Reduced Gate Leakage Current in N-polar GaN MIS-HEMTs

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GaN-based high electron mobility transistors (HEMTs) have exhibited a great potential for both of high-power and high-frequency device applications. Due to the III-nitrides' asymmetry in polarity, N-polar GaN HEMTs possesses several potentially advantages over a conventional Ga-polar GaN HEMTs. In the N-polar GaN HEMTs, a two-dimensional electron gas (2DEG) is formed in the topmost GaN layer, which is located above the AlGaN layer. Since this 2DEG is nearer to the gate than Ga-polar, this enables N-polar HEMTs faster switching for realizing the higher cut-off frequency device. The N-polar GaN HEMTs also have an advantage of lower ohmic contact resistances on source and drain electrodes, because the electrodes are deposited on the top GaN layers whereas on the top of AlGaN for Ga-polarity. In this paper, the metalorganic vapor phase epitaxy (MOVPE) of an N-polar GaN/AlGaN/GaN heterostructure on a vicinal sapphire substrate was demonstrated, and the electrical properties of N-polar HEMTs were investigated.

An N-polar GaN/$Al_{0.32}Ga_{0.68}N$/GaN HEMTs structure was grown on a sapphire substrate by MOVPE. The hall mobility (μ) and the 2DEG density (n_s) were 1,124 cm^2/Vs and 1.75×10^{13} cm^{-2}, respectively.

The conventional metal-semiconductor (MES) HEMTs had large leakage current, which was originated from the leakage characteristic of the Ni/GaN Schottky contact as shown in Fig. 1. In order to reduce the gate leakage current, a metal-insulator-semiconductor (MIS) HEMTs in which a 10-nm-thick SiN_x as an insulator was introduced between a Ni gate electrode and a GaN channel layer was fabricated. The leakage current of the N-polar MIS-HEMTs was much lower than that of the N-polar MES-HEMTs as shown in Fig.1. In this MIS-HEMTs, the transfer characteristics were successfully obtained as shown in Fig. 2. The pinch-off voltage was realized to be about −12 V though the operation mode was the normally-on. In conclusion, this work demonstrates the first step in realizing the N-polar devices more promising for high-power and high-frequency device application in microwave and milli-wave region.

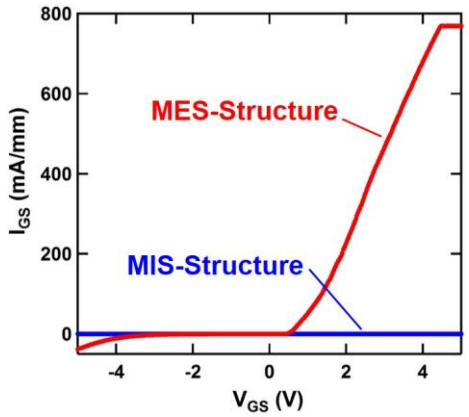

Fig. 1 I-V characteristics of Schottky gate contacts of both MES and MIS structures with N-polarity

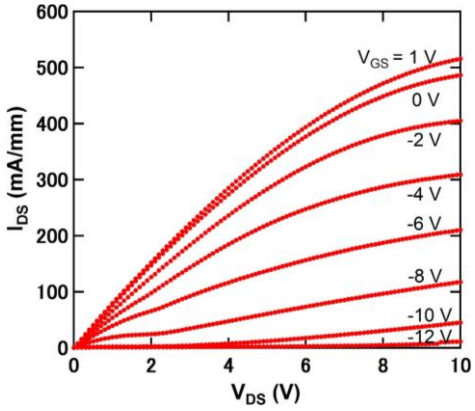

Fig. 2 I_{DS}-V_{DS} characteristics of N-polar GaN MIS-HEMTs