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Compact Modeling of Flicker Noise in HEMTs

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ABSTRACT In this paper, we present a physics-based compact model for low frequency noise in high electron mobility transistors (HEMTs). The model is derived considering the physical mechanisms of carrier number fluctuation and mobility fluctuation in the channel. The model is tunable and hence applicable to a wide range of HEMT devices of different geometries and construction. The model is in excellent agreement with experimental data and TCAD simulations.

INDEX TERMS HEMT, flicker noise, noise model.

I. INTRODUCTION

AlGaAs/GaAs based High Electron Mobility Transistors are widely used in RF circuits while Gallium Nitiride based HEMTs have recently emerged as very promising candidates for high-power and high frequency applications due to their excellent material properties. One of the important property of these devices is low noise compared to MOSFET [1], [2]. Advanced circuit design with these devices requires accurate compact models, specially for noise, considering their applications in low noise circuits. The compact models for these devices have evolved from empirical models [3] to threshold voltage-based models [4] and further to the recently reported surface-potential-based compact models [5], [6]. Although [5] and [6] accurately describe the current and capacitance characteristics of the device in terms of the surface-potential, they do not include the flicker noise behavior of the device in terms of surface-potential. There are several reports on flicker noise characterization in literature [7]–[10] but little effort has been put in modeling. Earlier, Bonani *et al*. [11], [12] demonstrated a CAD-oriented HEMT model using numerical charge control method; Laloue *et al*. [13] showed measurement based nonlinear distributed approach and Ziel *et al*. [14] used equivalent circuit approach for flicker noise modeling. Recently [15] presented black-box model approach for the same. Here, we present a surface-potential-based flicker noise model for HEMTs. Our model is derived considering the physical mechanisms of mobility fluctuation and carrier number fluctuation in the device. We have used a consistent solution of the Schrodinger's and Poisson's equations, considering the first two important energy levels [16] to calculate the bias dependance specifically for HEMTs. The model is in excellent agreement with TCAD simulations and measured data.

This paper is arranged as follows. In Section II, we present the derivation of flicker noise model. In Section III, we present the model correlation with TCAD and experimental data. In Section IV, we conclude our paper.

II. FLICKER NOISE MODEL

The main problem in flicker noise modeling is that the cause of the phenomenon is not properly understood and still debated. It has been reasoned that the flicker noise is due to the fluctuation of the effective resistance (channel). This can be caused either by charge fluctuation and/or by mobility fluctuation. These two possibilities give rise to the two competing theories of carrier number fluctuation and mobility fluctuation respectively. The first states the fluctuation in the number of carriers in the channel as the cause [17], while the second attributes the noise to mobility fluctuations due to carrier interaction with the lattice vibrations [18]. There exists models for MOSFETs that unify the two theories by correlating the two sources to get a unified low frequency noise model [19]. We have extended this approach to the case of HEMTs and come up with a model for flicker noise for the same.

Charge trapping in HEMT and their influence on device characteristics are complicated and has been under investigation by several groups [7], [10], [17], [20]–[23]. Assuming probability of tunneling of an electron to a trap site decreases exponentially with the distance of the trap from the channel, we get power spectral density (PSD) of the mean square fluctuations in number of occupied traps as [24], [25]

$$S_N(f) = N_t \frac{kT}{N_{P_t} f^{EF}} \tag{1}$$

where N_t is the concentration of traps (in cm^{-2}), k is the Botlzman constant and T denotes the temperature in Kelvin. The N_{P_t} factor comes from tunneling probability and EF is a modeling parameter. The drain current noise PSD is then given by

$$S_{if}(f) = \frac{S_N(f)}{WL^2} \int_0^L \left(\frac{\partial I_{DS}}{\partial N_t}\right)^2 dx \tag{2}$$

Denoting the 2DEG charge in the channel as Q, we can write the fluctuation in the carrier density caused by the fluctuation in the trapped electron density as

$$R = \frac{1}{q}\frac{\partial(-Q)}{\partial N_t} \tag{3}$$

R varies with applied biases and the calculation of the exact expression for R is shown in the appendix. The drain current I_{DS} is given as [5]

$$I_{DS} = \mu W(-Q(x))\frac{\partial \psi}{\partial x} \tag{4}$$

$$\partial I_{DS} = \mu W(-Q)\frac{\partial \psi}{\partial x}\left[\frac{1}{-Q}\frac{\partial(-Q)}{\partial N_t} \pm \frac{1}{\mu}\frac{\partial \mu}{N_t}\right]\partial N_t \tag{5}$$

$$\partial I_{DS} = I_{DS}\left[\frac{qR}{-Q} \pm \frac{1}{\mu}\frac{\partial \mu}{\partial N_t}\right]\partial N_t \tag{6}$$

The $+$ or $-$ sign depends on whether a trap is neutral or charged when filled, which will increase or decrease mobility.

