InGaAs/GaAs Composite Doped Channel Heterostructure Field-Effect Transistor

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INTRODUCTION

There is a growing interest in transistor operating at elevated temperatures due to the industrial requirements for space exploration, automotive, satellite technology and other applications (1). For HFET, the energy bandgap and background carrier concentration are decreased and increased with increasing the operating temperature (2), respectively. This induces the excess leakage current from gate electrode and substrate leakage path. Thus, device performances including Schottky diode characteristics, transconductance, output conductance, and voltage gain are all degraded. To overcome these disadvantages, a novel HFET with composite doped channel structure is presented in this work. Experimentally, the device performances show insignificant degradation with increasing the temperature.

EXPERIMENTAL

The studied device was grown by a low-pressure metalorganic chemical vapor deposition (LP-MOCVD) system on a (100)-oriented semi-insulated (SI) GaAs substrate. The schematic cross section of the studied device is shown in Fig. 1. The mesa etching process was used to etch the wafer into substrate to isolate the devices. The drain-source ohmic contacts were formed on n^+-GaAs cap layer by alloying evaporated AuGe/Ni metals. The gate Schottky contact was achieved by evaporating Au metal on the undoped $In_{0.49}Ga_{0.51}P$ layer. The used gate dimension is 1 × 100 μm².

RESULTS AND DISCUSSION

Figure 2 shows the typical common-source current-voltage (I-V) characteristics of the studied device measured at various temperature. All I-V curves show good pinch-off and saturation characteristics. The V_{th} values are -1.795 and -1.808 V at 300 and 450 K, respectively. The shift of V_{th} from 300 to 450 K is only of 13 mV. The maximum applied gate-source voltage is +1.5 V and no significant gate leakage current is found. This indicates the high turn-on voltage associated with good Schottky behaviors and good carrier confinement are achieved in the studied device. Figure 3 shows the voltage gain A_V (g_m/g_{ds}), transconductance g_m, and output conductance g_{ds} as function of temperature at V_{DS}=6.0 V and V_{GS}=+0.5 V. The device shows high A_V, high g_m, and low g_{ds} at the measured temperature regions. g_{ds} (g_m) values are 0.60 (161), 0.61 (155), 0.61 (151), 0.61 (147), 0.60 (141), and 0.60 (138) mS/mm at 300, 330, 360, 390, 420, and 450 K, respectively. The high A_V of 268, 254, 248, 241, 235, and 230 are obtained at 300, 330, 360, 390, 420, and 450 K, respectively. Therefore, the device shows good amplification performances even at higher temperature.

CONCLUSION

In summary, from the experimental results, the studied InGaAs/GaAs composite doped channel HFET shows the promise for high-temperature circuit applications.

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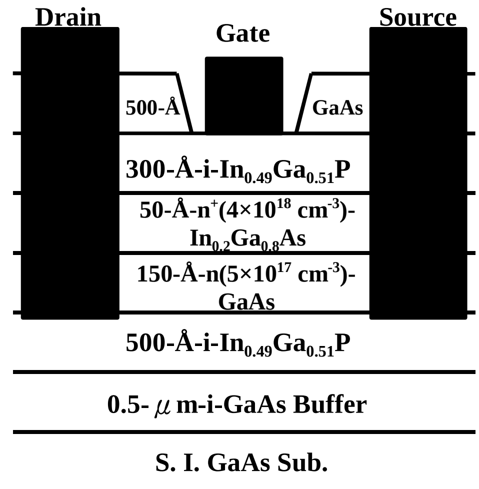

Fig. 1 The schematic cross section of the studied device.

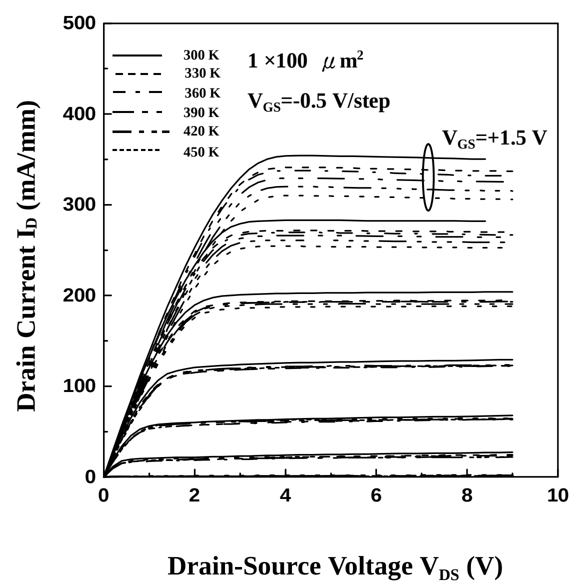

Fig. 2 The common source I-V characteristics of the studied device measured at 300, 330, 360, 390, 420, and 450 K, respectively.

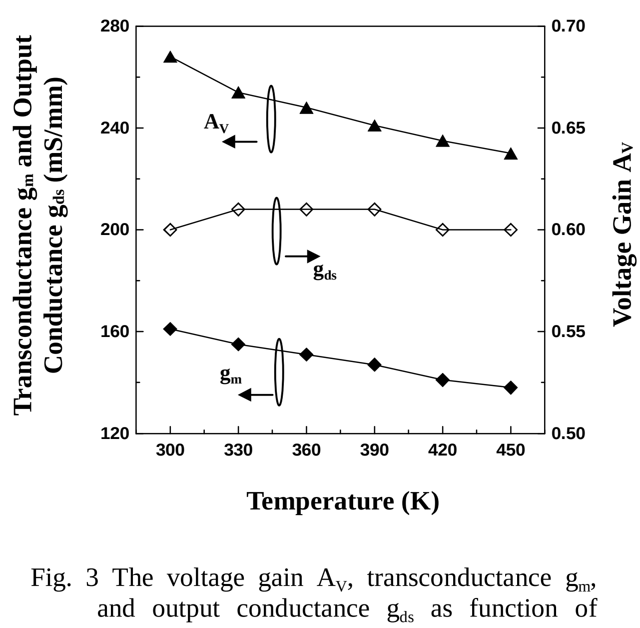

Fig. 3 The voltage gain A_V, transconductance g_m, and output conductance g_{ds} as function of temperature at V_{DS}=6.0 V and V_{GS}=+0.5 V.