actually upward bent at the ungated surface, so the occupancy of trap levels sufficiently close to $E_C$ can be appreciably modulated by the gate-source voltage.

In conclusion, we have shown experimental and numerical results linking the gate-lag characteristics of microwave power AlGaN/GaN HETs with the presence of acceptor-like surface states located over the gate-drain depletion region. Our study of both fresh and hot-carrier-stressed devices has provided a novel insight into the high-field degradation and robustness issues, which represent one of the main reliability bottlenecks for state-of-the-art microwave power amplifier technologies.

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Thin n-GaN films with low level of 1/f noise
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The authors report on the results of measurements of low frequency noise in thin (60 nm) Si-doped n-type gallium nitride (GaN) films grown on sapphire. At room temperature, the noise spectra have the form of 1/f noise with a Hooge parameter $\alpha = 2 \times 10^{-3}$. This value of $\alpha$ is three orders of magnitude smaller than that observed before in thin films of n-GaN.

Introduction: Gallium nitride (GaN) has an excellent potential for high temperature, high frequency, and high power microwave applications. The level of the low-frequency noise is one of the most important parameters, which determines whether the devices are suitable for microwave and optical communication systems. The authors of [1–4] presented the first reports on the low-frequency noise in thin (≤ 1 μm thick) GaN films. The estimated Hooge parameter, $\alpha$, was very high ($\alpha = 3–5$). This value is comparable with the values of $\alpha$ for such disordered materials as conducting polymers [5]. Much lower magnitudes of $\alpha (5 \times 10^{-4})$ were reported in [6] for 20μm thick films with an electron mobility of 790 cm$^2$/Vs at 300 K and with a mobility temperature dependence $\mu(T)$ close to that predicted by theory [7]. However, all modern GaN and GaN/GaNAlN devices (photoreceivers, HEMTs, MOSFETs) are based on thin epilayers with a thickness of less than approximately 1μm, which is why the level of low-frequency and 1/f noise in thin GaN layers is especially important for device applications.

In this Letter, we report on GaN thin (60 nm thick) layers with magnitude of a Hooge parameter $\alpha$ of approximately $2 \times 10^{-3}$. This value of $\alpha$ is three orders of magnitude smaller than that observed before in thin films of n-GaN.

Experimental details: The structures were grown by low-pressure MOCVD on (0001) sapphire substrates. The deposition of approximately 2μm of nominally undoped GaN was followed by the growth of an Si-doped GaN layer. The thickness and doping level of that layer (extracted from the capacitance-voltage characteristics) were ~60 nm and $10^{18}$ cm$^{-3}$, respectively. The electron Hall mobility was close to $\mu = 100 \text{ cm}^2/\text{Vs}$ at 300 K. The transmission line model (TLM) structures and GaN MESFETs [8] were fabricated on the same wafer. A low-frequency noise measurement was performed in the frequency range from 1 Hz to 100 kHz with the sources grounded. All measurements were made in the linear (ohmic) regime.

Fig. 1 Relative spectral noise density $S_n/f$ against distance $L$ between pads of TLM structure

Frequency of analysis $f = 200$ Hz

Results and discussion: The noise spectra $S_n/f$ were measured with TLM, and MESFET structures have the form of 1/f noise with $\Gamma$ close to unity ($\Gamma = 1.0–1.15$). At low drain biases, the spectral noise density of the drain current fluctuations $S_d/I_d$ was proportional to the square of the drain voltage $S_d/V_d^2$. The standard measurements using TLM structures showed that the contact resistance $R_c$ was negligible compared with the channel resistance.

To determine the contribution of the contact noise to the measured noise spectra, the noise measurements were performed on the TLM structures with distance, $L$, between the TLM pads ranging from 2 to 20μm (see Fig. 1). The experimental points in Fig. 1 represent the dependence of the relative spectral noise density $S_n/I$ in $L$ at the frequency of analysis $f = 200$ Hz. If the contact resistance is much smaller than the resistance of the GaN layer, the spectral noise density of the current fluctuations $S_n/I$ should be proportional to $1/L^2$ when the contact noise is dominant. When the bulk noise is dominant, $S_n/I$ should be proportional to $1/L^3$ [9]. Since the experimental dependence is close to the $1/L$ law, we conclude that the contacts do not contribute much to the noise. The $\alpha$ value estimated from TLM measurements is equal to $10^{-3}$.

