High frequency noise characterisation of graphene field-effect transistors at different temperatures

Junjie Li[1], Xinxin Yang[1], Marlene Bonmann[1], Muhammad Asad[1], Andrei Vorobiev[1], Jan Stake[1], Luca Banszerus[2], Christoph Stampfer[2], Martin Otto[3], Daniel Neumaier[3]

[1]*Terahertz and Millimetre Wave Laboratory, Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-41296 Gothenburg, Sweden,*
[2]*2nd Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany,*
[3]*Advanced Microelectronic Center Aachen, AMO GmbH, 52074, Aachen, Germany*

Graphene is a promising material for high frequency electronics applications thanks to its intrinsically high carrier mobility and velocity, and graphene transistors are continuously pushed toward higher operating frequencies [1]. For high frequency low noise amplifiers, it is important to evaluate the noise parameters of the graphene field-effect transistors (GFETs). In this work, we present the noise performance of the GFETs made of chemical vapour deposition (CVD) in the frequency and temperature ranges of 2-18 GHz and -60-25 °C. The noise figure with 50 Ω impedance termination (F_{50}) was measured using the cold-source method and then the minimum noise figure (F_{min}) was estimated using the Pospieszalski's noise model [2, 3]. In Fig. 1 and Fig. 2, the F_{min} of a GFET with a gate length of 0.5 µm as a function of the frequency (f) and drain voltage (V_d) at different temperatures are shown. This GFET revealed maximum frequency of oscillation (f_{max}) of 18 and 21 GHz at 25 and -60 °C, respectively. It can be seen from Fig. 1, that the F_{min} at 8 GHz is approx. 2 dB lower than that of the previously published CVD GFETs and comparable with that of the best published SiC GFETs [4, 5]. The F_{min} decreases significantly with temperature down to 0.3 dB at 8 GHz, competing with Si CMOS [6]. It can be seen from Fig. 2, that F_{min} decreases with the V_d and saturates above approx. 1 V, where GFETs operate in the velocity saturation mode [1]. Analysis of the dependences allows for further development of the GFETs for advanced low noise amplifiers.

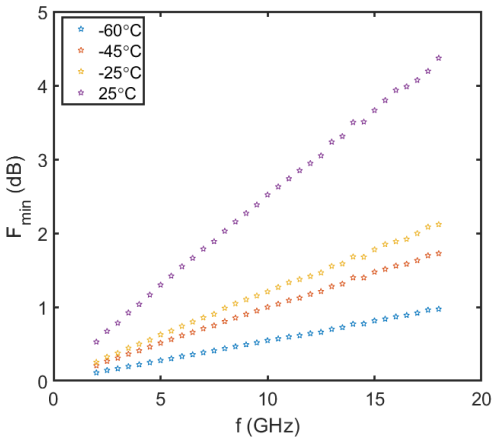

Fig. 1. F_{min} versus frequency at different temperatures (-60, -45, -25 and 25 °C), gate voltage of 0.5 V and drain voltage of -1.4 V.

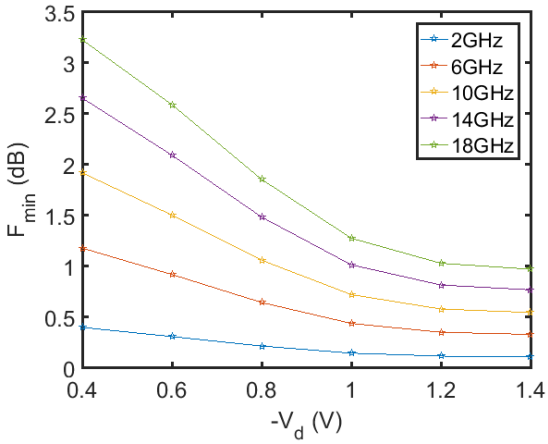

Fig. 2. F_{min} versus drain voltage at temperature of -60°C for different frequencies (2, 6, 10, 14 and 18 GHz) at gate voltage of 0.5 V.

References

[1] M. Bonmann, M. Asad and X. Yang et al., *IEEE Electron Device Lett*. , 40 (1), 131 (2019).
[2] M. W.Pospieszalski, *IEEE Trans. Microw. Theory Tech*., 37 (9), 3476840 (1989)
[3] P. J. Tasker, W. Reinert and J. Braunstein et al., *European Microwave Conference*, 157–162 (1992).
[4] M. Tanzid, M. A. Andersson and J. Sun, et al., *Appl. Phys. Lett*., 104 (1), 013502 (2014)
[5] C. Yu, Z. Z. He, X. B. Song et al., *Appl. Phys. Lett*., 111 (3), 033502 (2017);
[6] L. Belostotski, J. W. Haslett, *IEEE Solid-State Circuits Lett*. , 42 (11), 9671178, (2007)