

1/f Noise Measurement and Theory in GaN HFETs

Peter H. Handel and Shuhan Lin

Department of Physics and Astronomy, University of Missouri-St. Louis
St. Louis, MO 63121

We report investigation of low frequency noise through measurement of heterostructure field effect transistors (HFETs) grown on various substrates, SiC, Sapphire, and HVPE. The experimental results are discussed and are compared with the quantum theory of 1/f noise.

Low frequency noise can be described in terms of resistance fluctuations, dR/R . If the current in a circuit is held constant, dR/R equals the fractional voltage fluctuations dV/V at the end of samples or device under study. We denoted the spectral density of fractional resistance fluctuations with $S_{dR/R}(f) = R^{-2} \langle (dR)^2 \rangle_f$. The main experimental results are:

(1). At $V_g = 0$, the lowest $S_{dR/R}(f)$ was measured for a HFET on the SiC substrate with $S_{dR/R}(f) = 3.9 \cdot 10^{-13}$, followed by with $S_{dR/R}(f) = 2.0 \cdot 10^{-11}$ on Sapphire, and the noisiest, with $S_{dR/R}(f) = 7.8 \cdot 10^{-11}$ on HVPE.

(2). When V_g changes from 0 volt to -3.0 volts for HEFT on SiC, the $S_{dR/R}(f)$ increases from $1.24 \cdot 10^{-12}$ to $1.64 \cdot 10^{-10}$, about two orders of magnitude.

Agreement between the experimental values and the theory values is remarkable. This research also indirectly proves that increasing the device channel width is very effective for decreasing the low frequency noise. This is very important for high power density microwave generation.

The apparatus is in Fig. 1 below, a typical spectrum and background in Fig. 2.

SYNOPSIS

<u>Substrate</u>	<u>R_{DS}/Ω</u>	<u>V_{DS}/V</u>	<u>$fS_{dR/R}$</u>	<u>α_{exp}</u>	<u>α_{theor}</u>
HVPE					
STD3	36	0.9	7.8E-11	9.99E-5	3.0E-5
Sapphire					
STD7	20.5	0.27	2.0E-11	2.06E-5	2.7E-5
SiC					
STD12	37.3	0.53	3.9E-13	2.69E-7	1.5E-7
STD4	40.4	2.1	1.24E-12	7.92E-7	3.3E-6

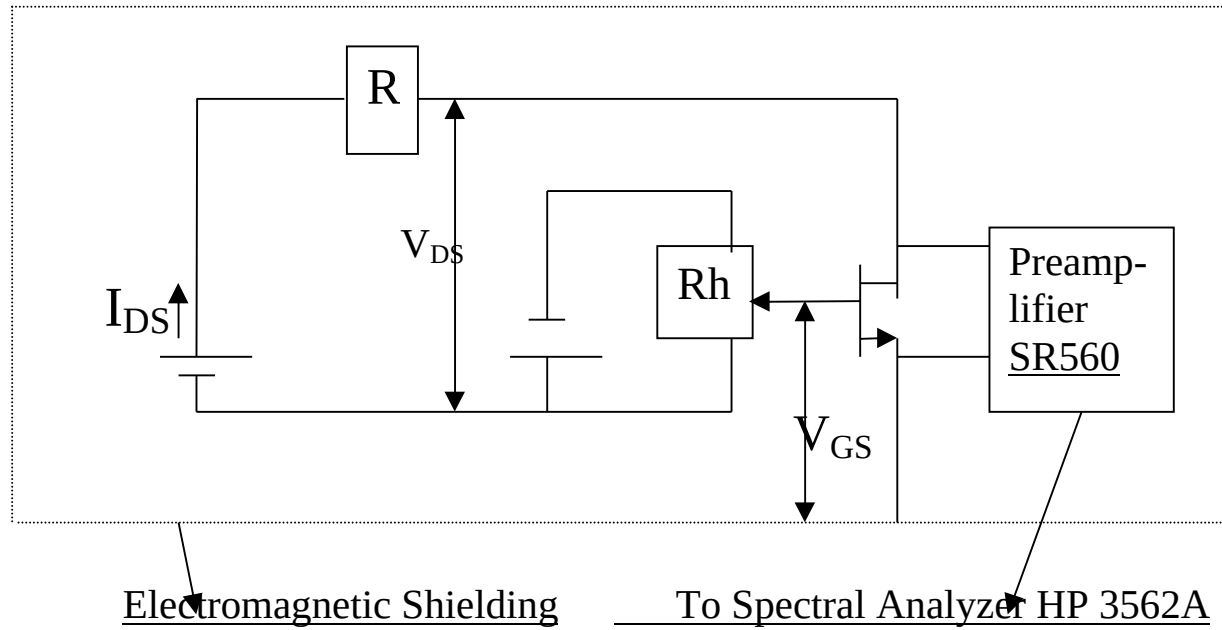


Fig. 1: Experimental Set-Up

As shown in Fig. 1, the gate voltage V_G of the device under test is controlled with a Rheostat Rh . The devices were open, i.e., not capped. They were never touched in any way.

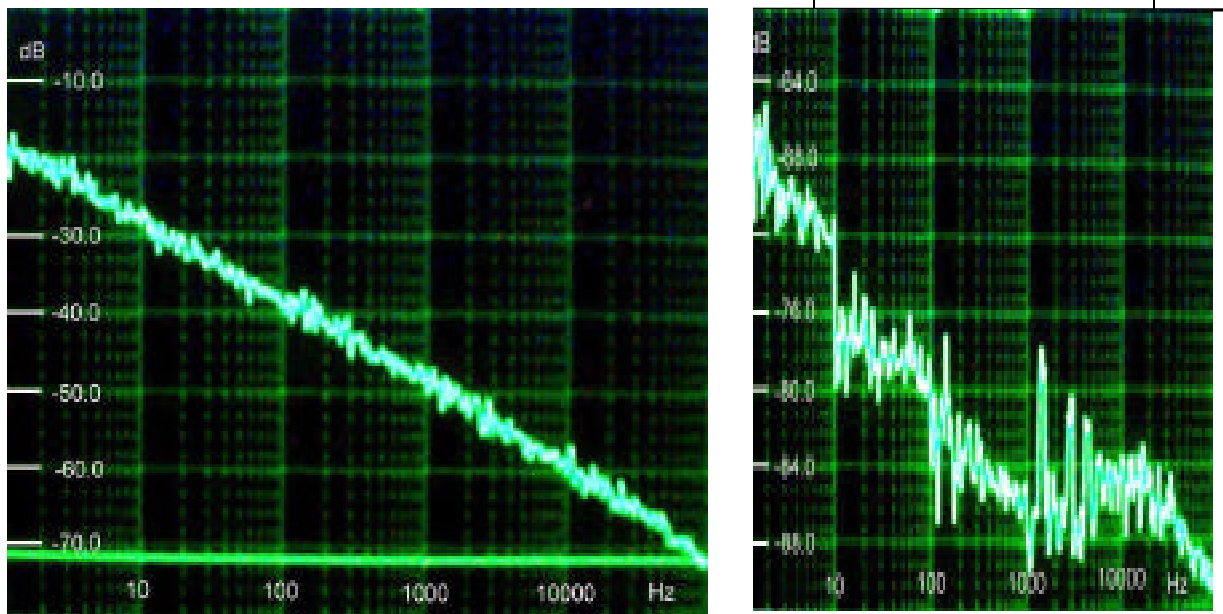


Fig. 2: Typical $1/f$ noise spectrum of the HFET channel, with much lower background on the right.