By including the dependence of mobility on the occupied trap density, we have incorporated the mobility fluctuations in our unified low frequency noise model. Therefore, we can get the accurate noise PSD from (7) where $P(f) = \frac{kT}{N_{P_t} WL^2 f^{EF}}$. However, from a compact modeling point of view, it is very important that the model be robust and efficient computationally and tunable for a wide range of devices. For this, the term $\frac{q^2R^2}{N_{P_t}} N_t \left[1 \pm \frac{1}{\mu}\frac{\partial \mu}{\partial N_t}(\frac{-Q}{qR})\right]^2$, which is a quadratic in $-Q$ is approximated as $\Gamma_1 + \Gamma_2(-Q) + \Gamma_3(-Q)^2$ where Γ_1, Γ_2, Γ_3 are parameters which can be used to tune the model for different HEMT device technologies. Here, we have assumed R to be a constant to make the model derivation simpler.

TABLE 1. Relevant parameter values [5].

Parameter	Description	Value
EF	Flicker noise parameter	0.99
Γ_1	Flicker noise Parameter	-3.18×10^{33}
Γ_2	Flicker noise parameter	2.24×10^{34}
Γ_3	Flicker noise parameter	2.11×10^{34}
V_{off}	Cut-off voltage	-2.7
U0	Mobility Parameter	41×10^{-3}
UA	Mobility degradation co-efficient (1/V)	1×10^{-10}
v_{sat}	Saturation velocity	2×10^5
ETA0	DIBL Parameter	20×10^{-3}

The 2DEG charge (-Q) is given by $C_g(V_{go} - \psi)$, where C_g is the gate capacitance and $V_{go} = V_g - V_{off}$. Also from [16],

$$dx = \frac{L(V_{go} - \psi + V_{th})d\psi}{(V_{go} - \psi_m + V_{th})(\psi_d - \psi_s)} \tag{10}$$

where $\psi_m = \frac{\psi_d + \psi_s}{2}$ and V_{th} is the thermal voltage. Using (10) we can write the noise PSD as (8), where $K_r = L/\left[(V_{go} - \psi_m + V_{th})(\psi_d - \psi_s)\right]$ and $P_1(f) = N_{P_t}P(f)$. Eq. (8) can be easily integrated to get the total noise PSD (S_{if}) given by (9), where $-Q_d$ and $-Q_s$ represent the charge densities at the drain and source ends, respectively.

III. RESULTS AND DISCUSSION

The noise PSD is plotted as a function of frequency and bias voltages, and is compared with the data obtained from TCAD simulations as well as measurement. Values used for relevant parameters are given in Table I.

A. VALIDATION WITH TCAD

A TCAD device with $L_G = 0.5\mu m$ and gate-drain and gate-source lengths of $1\mu m$ each was used for the simulation as shown in Fig. 1.

It is known that due to the trapping/de-trapping process, each trap gives rise to a Lorentzian spectrum of form [19]

$$S_N(f) = \frac{4\overline{\Delta N}^2 \tau_t}{1 + \omega^2\tau_t^2} \tag{11}$$

where $S_N(f)$ denotes the PSD of the fluctuation in the number of carriers, $\overline{\Delta N}^2$ is the variance of the number of carriers, and τ_t is the associated lifetime of carriers. The sum of lorentzian spectra of all the traps, gives rise to an overall approximate $\frac{1}{f}$ characteristic. This is the basis of the McWhorter model. If we also assume fluctuation in mobility as suggested by Hooge, we get an overall $\frac{1}{f^\alpha}$ characteristic similar to what is observed in MOSFETs. As a result, the frequency dependent part of the model is quite similar to that of MOSFETs.

