1/f Noise Characteristics and High-Frequency Noise Performance of InGaP/InGaAs/GaAs and InGaP/InGaAs/AlGaAs PHEMTs

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Abstract

We have previously compared the DC and RF performance between InGaP/InGaAs/AlGaAs and InGaP/InGaAs/GaAs PHEMTs [1]. In this paper, we will report the study of their respective noise characteristics. The InGaP gate barrier has the advantages of providing an adequate carrier confinement for the channel carriers while eliminating the common problems associated with the AlGaAs barrier. Between the two structures, the InGaP/InGaAs/AlGaAs PHEMTs exhibit better noise characteristics due to a better carrier confinement at the back channel. Our study also demonstrated an unprecedented low-frequency noise performance of PHEMT with an InGaP Schottky barrier.

INTRODUCTION

Transistors with high electron mobility have been widely used in high-frequency and low-noise applications [2-3]. Presently, the Al-free InGaP Schottky layer has shown promises for more reliable operation of the PHEMT devices. Furthermore, recent experimental results from InGaP PHEMTs have indicated the absence of flicker noise [4-5]. In this study, we had explored the use of AlGaAs as the barrier at the back channel interface and compared the differences in both high -and low-frequency noise performance between InGaP/InGaAs/AlGaAs and InGaP/InGaAs/GaAs PHEMTs.

DEVICES AND MEASUREMENT RESULTS

The layer structures of InGaP/InGaAs/GaAs and InGaP/InGaAs/AlGaAs PHEMTs are depicted in Figure 1. Figure. 2, shows the effect of different back barriers on the device noise performance at high frequencies. The minimum noise figure at 12 GHz was measured for devices with different gate lengths, and common bias conditions: Vds=2V; and Ids=100mA/mm. From figure 2, it is seen that InGaP/InGaAs/AlGaAs exhibits a better noise performance at the measurement frequency.

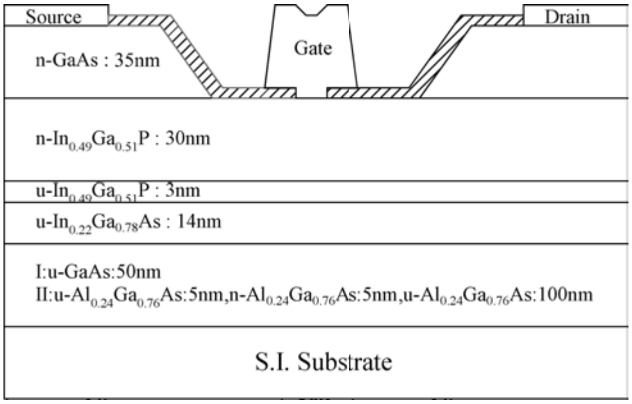

Figure 1: The layer structure of InGaP/InGaAs/GaAs and InGaP/InGaAs/AlGaAs PHEMTs.

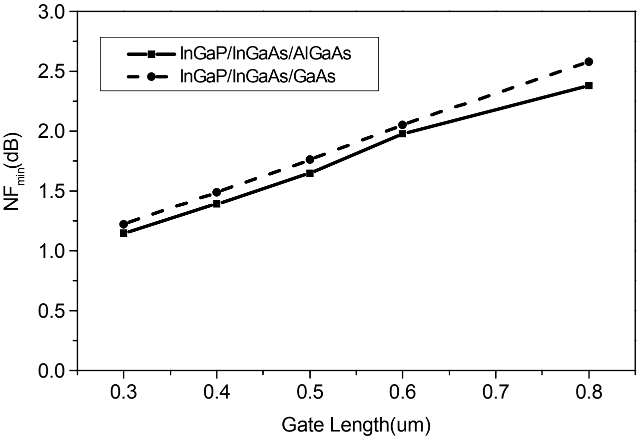

Figure 2: Minimum Noise Figure vs. gate length with device biased at Vds=2V and Ids=100mA/mm.

Figure. 3 plots the respective normalized low-frequency noise spectra of drain current at room temperature for InGaP/InGaAs/GaAs and InGaP/InGaAs/AlGaAs PHEMTs with a drain bias of 50mV, and a gate bias of 0V. The measured low frequency noise spectra density was one of the lowest ever reported. While keeping Vds at 50mV, the noise spectra were measured at 10 Hz by sweeping gate bias from –0.6 to 0.6V for InGaP/InGaAs/GaAs and InGaP/InGaAs/AlGaAs PHEMTs in the linear region, and the results are given in Figure 4.

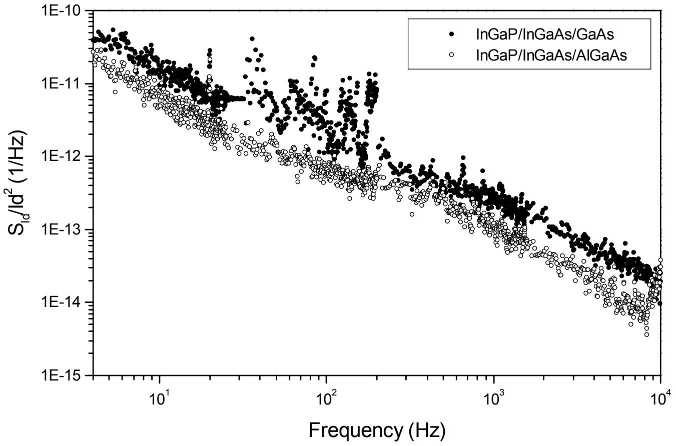

Figure 3: Normalized low-frequency drain current noise spectra for Vds=50mV and Vgs=0V.

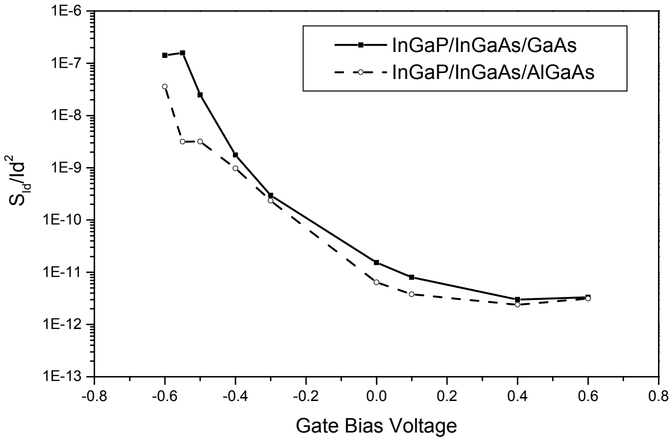

Figure 4:Normalized drain current noise spectral density at 10Hz for Vds=50mV.

From these measured results at both low and high frequencies, InGaP/InGaAs/AlGaAs PHEMTs were found to exhibit better noise performance than InGaP/InGaAs/GaAs PHEMTs, which can be attributed to a better carrier confinement due to elevated barrier at the back channel interface.

CONCLUSIONS

InGaP/InGaAs/AlGaAs PHEMT was shown to exhibits a better noise performance than InGaP/InGaAs/GaAs PHEMT. In addition to this superior noise performance, InGaP/InGaAs/AlGaAs PHEMT is also known to be more reliable under normal operating conditions, and therefore is more suitable for low-cost production and a better candidate technology for microwave communication applications.

REFERENCES

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ACRONYMS

PHEMT: Pseudomorphic High Electron Mobility Transistors.