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Temperature effects on the Drain Current in GaN Dual-Gate MESFET using Two-Dimensional Device Simulation

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Abstract

Temperature dependence of the GaN-Dual-Gate MESFET (GaN-DGMESFET) DC-characteristics is investigated using two dimensional numerical simulations. Differential equations derived from a Hydrodynamic electron transport model describe the physical proprieties of the device. Simulation results over a wide range of temperature from 300 K to 900 K performed on an industrial software Atlas from SILVACO are presented for a GaN-DGMESFET with a gate length of 0.5 μm. The results show a significant degradation of the DC characteristics. Variation of the electron temperature with the drain-source voltage (Vds) is studied and a large temperature is observed for Vds > 1 V. At low drain-source voltage (Vds < 1 V) the electron temperature is closed to the lattice temperature.

Keywords: *DGMESFET, GaN, Temperature, Steady-state.*

1. Introduction

In recent years, GaN-based field effect transistors (FETs) have emerged as a promising candidate for high power, high temperature microwave applications and power electronics. These devices' impressive performance is due to the material's properties, such as wide band gap, high breakdown field, and high electron saturation velocity [1, 2] and relatively high electron mobility. Because of the relatively higher band gap energy of GaN (3.47 eV at 300 K) the onset of diffusion-dominated leakage currents generally occurs at much higher temperatures than in GaAs. This provides a potential advantage for GaN IC's.

DGMESFET have been commonly used at very high frequency in many different applications such as gain controlled amplifiers, frequency multipliers, phase shifters, stabilised oscillators, power combiners and splitters, [3].

In general, a DGMESFET is basically modelled as a cascade connection of two single-gate MESFET's (SGMESFET) FET_1 and FET_2 as shown in figure 1, where each FET part has a current generator [4]. This configuration improves the output impedance, reduces the feedback capacitance and features a reduction of short-channel effects compared to those observed in single-gate FETs [5].

The temperature effect on the DC characteristics of GaAs DGMESFET for both planar and vertical structures over a wide range of temperature from 250 K to 400 K has been reported [6, 7, 8]. The temperature effects on the DC GaN-DGMESFET characteristics have received a little attention. Indeed, much of the working on the GaN MESFET devices has concentrated their effort on the DC, AC and noise [9, 10].

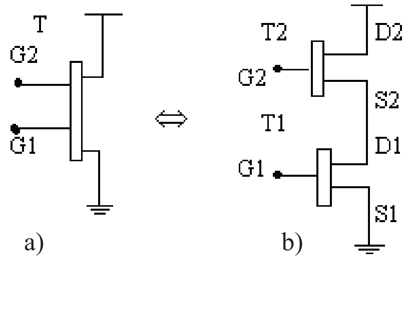

Fig. 1 Symbolic diagram of: (a) DGMESFET, (b) Cascade circuit of two SGMESFET's [4].