$$S_{if}(f) = P(f)I_{DS}^2 \int_0^L N_t \left[1 \pm \frac{1}{\mu}\frac{\partial \mu}{\partial N_t}\left(\frac{-Q}{qR}\right)\right]^2 \left(\frac{qR}{-Q}\right)^2 dx \tag{7}$$

$$S_{if}(f) = P_1(f)I_{DS}^2 \frac{K_r}{C_g^2} \int_{-Q_s}^{-Q_d} \frac{[\Gamma_1 + \Gamma_2(-Q) + \Gamma_3(-Q)^2][V_{th}C_g - Q]}{(-Q)^2} d(-Q) \tag{8}$$

$$S_{if}(f) = P_1(f)\frac{I_{DS}^2 K_r}{C_g^2}\left[\Gamma_1 V_{th}C_g\left(\frac{1}{Q_d} - \frac{1}{Q_s}\right) + (\Gamma_1 + \Gamma_2 V_{th}C_g)ln\left(\frac{Q_d}{Q_s}\right) + (\Gamma_2 + \Gamma_3 V_{th}C_g)(-Q_d + Q_s) + \frac{\Gamma_3}{2}(Q_d^2 - Q_s^2)\right] \tag{9}$$

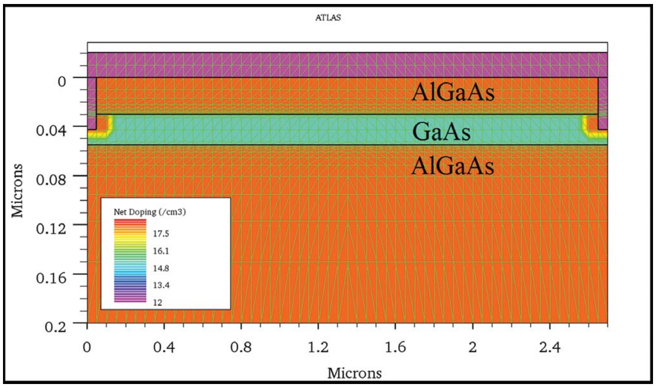

FIGURE 1. **TCAD device with $L_G = 0.5\mu m$ was used with gate-drain and gate-source lengths of $1\mu m$ each.**

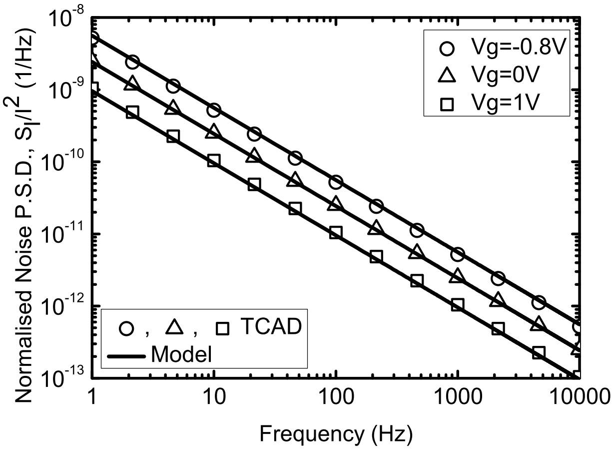

FIGURE 2. **Normalised noise spectral density versus frequency ($L_G = 0.5\mu m$; $L_{SG} = L_{DG} = 1\mu$m; $V_g = -0.8V, 0V, 1V$; $V_d = 0.5V$). TCAD device shown in Fig. 1 is used. The simulations follow the expected linearly decreasing trend with frequency. The normalised noise P.S.D. decreases with increasing gate voltage which is validated by Fig. 3.**

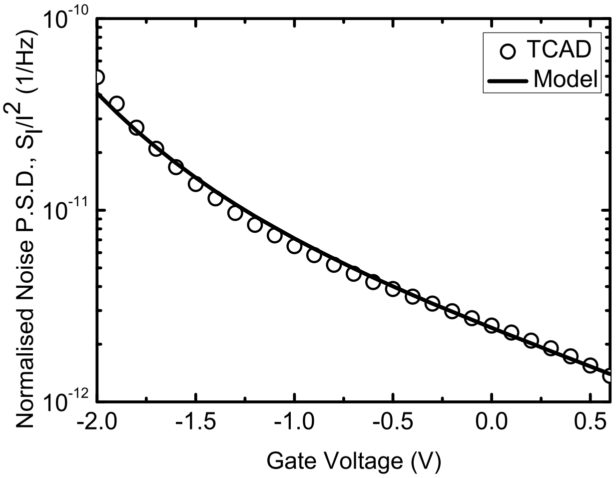

FIGURE 3. **Normalised noise spectral density versus gate bias ($L_G = 0.5\mu m$; $L_{SG} = L_{DG} = 1\mu m$; *frequency* $= 1KHz$; $V_d = 0.5V$). TCAD device shown in Fig. 1 is used. Although the noise P.S.D. increases with gate voltage, the increase in I_{DS} is faster, resulting in the decreasing trend of the normalised noise P.S.D.**

