An n^+-InGaAs/n-GaAs Dual-Doped-Channel Heterostructure Field-Effect Transistor (DDC-HFET) Grown by LP-MOCVD

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The characteristics of an InGaAs/GaAs dual-doped-channel (DDC) heterostructure field-effect transistor have been studied. The schematic cross section of the fabricated device is shown in the Fig. 1. The thin n^+-InGaAs and n-GaAs channel layers are employed to increase the effective energy-gap and improve the operation capability under higher electric field, respectively. This can eliminate the impact ionization effect and reduce the leakage current. The upper InGaP layer provides good Schottky characteristics and lower InGaP layer is used to suppress the substrate leakage current through the substrate leakage path. Figure 2 shows the gate-drain current-voltage (I-V) characteristics of the studied device at room temperature. In addition, the reverse gate-drain breakdown voltages BV_{GD} and forward turn-on voltage V_{on}, defined at a gate current level of 0.5 mA/mm, as a function of temperature are revealed, respectively, in the upper and lower inset of Fig. 2. BV_{GD} (V_{on}) value is 24.5 (2.05) at room temperature. Even at a higher temperature of 450 K, the device still shows high BV_{GD} (V_{on}) of 22.0 (1.70) V. The common source I-V characteristics of the studied device measured at different temperatures are shown in Fig. 3. The maximum applied gate-source voltage is V_{GS}=+1.5 V. The device shows good pinch-off and saturation behaviors. The measured threshold voltages V_{th}'s are -1.795 and -1.808 V at room temperature and 450 K, respectively. It is believed that due to the reduction of drain leakage current flowing into the buffer layer and good carrier confinement in the DDC structure, the deviation of V_{th} with increasing temperature is insignificant. The dependence of the frequency response on drain current is demonstrated in Fig. 4. The bias voltage is fixed at V_{DS}=6.0 V. The studied device shows good microwave characteristics and maintains 80% of its f_T and f_{max} peak values over a large range of drain current between 30 to 360 mA/mm. The corresponding gate voltage swing is about of 2.5 V (-1.0 V<V_{GS}<1.5 V). Therefore, the studied device also provides promise for high-frequency applications.

In summary, the characteristics of an InGaP/InGaAs/GaAs DDC heterostructure field-effect transistor have been studied. Experimentally, it is shown that the degradation of device performance with increasing temperature is insignificant. In addition, the studied device also shows good microwave characteristics with flat and wide operation regime. Therefore, the studied device is suitable for high-temperature and microwave circuit applications.

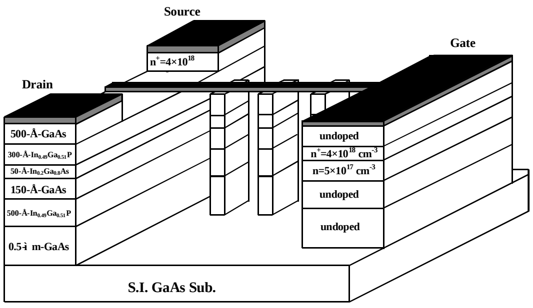

Fig. 1 The schematic cross section of the fabricated device

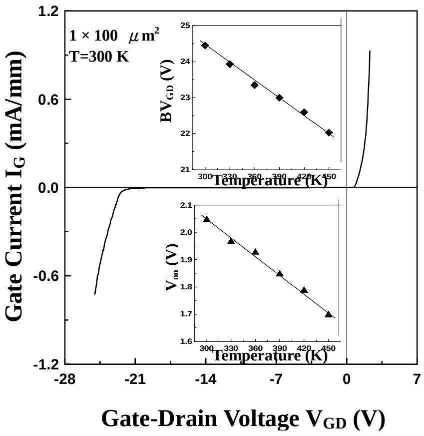

Fig. 2 The gate-drain current-voltage (I-V) characteristics of the studied device at room temperature. The insets show the reverse gate-drain breakdown voltages BV_{GD} and forward turn-on voltage V_{on} as a function of temperature.

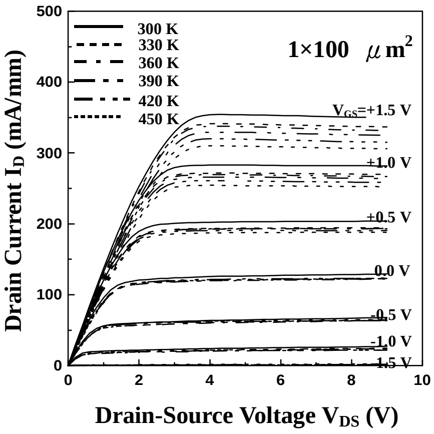

Fig. 3 The common source I-V characteristics of the studied device

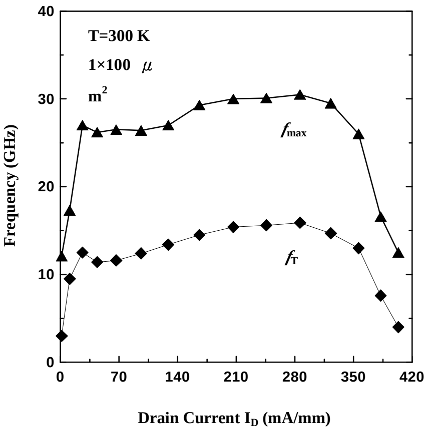

Fig. 4 The dependence of the frequency response on drain current