# 1/*f* Noise in GaN-Based HFETs: Is It Tunneling?

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The level of the low frequency noise ($10^0$–$10^4$ Hz). is one of the most important characteristics of devices used in microwave ($10^9$ Hz - $10^{12}$ Hz) and optical ($10^{13}$ Hz - $10^{15}$ Hz) communication systems. The low-frequency noise level upconverts into phase noise that limits performance of oscillators, mixers, and other systems.

Gallium nitride-based electronic devices, especially AlGaN/GaN high-mobility transistors (HFETs), are now at the forefront of the semiconductor research because of their potential for high temperature, power, frequency, and radiation hard applications. A major challenge is to develop techniques reducing the low frequency noise in these devices. To meet this challenge requires a clear understanding of the nature of the 1/*f* noise in these structures.

Attempts to explain the nature of the 1/*f* noise in AlGaN/GaN HFETs involve three different mechanisms. All three deal with a rather amazing fact that the noise in AlGaN/GaN HFETs fabricated on thin GaN films is two to three orders of magnitude smaller than the level of the 1/*f* noise in these GaN films prior to HFET fabrication. The first mechanism links 1/f noise to the occupancy fluctuations of the tail states near the band edges.[1] The second mechanism involves fluctuations in the space charge regions surrounding dislocations (either mobility fluctuations or fluctuations of the depletion region width), which modulate the resistance of the channel and cause 1/*f* noise.[2] Our experimental data support a third mechanism involving the electron tunneling from the 2D gas into the traps in the adjacent GaN or AlGaN layers.[3]

Four main arguments support this mechanism:

- very weak temperature dependence of the 1/*f* noise in the 8–300 K temperature interval;
- behavior of spectral noise density of the drain current fluctuations, $S_I$, close to the saturation voltage, which can be explained by the tunneling mechanism of noise;
- observed temperature dependence of noise in the doped channel AlGaN/GaN HFETs, which is again explained by the tunneling model;
- The concentration dependence of the Hooge parameter typical for noise caused by the electron tunneling.

Based on this tunneling mechanism, we will discuss different device designs for reducing low frequency noise in GaN-based HFETs.

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1 M. E. Levinshtein, F. Pascal, S. Contreras, *et al.* "Low-frequency noise in GaN/GaAlN heterojunctions", *Appl. Phys. Lett.* **72**, 3053 (1998).

2 J. A. Garrido, B. E. Foutz, J. A. Smart, *et al.* "Low-frequency noise and mobility fluctuations in AlGaN/GaN heterostructure field-effect transistors", *Appl. Phys. Lett.* **76,** 3442 (2000).

3 S. L. Rumyantsev, Y. Deng, *et al.* "Low frequency noise in GaN/AlGaN heterostructure field effect transistors at cryogenic temperatures", *J. Appl. Phys.* **92**, 4726 (2002).