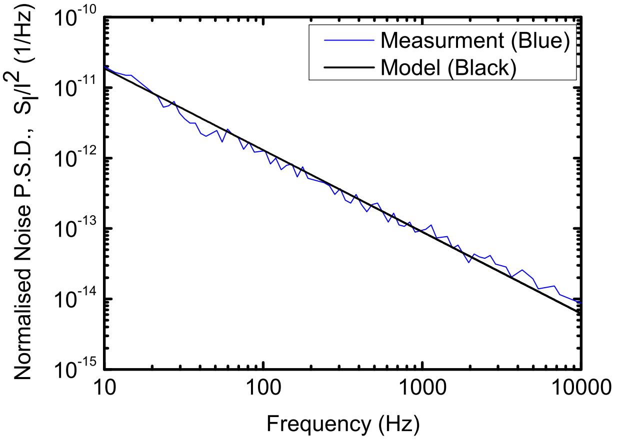

FIGURE 4. **Normalised noise spectral density (1/Hz) versus frequency ($V_{gs} - VOFF = 1V$, $V_d = 1V$). Measured data is for a $0.7\mu m$ *GaN* device with $EF = 1.15$ [8]. The expected trend with frequency is followed.**

The plots for HEMT obtained from the proposed model and TCAD simulations are shown in Fig. 2.

Experiments show that applying a large gate voltage induces an increase in number of traps getting filled and hence increases flicker noise [19]. However, with increasing gate voltage, the increase in drain current overpowers the increase in the noise resulting in an overall decreasing curve for the normalised noise PSD ($\frac{S_{if}}{I_{DS}^2}$). This can be seen in the variation of the normalised drain current noise PSD with gate bias as shown in Fig. 3, which illustrates the excellent matching between the TCAD data and the proposed model.

B. VALIDATION WITH EXPERIMENTAL DATA

Since TCAD only takes the Hooge model into account, and is not very accurate, we have also validated the model with real measured data from both GaN and GaAs devices. The comparison of the model and the measured flicker noise for a $0.7\mu m$ GaN device [8] is shown in Fig. 4. The increasing trend of the flicker noise with increasing gate voltage is clearly shown in Fig. 5. The figure uses measured data from an $1\mu m \times 50\mu m$ $GaN/Al_{0.15}Ga_{0.85}N$ device [9] which matches well with our model.

The frequency dependance of the noise PSD for our model match very well with the measurement from a $0.13\mu m \times 0.93\mu m$ GaAs HEMT [26] as is shown in Fig. 6. Fig. 7 shows the variation of the normalised drain current noise PSD with gate bias for measured data from a $1.7\mu m$ $AlGaAs/InGaAs$ device [7] and the corresponding match using our proposed model.

IV. CONCLUSION

A surface-potential-based flicker noise model for HEMTs is presented. The model is derived considering the two physical mechanisms of flicker noise: mobility fluctuation and carrier number fluctuation, with suitable approximations. The model has one parameter (EF) to tune the variation with frequency and only three parameters ($\Gamma_1, \Gamma_2, \Gamma_3$) for tuning the variation with applied biases, much like the widely accepted