Fig. 2 shows the temperature dependence of noise for one of the MESFETs. As seen from the Figure, the weak noise maxima shifted to higher temperatures at higher frequencies. This behaviour is typical for generation-recombination (g-r) noise [10]. However, the contribution of g-r noise was too weak compared to the 1/f noise in order to extract the local level parameters.
The value of the Hooge parameter $\alpha$ estimated for MESFETs was the same order of magnitude as for TLM structures, $\alpha = (2-3) \times 10^{-3}$. This value of $\alpha$ is three orders of magnitude smaller than that reported for thin GaN films earlier [1–4]. We also found that the value of $\alpha$ in MESFETs does not depend on the gate voltage $V_G$, i.e., on the channel volume (thickness). Since $\alpha$ does not depend on the device geometry and volume, we conclude that the 1/f noise in thin GaN films is of bulk origin. Note that electrons in these GaN films are not degenerate, since the electron density of states in GaN at room temperature $N_c = 2.2 \times 10^{19}$ cm$^{-3}$ (i.e., larger than the electron concentration).

Fig. 2 Temperature dependence of noise $S_f/\nu$ for MESFET at different frequencies of analysis

Conclusion: Measurements of low-frequency noise in GaN TLM and MESFET structures fabricated on 60nm thick film have shown that, at room temperature, the noise has the form of 1/f-like noise. The temperature dependence of the noise shows the weak contribution of generation-recombination noise at elevated temperatures. The Hooge parameter $\alpha$ for TLM structures and MESFETs is approximately the same and does not exceed $\alpha = (2-3) \times 10^{-3}$. This value of $\alpha$ is three orders of magnitude smaller than that reported for thin GaN films earlier and is of the same order of magnitude as for GaN/AlGaN HFETs. In GaN MESFETs, $\alpha$ does not depend on the gate voltage, indicating that the noise originates in the bulk.

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References

Adaptive minimum-BER linear multiuser detection for CDMA signals in multipath channels with 4-QAM constellation

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An adaptive minimum-BER linear multiuser detector called the least BER (LBBER) algorithm, originally developed for BPSK modulation, is extended to 4-QAM modulation.

Introduction: The design of linear multiuser detectors is often based on the minimum mean square error (MMSE) principle. Adaptive MMSE detectors can readily be implemented using the LMS algorithm [1]. However, it is well known that the MMSE solution can in certain cases be distinctly inferior to the optimal minimum bit error rate (MBER) solution. Adaptive MBER linear multiuser detectors have recently been developed [2, 3]. These two adaptive MBER multiuser detectors were inspired, respectively, by the two adaptive MBER linear equalisers called the approximate BBER (AMBER) algorithm [4] and the LBER algorithm [5], and they are both designed for a binary signalling scheme. Previous studies [3, 5] have shown that the LBER algorithm performs better than the AMBER algorithm in terms of convergence speed and steady-state BER. We extend the LBER detector to complex-valued signalling schemes. The 4-QAM modulation scheme is used for this extension.

Fig. 1 Discrete-time model of synchronous CDMA downlink

System model: The discrete-time model of the synchronous CDMA downlink system with $N$ users and $M$ chips per symbol is depicted in Fig. 1, where $b_{i}(k) = b_{i}(k) + b_{i}(k) = [\{1 2 \cdots M\}]^{T}$ denotes the $i$th symbol of user $i$, the unit-length spreading code for user $i$ is $s_{i} = [s_{i}(1) \cdots s_{i}(M)]^{T}$, and the channel impulse response (CIR) is defined by $C_{i}(z) = c_{0} + c_{z}z^{-1} + \cdots + c_{M-z}z^{-M}$ with $[c_{i}]$ denoting the complex-valued channel taps. The received signal sampled at the chip rate is given by

$$ r(k) = \mathbf{P} \begin{bmatrix} b(k) \\ b(k-1) \\ \vdots \\ b(k-L+1) \end{bmatrix} + \mathbf{n}(k) = \bar{r}(k) + n(k) \quad (1) $$

where the complex Gaussian channel noise vector $\mathbf{n}(k) = [n_{1}(k) \cdots n_{M}(k)]^{T}$ with $E[n_{i}(k)n_{i}^{*}(k)] = 2\sigma_{n}^{2}I$, $b(k) = [b_{1}(k) \cdots b_{M}(k)]^{T}$ is the