaN interface can improve the channel mobility of vertical GaN MOSFETs.

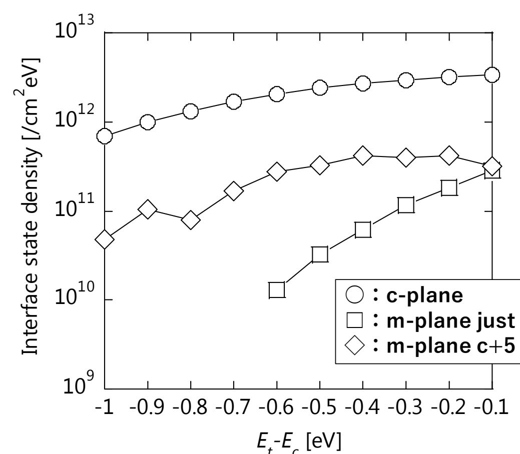

Figure 1 Interface state density of GaN MOS capacitors

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