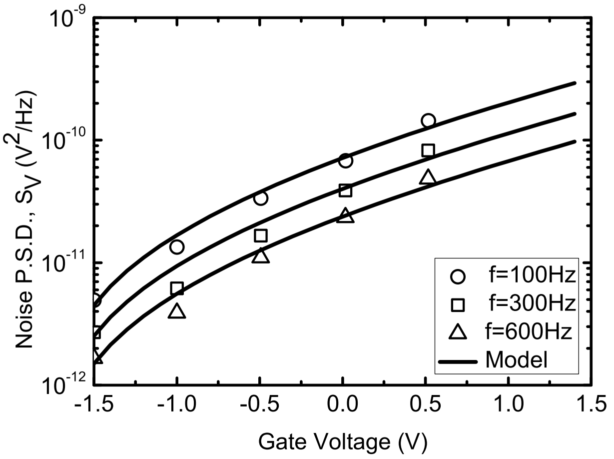

FIGURE 5. **Noise spectral density versus gate bias (*freq* = 0.1*KHz*, 0.3*KHz* and 0.6*KHz*; $V_d = 0.5V$; $\Gamma_1 = 6e14$, $\Gamma_2 = -1.6e14$, $\Gamma_3 = -2.4e19$). Measured data is for a 1μm × 50μm *GaN/Al$_{0.15}$Ga$_{0.85}$N* device [9]. This clearly shows the increase in flicker noise due to increasing gate voltage which induces an increase in the number of traps getting filled.**

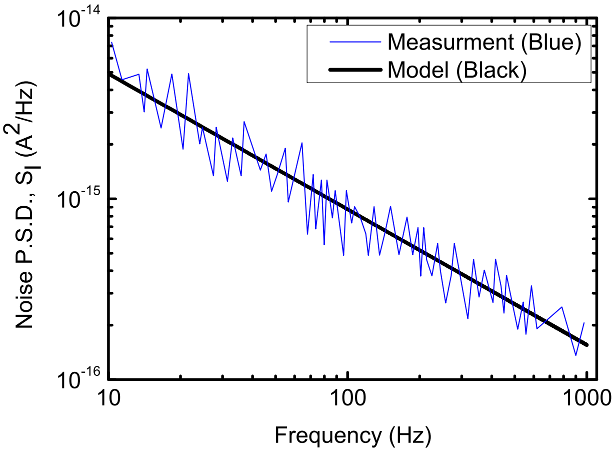

FIGURE 6. **Noise spectral density versus frequency. Measured data is for a 0.13μm × 0.93μm *GaAs* device with *EF* = 0.75 [26]. The noise P.S.D. decreases with frequency as is expected.**

BSIM models. Γ_1, which deals with the carrier number fluctuation, affects the region of gate bias just above V_{off}, Γ_2 modulates the overall noise PSD level and Γ_3, which predominantly affects the mobility fluctuation part, dominates for high gate bias. The model shows excellent agreement with TCAD simulations and measured flicker noise data from GaAs and GaN HEMTs. The developed model extends our previous work of surface-potential-based drain current and charge model in these devices to make it a more complete surface-potential-based compact model for HEMTs.

APPENDIX

CALCULATION OF R [27]: Along the vertical direction, under gradual channel approximation, we can write

$$V_{go} = \frac{-Q}{C_g} + \psi \tag{12}$$

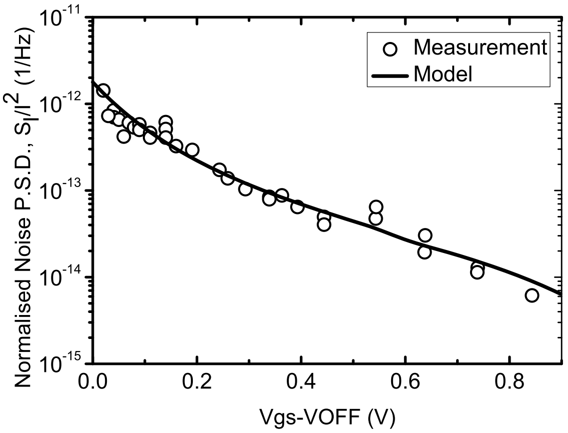

FIGURE 7. **Normalised noise spectral density (1/Hz) versus gate bias (*freq* = 10*Hz*, *Vd* = 0.3*V*; $\Gamma_1 = -6e11$, $\Gamma_2 = -1e12$, $\Gamma_3 = 0.6e18$). Measured data is for a 1.7μm *AlGaAs/InGaAs* device [7]. The trend is consistent with that of TCAD simulations as shown in Fig. 3.**

Taking the derivative with respect to the surface potential, we can rewrite (12) as

$$\Delta\psi = \frac{\Delta V_{go}}{1 - \frac{1}{C_g}\frac{\partial Q}{\partial \psi}} \tag{13}$$

Also,

$$\Delta Q = \frac{\partial Q}{\partial \psi}\Delta\psi \tag{14}$$

Charge neutrality states that $-Q = Q_G$, where Q_G is the gate charge. Let $|Q| = |Q_G| = Q_0$. Therefore, the total voltage V is equal to $Q_0 C_{eff}$. Let ΔQ_0 charge be trapped at a distance x from the top. Assuming large W and L compared to the depth of the 2DEG layer from the gate ($= d$), we can write

$$V' = \frac{Q_0 - \Delta Q_0}{\epsilon_1}x + \frac{Q_0}{\epsilon_2}(x - d) \tag{15}$$

where ϵ_1 is the effective permittivity for the region between the gate and x, while ϵ_2 is the effective permittivity for the region between x and d. For a simplistic device where there is a single material layer between the gate and the 2DEG, neglecting the centroid shift, we can write $\epsilon_1 = \epsilon_2 = \epsilon$. Using (15),

$$\Delta V = -\frac{-\Delta Q_0}{WLC_g}\frac{x}{d} \tag{16}$$

Substituting (16) and (13) in (14),

$$\Delta Q = -\frac{\frac{\partial Q}{\partial \psi}\frac{\Delta Q_0}{WLC_g}}{1 - \frac{1}{C_g}\frac{\partial Q}{\partial \psi}}\frac{x}{d} \tag{17}$$

If the electron concentration in the traps is n, and if there is a fluctuation Δn,

$$\Delta Q_0 = q\Delta n \Delta x \Delta A \tag{18}$$

$\Delta x \Delta A$ being the volume element. Assuming uniform fluctuation over the whole area, we can say that $\Delta Q_0 = qA\Delta n\Delta x$.

Thus, R can be given from (17) as

$$R = \frac{1}{q} \frac{\frac{1}{C_g} \frac{\partial Q}{\partial \psi}}{1 - \frac{1}{C_g} \frac{\partial Q}{\partial \psi}} \tag{19}$$

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REFERENCES

[1] U. K. Mishra, P. Parikh, and Y.-F. Wu, "AlGaN/GaN HEMTs: An overview of device operation and applications," *Proc. IEEE*, vol. 90, no. 6, pp. 1022–1031, Jun. 2002.

[2] F. Danneville, "Microwave noise and FET devices," *IEEE Microw. Mag.*, vol. 11, no. 6, pp. 53–60, Oct. 2010.

[3] I. Angelov, H. Zirath, and N. Rorsman, "A new empirical non-linear model for HEMT and MESFET devices," *IEEE Trans. Microw. Theory Techn.*, vol. 40, no. 12, pp. 2258–2266, Dec. 1992.

[4] M. Li and Y. Wang, "2-D Analytical model for current-voltage characteristics and transconductance of AlGaN/GaN MODFETs," *IEEE Trans. Electron Devices*, vol. 55, no. 1, pp. 261–267, Jan. 2008.

[5] S. Khandelwal *et al.*, "A robust surface-potential-based compact model for GaN HEMT IC design," *IEEE Trans. Electron Devices*, vol. 60, no. 10, pp. 3216–3222, Oct. 2013.

[6] S. Khandelwal and T. A. Fjeldly, "Analysis of drain-current nonlinearity using surface-potential-based model in GaAs pHEMTs," *IEEE Trans. Microw. Theory Tech.*, vol. 61, no. 9, pp. 3265–3270, Sep. 2013.

[7] T. Mizutani, M. Yamamoto, S. Kishimoto, and K. Maezawa, "Low frequency noise characteristics of AlGaAs/InGaAs pseudomorphic HEMTs," *IEICE Trans. Electron.*, vol. E84-C, no. 10, pp. 1318–1322, 2001.

[8] H. Chiu *et al.*, "Characteristics of AlGaN/GaN HEMTs with various field-plate and gate-to-drain extensions," *IEEE Trans. Electron Devices*, vol. 60, no. 11, pp. 3877–3882, Nov. 2013.

[9] A. Balandin *et al.*, "Flicker noise in $GaN/Al_{0.15}Ga_{0.85}N$ doped channel heterostructure field effect transistors," *IEEE Electron Device Lett.*, vol. 19, no. 12, pp. 475–477, Dec. 1998.

[10] A. Balandin *et al.*, "Low flicker-noise GaN/AlGaN heterostructure field-effect transsitors for microwave communications," *IEEE Trans. Microw. Theory Techn.*, vol. 47, no. 8, pp. 1413–1417, Aug. 1999.

[11] F. Bonani, G. Ghione, and C. U. Naldi, "A CAD-oriented quasi-physical HEMT noise model for device design and optimization," in *Proc. Gallium Arsenide Appl. Symp.*, Noordwijk, The Netherlands, Apr. 1992, pp. 27–29.

[12] F. Bonani *et al.*, "HEMT short-gate noise modelling and parametric analysis of NF performance limits," in *Proc. IEEE Int. Electron Device Meeting*, San Francisco, CA, USA, Dec. 1992, pp. 581–584.

[13] A. Laloue *et al.*, "A measurement based distributed low frequency noise HEMT model: Application to design of millimeter wave automotive radar chipsets," in *Proc. IEEE MTT-S Int. Microw. Symp. Dig.*, 2001, pp. 423–426.

[14] A. van der Ziel, "1/f Noise in HEMT type GaAs FETs at low drain bias," *Solid State Electron.*, vol. 26, no. 5, pp. 385–386, 1983.

[15] S. Colangeli, A. Bentini, W. Ciccognani, and E. Limiti, "Polynomial noise modelling of silicon based GaN HEMTs," *Int. J. Numer. Model. Electron. Netw. Devices Fields*, vol. 27, nos. 5–6, pp. 812–821, May 2013.

[16] S. Khandelwal, Y. S. Chauhan, and T. A. Fjeldy, "Analytical modeling of surface-potential and intrinsic charges in AlGaN/GaN HEMT devices," *IEEE Trans. Electron Devices*, vol. 59, no. 10, pp. 2856–2860, Oct. 2012.

[17] A. L. McWhorter, "1/f noise and germanium surface properties," in *Semiconductor Surface Physics*, Philadelphia, PA, USA: Univ. Pennsylvania Press, 1957, pp. 207–228.

[18] F. N. Hooge and L. K. Vandamme, "Lattice scattering causes 1/f noise," *Phys. Lett.*, vol. 66A, no. 4, pp. 315–316, May 1978.

[19] C. McAndrew, "Unified flicker noise model," in *Operation and Modeling of the MOS Transistor*, Oxford, U.K.: Oxford Univ. Press, 2011 [Online]. Available: http://global.oup.com/us/companion.websites/9780195170153/pdf/UnifiedFlickerNoiseModel.pdf

[20] Y. Chan and D. Pavlidis, "Trap studies in GaInP/GaAs and AlGaAs/GaAs HEMT's by means of low-frequency noise and transconductance dispersion characterizations," *IEEE Trans. Electron Devices*, vol. 41, no. 5, pp. 637–642, May 1994.

[21] J. M. Tirado, J. L. Sanchez-Rojas, and J. I. Izpura, "Trapping effects in the transient response of AlGaN/GaN HEMT devices," *IEEE Trans. Electron Devices*, vol. 54, no. 3, pp. 410–417, Mar. 2007.

[22] S. C. Binari, P. B. Klein, and T. E. Kazior, "Trapping effects in GaN and SiC microwave FETs," *Proc. IEEE*, vol. 90, no. 6, pp. 1048–1058, Jun. 2002.

[23] S. C. Binari *et al.*, "Trapping effects and microwave power performance in AlGaN/GaN HEMTs," *IEEE Trans. Electron Devices*, vol. 48, no. 3, pp. 465–471, Mar. 2001.

[24] S. Christensson, I. Lundstrom, and C. Svensson, "Low frequency noise in MOS transistors-I theory," *Solid-State Electron.*, vol. 11, no. 9, pp. 797–812, Sep. 1968.

[25] K. K. Hung, P. K. Ko, C. Hu, and Y. C. Cheng, "A physics-based MOSFET noise model for circuit simulators," *IEEE Trans. Electron Devices*, vol. 37, no. 5, pp. 1323–1333, May 1990.

[26] C. Sanabria, "Noise of AlGaN/GaN HEMTs and oscillators," Ph.D. dissertation, Dept. Electr. Eng., Univ. California, Santa Barbara, CA, USA, 2006.

[27] R. P. Jindal and A. van der Ziel, "Carrier fluctuation noise in a MOSFET channel due to traps in the oxide," *Solid State Electron.*, vol. 21, no. 6, pp. 901–903, 1978.

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